UNIVERSITY OF KWAZULU-NATAL

DETERMINING THE POTENTIAL FOR SMALLHOLDER ORGANIC PRODUCTION AMONG THREE FARMING GROUPS THROUGH THE DEVELOPMENT OF AN EMPIRICAL AND PARTICIPATORY DECISION SUPPORT TOOL

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ABSTRACT

Organic farming is increasingly viewed as a plausible production system for sustainable agriculture for smallholder farmers. However, there is not enough scientific evidence and knowledge to advocate certified organic farming for African smallholder farmers who face several constraints related to production, storage and marketing. The potential for organic farming for smallholder farmers, faced by these constraints, is not clearly defined. As a result, this study set out to evaluate the production potential of organic agriculture among three smallholder farmer groups. Production questions were used to investigate and evaluate the potential for organic agriculture among three smallholder farmer groups and constituted the following sub-problems:

- What crops can be grown in the three study areas, based on climatic data ?
- Do farmers concur that these are the most suitable potential organic crops?
- How useful do the farmers find the decision making tool?
- What constraints threaten commercial production of the identified crops for these farmers?

Participatory methodologies that included the use of Force Field Analysis, discussions and workshops were used to identify organic production constraints related to production decisions. Farmers faced constraints related to finance, capacity enhancement, technical knowledge, fencing, irrigation, and a lack of, or inappropriately trained extension officers. As a response to identified production constraints, a decision support tool was developed.

Natural resource data, including climatic and agronomic data, was used to create a specially calibrated Microsoft Excel spreadsheet interface that functions as an empirical organic production decision support tool for organic and aspirant organic smallholder farmers, by providing answers for farmer-prioritised production constraints. A list of potential crops for each of the three study areas was subjected to a series of checks against suitability for climate and disease conditions and nutrient requirements.

A limited supply of manure, to meet the enormously high requirements for organic production in the poor soils of these areas, is the major constraint to exclusive organic production and renders certified organic production difficult and unsustainable. Farmers disagreed with some of the crops on the list, arguing that familiar crops were rejected by the model, but they were excited by the prospects for production of “new” crops suggested as suitable by the decision support tool, but not yet grown in the study areas. End users welcomed the model and expressed the opinion that it would be useful in decision making related to organic crop production.

The study concludes that, although a number of agronomically-suitable crops can grow in the study areas, organic production is restricted by rather high manure requirements, lack of compost making skills, lack of knowledge on natural pest and disease control and poorly nourished soils, leading to poor yields. The rainy season creates a disease-supporting environment, rendering organic farming risky for rain-fed smallholder farming. Risk in certified organic farming for smallholders was further exacerbated by a hardly inconducive policy environment that low literacy levels exist amongst farmers.

This study is innovative for three reasons. First, farmers were true participants and drivers of the research. Second, trans-disciplinary expert seminars were attended by experts from different disciplines who critiqued the conceptualisation, design, and implementation of the study. Third, the development of a practical decision-support tool shows innovation towards solving complex smallholder farmers decisions.

If organic farming is to be promoted, commitment by government is needed in order to establish policy and legislation on organic farming to direct and govern training, information provision and marketing. Intensive training and knowledge building of organic production for smallholder farmers and extension officers is critical. There are also agroecological risks associated with organic farming for smallholder farmers.

Recommendations for future research include comparison between organic agriculture and conventional agriculture, where sustainability of certified organic farming and economic viability can be conducted in the South African context. Improvement of the decision making tool will require involving information technology specialists so that the tool can be installed in community centres, extension offices and other accessible places for farmers and others.

DECLARATION

I, Joyce Magoshi Chitja, declare that:

- The research reported in this thesis, except where otherwise indicated, is my original research.
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LIST OF ABBREVIATIONS

AIDS	Acquired Immune Deficiency Syndrome
AFRISCO	African Farms Certified Organic
BDOCA	Bio-Dynamic and Organic Certification Authority
DfID	Department for International Development
DoA	Department of Agriculture
DAEA	Department of Agriculture and Environmental Affairs
EFO	Ezemvelo Farmers' Organisation
EM	Effective micro organisms
EPOPA	Export Promotion of Organic Products from Africa
EU	European Union
FAO	Food and Agriculture Organisation
FFA	Force Field Analysis
H	High
HIV	Human Immunodeficiency Virus
IDP	Integrated Development Plan
IFOAM	International Federation of Organic Agriculture Movement
IFRUTEC	Institute of Fruit Technology
K	Potassium
L	Low
M	Medium
N	Nitrogen
NGO	Non-Governmental Organisation
NPK	Nitrogen, Phosphorous, Potassium
OFRF	Organic Farming Research Foundation
P	Phosphorous
TA	Traditional Authority
UKZN	University of KwaZulu-Natal
USDA	United States Department of Agriculture

CHAPTER 1: THE PROBLEM AND ITS SETTING

1.1 The rationale for the study

Organic farming has received much attention as a sustainable agricultural production method in recent years (Hellin & Higman, 2002). For many reasons, organic farming is often promoted as an opportunity for smallholder farmers in Africa, at subsistence and commercial levels (Walaga, 2002), including environmental sustainability, cultural factors, similarities in production, enhancing indigenous knowledge systems and profit opportunities. Despite the success of conventional farming in increasing yields in many parts of the world, conventional agriculture has also been detrimental to the environment through the accumulation of agrochemicals and increased energy costs related to manufacturing and transportation of agrochemicals (Madër *et al*, 2002). There is a need to find more sustainable ways of farming. Organic farming offers an alternative method that takes the above functions into consideration. Despite the success in productivity of organic farming in other parts of the world (Pimentel, 2005), it is not known if the same success and sustainability can be replicated by smallholder farmers in South Africa.

South African smallholder farmers typically live in poor communities (Aliber *et al*, 2006). Certified organic products often fetch a premium price in the marketplace (Oberholzer *et al*, 2005) and may be beneficial to smallholders who enter into commercial production. Smallholder farmers in Africa are faced with a complex mix of constraints, including poor technical knowledge of organic agriculture (Juma, 2007). Although organic farming is promoted as a suitable production system for smallholder farmers (Walaga, 2002), there is a lack of adequate information to support the view that certified organic production is the best production method and a better income earner for smallholder farmers in developing countries. Critical issues, such as policy and markets for organic products, are often absent in developing countries. South Africa like most developing countries lacks policy mechanisms and adequate marketing channels for organic produce. Although, there are some formal marketing channels for organic produce such as Woolworths, Pick and Pay and Checkers supermarkets and direct farmer markets which are discussed later, South Africa does not have legislated organic standards to govern the industry although draft organic standards have been prepared and distributed to World Trade Organisation member states for comment (Erasmus, 2007). Furthermore, organic farming is a knowledge-based system that requires long-term investments in capacity building, among other issues (Scialabba, 2007).

Farmer decision-making is complex and is influenced by on- and off-farm factors (FAO, 2006). Farmers do not make decisions in a linear way but rather make multiple decisions simultaneously (FAO, 2006). The need to understand crucial farm management decision-making is important for appropriate extension and design of development strategies to assist in reducing farmer risks, especially when considering adopting and/or scaling up commercial organic agriculture.

There is insufficient appropriate information to help farmers make the best decisions in organic farming and risk management. Some of the most important areas for decision-making in organic production and gaining certification to enter niche markets include: production, supply chain management, pest and disease control and certification above and beyond general farm management. Typical general farm management decisions include: choice of agricultural enterprises, allocation of labour, acquisition of land, capital and inputs and marketing of produce (FAO, 2006).

Farming is a risky business, owing to unpredictable factors such as climatic variation, price fluctuations and destruction by diseases and pests. Organic farming presents an even more pronounced risk due to the fact that agrochemicals, such as pesticides including herbicides, are disallowed in certified organic farming (OFRF, 2001). Many different kinds of decisions will have to be taken in addition to those that one would normally take in conventional farming. Established commercial organic farmers in South Africa generally have access to support for decision-making with regard to conventional production and, to some extent, organic production (Aliber, 2006); for example state research and information agencies such as the Agricultural Research Council (ARC) and Institute of Fruit Technology (INFRUTEC). Historically, smallholder farmers in South Africa have received little attention in respect of appropriate extension and research support (May *et al*, 1998). There is clearly an urgent need for better tools to assist small and emerging farmers in decision-making to minimise risks and improve productivity and enterprise success.

A study by Belaineh (2002) identified that among others, production and market risks are determined by farm size, proximity to markets, access to roads for transportation of produce and agro-ecological conditions. These factors are crucial in a niche market such as organics, and even more so for smallholder farmers with limited resources because they do not have resources to cushion the added risk of organic farming.

Despite the importance of the need for a comparison between organic and conventional production to investigate economic viability and sustainability, this study focused on a production related analysis. The production potential for organic farming among smallholder farmers in three different agro-ecological zones in KwaZulu-Natal was investigated. An empirical computer decision support tool (interface) was designed to assess the production potential in three agro-climatic zones and a user interface for assisting farmer decision-making was developed. The three main interface outputs on production are: a list of potential low-risk crops per area; an assessment of organic soil nutrient requirements; and, disease risk level per selected area. This information could assist farmers in making decisions regarding adoption or intensification of organic agriculture.

1.2 Statement of the problem

Is smallholder organic production of agronomically suitable crops possible and low risk in Mbumbulu, Muden and Centocow?

1.3 Sub-problems

Sub-problem 1: What crops can be grown organically in the three areas based on climatic data?
Sub-problem 2: Do farmers concur that these are the most suitable potential organic crops?
Sub-problem 3: How useful do the farmers find the decision-making tool?
Sub-problem 4: What constraints threaten commercial organic production of the identified crops for these farmers?

1.4 Study limits

One farmer group in each of the three climatic zones were selected for this study. The list of crops on which the model was based is specific to each climatic zone.

Absolute growth conditions, as opposed to optimum growth conditions, to assess crop growth potential were used, on the basis of the historical fact that many South African smallholder farmers are located in agro-ecologically less favourable areas.

Despite the importance of a comparison between organic farming and conventional farming in terms of economic viability and sustainability in determining whether organic farming is profitable for smallholder farmers, the study focused only on evaluating the potential for organic production in three areas.

The risk element of production in the study was limited to only two factors –manure availability and disease onset. The availability of the required quantity of manure within the community was used as a determinant of farmers' ability to ensure organic soil fertilisation. Soil nutrition may also be improved with the use of green manure and other permitted inputs in compost-making but these were not investigated. Although pests are an important environmental risk, pest occurrence was not included in the study because this would have made the study too broad. Instead, only diseases were included in determining risk.

1.5 Organisation of the thesis

Chapter 1 outlines the rationale for the study, the study problem, sub-problems and the conceptual framework. Chapter 2 includes a review of the literature and seeks to give a detailed account of what is known and not known on the research question. Chapter 3 presents the background to the study and provides characteristics of the participating farmer groups in relation to location, size and interests of the groups.

Chapter 4 presents a participatory analysis of production constraints on which the development of the decision-support tool is based. The processes involved in the development of the decision-support tool are discussed in chapter 5. A comparative application of the decision-support tool for the farmer groups is presented in chapter 6. A summary, conclusions and recommendations of the study are presented in Chapter 7.

CHAPTER 2: LITERATURE REVIEW[1]

2.1 Introduction

Agricultural production systems used to produce food and/or fibre without the use of agrochemicals such as pesticides including herbicides and commercial synthetic fertilisers are known as organic (OFRF, 2001). Organic farming involves the use of organic compost, manure and natural disease and pest control. Many agricultural products are produced organically, including fresh produce, grains, meat, dairy, eggs, fibre such as cotton and flowers. The management of organic farming relies on developing biological diversity in the field to discourage and manage pests. Organic farming uses readily available resources in nature to improve soil fertility and remove pests (OFRF, 2001).

Growth in the world organic market and increased imports of organic produce from developing countries is contributing to the view that organic agriculture can contribute to sustainable ecological and socio-ecological development, especially in poor countries (Willer & Yussefi, 2007). There is increased promotion of organic agriculture in developing countries, including Africa. Despite its theoretical potential to impact on local economic development, plus its compatibility with cultural/traditional smallholder practices (Walaga, 2002), there is little reliable data on of the current role of organic agriculture in developing countries, especially in Africa (Willer & Yussefi, 2007).

The environmental benefits of organic agriculture are widely publicised (Greene & Kremen, 2003; Halberg *et al*, (2007); Mäder *et al*, (2002)). Certified organic products often fetch premium market prices and could play a role in alleviation of food insecurity by driving economic development to benefit poor smallholder farmers (Willer & Yussefi, 2007). However, there is a lack of adequate information to support the proposition that organic production is a vehicle for economic development among smallholder farmers in developing countries (Willer & Yussefi, 2007). Critical

[1] A paper based on this chapter has been accepted publication (Thamaga-Chitja JM & Hendriks SL (forthcoming). *Emerging issues in smallholder organic production and marketing in South Africa*. Development Southern Africa)

supporting policies and markets for organic products are often absent in developing countries. South Africa does not have organic standards (although a draft policy exists) (Erasmus, 2007). This lack of standards does not encourage development of farming and effective mechanisms and marketing channels for organic produce.

Decision-making for farming and related activities is complex and is complicated by on- and off-farm factors (FAO, 2006). Farmers do not make multiple and interrelated farm decisions in a linear manner but in simultaneous ways (FAO, 2006). The need to understand crucial farm management decisions is important for appropriate extension and design of development strategies aimed at assisting farmers reduce risks, especially when considering adopting and/or scaling up organic agriculture.

Typical general farm management decisions include the choice of: agricultural enterprises; allocation of labour and land; acquisition and allocation of capital; and, inputs and marketing (FAO, 2006). Some of the most important areas for decision-making above and beyond general farm management in organic production and gaining certification to enter niche markets – include production, marketing, pest and disease control and certification. There is insufficient appropriate information to help farmers make better decisions in organic farming and risk management.

Farming is a risky business owing to unpredictable environmental factors (Jarvis *et al*, 2006). Organic farming presents even more pronounced risks due to the fact that the application of agrochemicals, such as pesticides and herbicides are not allowed (OFRF, 2001). In organic farming, farmers have to rely on high level management practices based on a sound understanding of the biological system. Production and market risks are often determined by farm size, proximity to markets and roads and agro-ecological conditions (Belaineh, 2002). Such risks are increased for niche markets, such as organics, and even more so for smallholder farmers with limited resources. Profitability, without the required experience and knowledge of the organic farming system, is unlikely. Historically, smallholder farmers in South Africa have received little attention with respect to appropriate extension and research (May *et al*, 1998). There is clearly an urgent need for tools to assist smallholder farmers in decision-making, especially so with organic farming if this system is to be promoted. Without such interventions, smallholder farmers' food security may be threatened.

This literature review shows that there is potential for smallholder farmers to benefit from organic farming but availability and access to resources, inputs and appropriate production information is important to make informed decisions about organic production and its associated risks. The chapter assesses issues related to the potential for organic farming among smallholder farmers and highlights the strengths and challenges for smallholders investigating entry into commercial organic production. The issues discussed include: reasons for adopting organic farming, opportunities and constraints for smallholder farmers, agro-ecological considerations, processes involved in organic certification, the size of the organic market in South Africa and decision-making and support required for smallholder organic production.

2.2 Reasons for smallholder adoption of organic farming

Smallholder farmers in Africa and other parts of the developing world are engaged in farming activities for food security reasons. Smallholder agriculture is too important to employment, human welfare and political stability in sub-Saharan Africa to be ignored or treated as an unimportant sector of the market economy (Aliber *et al*, 2006). Organic agriculture, though with constraints, offers benefits to the multi-dimensional nature of food security in the dimensions of food availability, access, stability and utilisation (Scialabba, 2007). Up-to-date hypothetical models of global supply indicate that organic agriculture could produce enough food globally on a per capita basis for the current world population (Badgley *et al*, 2007; Halberg *et al*, 2007). Organic farming has been shown to increase yields by up to 180% for subsistence systems, if well resourced (Badgley *et al*, 2007). However, in South Africa smallholders are mostly in communal land (can't use land as collateral for loans), practice mostly rainfed agriculture and are located in areas of inferior agricultural performance (Aliber, 2006).

Over the past 20 years, increasing attention has been focused on organically-oriented agricultural development in the southern hemisphere (Green & Kremen, 2003). This has occurred due to growing recognition that organic farming production methods support environmental sustainability through biological pest management and composting, while simultaneously discouraging the use of synthetic chemicals, antibiotics and hormones in crop production (Greene & Kremen, 2003). The maintenance and replenishment of soil fertility is important. Synthetic pesticides or fertilizers are not allowed in organic farming. Key traits of organic farming include the design and implementation of sound organic practices in production that track all products; a detailed record-keeping system that tracks all products from the field to point of sale; and, maintenance of buffer zones to prevent contamination by synthetic farm chemicals from adjacent conventional fields (OFRF, 2001).

Organic farming appears to offer smallholder farmers opportunities to realise commercial goals that may not be possible through conventional agriculture (Hellin & Higman, 2002). The elimination of agricultural chemicals (pesticides and fertilisers) in organic farming reduces the cost of purchased inputs (OFRF, 2001). However, a good understanding of the farming ecosystem and its management is critical for the success of an organic farming enterprise. Before the advent of the green revolution, most African farmers had a good understanding of traditional farming systems mainly the good understanding of crop rotations similar to the organic system. However, in some cases this indigenous knowledge has been eroded and totally lost in others (Juma, 2007).

2.2.1 Similarities between organic farming and African farming systems

Before the advent of agrochemicals most original farming was similar to organic farming. Original farming practices typically included: companion cropping, crop diversification, crop rotation, mulching application of green manure, crop rotation with nitrogen-fixing legumes and natural disease control (e.g use of ash as a pesticide). Crop rotation and mulching also had a positive impact on disease control. The long use of agrochemicals has eroded organic production and management knowledge that existed among farmers, including traditional African farmers. Today’s organic production systems are similar to many traditional African production systems (Vezi, 2007; Makhanya, 2006). Some smallholder farmers already have this knowledge and in essence have been practicing organic-based farming through traditional systems. In cases where this knowledge is lost due to the influence of chemical-based agriculture, retraining of farmers and extension officers in terms of knowledge and skills for organic agriculture is important for organic agriculture to be successful in Africa (Juma, 2007).

Furthermore, many African smallholder farmers typically have access to land that has not been exposed to intensive chemical agriculture. Such farmers could gain certification faster than the three-year conversion period recommended by the European Union (Biodynamic & Organic Certification Authority (BDOCA), 2006). Organic certification may afford small farmers the opportunity to market their products in the fast growing domestic and international organic markets.

2.2.2 Expanding niche markets for organic produce

The organic food market is one of the fastest growing markets in the developed world (Makatouni, 2001). Some wine farmers in South Africa reported an increase of 400% in organic wine sales in 2003 (Business Day, 2005). In Europe, North America, Australia and Japan organic food sales exceeded $114.5 billion per annum in 1999 (Makatouni, 2001). Many developed countries experience annual growth rates of 20-30% for organic foods (Makatouni, 2001). To ensure food security through organic agriculture for the northern countries, southern countries should make an effort to develop local organic markets (Willer & Yuseefi, 2007).

Smallholder farmers in Africa have an opportunity to produce premium-priced products in organic markets and obtain higher revenue than that typically gained from conventional agricultural markets. Nakashini (2003) reports that Chinese farmers are taking up opportunities offered by emerging organic markets where sales were projected to reach US$20 billion per annum by 2005. Chinese sales were projected to exceed the United States sales by US$7 billion in 2005.

Barret *et al* reported 2002 that the demand for organic foods in the United Kingdom was skyrocketing, but organic farmers in the United Kingdom were not able to meet the rapidly growing demand. Up to 75% of organic food in the United Kingdom was imported in 2001, primarily from the southern hemisphere (Rigby *et al*, 2001). The growing demand in the United Kingdom is attributable to government support for the organic farming sector (Rigby *et al*, 2001). In the United Kingdom, the conversion to organic farming was supported by the government's Organic Conversion Information Service and the Organic Advisory service (Rigby *et al*, 2001). In the United States, consumer demand for organically produced goods has risen sharply for over a decade, providing market incentives for farmers across a broad range of products (Green & Kreemen, 2003). In the United States, the Organic Farming Scheme provides a financial incentive in the form of lump sum payments over three years for converting to organic farming (Rigby *et al*, 2001).

A few studies have attempted to examine consumer perceptions, attitudes and reasons for buying or not buying organic foods (Makatouni, 2001). One study conducted in Reading, the United Kingdom, showed that people bought organic foods for health, environmental and ethical reasons (Makatouni, 2001). Regarding perceptions of organic farmers, Rigby *et al* (2001), found that the main motivating factors for converting to organic farming in the United States were concerns about family health; farming practices (e.g. soil degradation); lifestyle choices (ideological, philosophical and religious); and higher income due the premium prices organic products fetch in the marketplace.

Some South African supermarket chains already stock a range of organic produce. Woolworths began marketing small supplies of organic fresh produce, including fresh vegetables and herbs, and has now expanded its organic range to animal products such as milk, milk products and meat (Ferreira, 2004). A growing number of South African consumers are also adopting global organic food trends. Woolworths has experienced consistent growth in the demand for organic food. In 2004, Woolworths reported a 50% year-on-year growth in organic food sales (Business Day, 2005). Another retailer, Pick 'n Pay predicted a total sales growth of 5% in the short term, 10% in the medium term and up to 20% in the long term (Business Times, 2004). Although the growth in South Africa has been good, there is a view that South Africa is five years behind organic trends in the United Kingdom (Business Day, 2005). The reasons reported for low organic sales in other countries include the high prices, lack of adequate information and inadequate supply (Makatouni, 2001). Why South African consumers are increasingly motivated to buy organic foods is not clear and should be investigated to better understand the opportunities for smallholder production in South Africa.

The current commercial boom in organic agriculture demands a ‘new African farmer’ requiring a supportive environment including technical, market and financial assistance to ensure economic benefits from new consumer trends (Hellin & Higman, 2002). It seems plausible that with the appropriate supportive environment, organic agriculture could contribute to economic development for smallholder farmers (Anon, 2003).

2.3 Opportunities and constraints for African farmers

Most African production systems are similar to organic production systems, making conversion and organic certification simpler (Jackson, 2006). Historically, African farmers have had limited access to finance to expand production or invest in substantial external inputs (Matungul, 2002). As a result, many African farmers have not practiced intensive chemical agriculture involving high use of chemicals. With the required knowledge and investment in building on existing knowledge, African farmers may be well-placed to meet organic production requirements. African farmers enjoy more favourable climatic conditions, conducive for longer production cycles, than farmers in the northern hemisphere. Organic farming is one of the ways in which farmers can earn higher incomes from organic premiums, plus the opportunity to earn foreign income through exports (OFRF, 2001). In striving to meet northern hemisphere demands for organic food, African farmers could also improve their livelihoods if they are able to meet certification requirements and gain access to lucrative export markets.

Historically, smallholder agriculture has not enjoyed opportunities to participate in the production of high value crops for commercial purposes due to limited resources and institutional constraints (Ortmann & Machete, 2003). The South African government’s efforts to address these constraints are likely to forge opportunities for smallholder farmers to participate in the production of high value crops by strengthening the linkages between smallholder farmers and commercial farmers, and by stimulating non-farm linkages (Ortmann & Machete, 2003). Although there are many opportunities for smallholder African farmers to profit from organic farming, some key challenges are presented in Table 2.1.

Table 2.1: Challenges facing African farmers with regard to successful organic farming (Quansah, 2003)

- Access to land and financial support
- Access to water and resources, especially for smallholder farmers
- Lack of awareness of niche markets for organic produce
- Problems in accessing local, national and international markets
- Dependence on standards set by northern hemisphere countries, which limit the development of other countries' standards
- Lack of technical skills among farmers for organic production
- Lack of appropriate extension services for organic production systems.

The following section discusses some key constraints, including labour demands (especially in the face of HIV/AIDS); organic management knowledge; and, access to markets and certification. These constraints relate to the access dimension of food security. Due to resource limitations, linked mostly to the dualist nature of South African smallholder agriculture, most constraints experienced by smallholder farmers fall into this dimension (Aliber *et al*, 2006).

2.3.1 Labour demands

The demands for labour are increased in organic farming due to the exclusion of agrochemicals and the requirement of working with natural processes such as physical methods of controlling pests and diseases, which necessitates a hands-on approach to managing biodiversity in time (crop rotations) and space (mixed cropping) to prevent the onset of disease (Scialabba, 2007). Once disease and pests are present, control is even more demanding in terms of manpower. A study conducted in the southern province of Zambia by Kalinda *et al* (2000), indicated that labour and livestock were important elements for organic production. Labour demands limit the expansion of production. Kalinda *et al* (2000) found that in southern Zambia, having a number of wives and children was considered an asset to smallholder farmers as members contributed to agricultural labour and lowered the need to hire labour. Women typically clear fields, control pests, scare off animals or birds from fields, herd animals and transport and market produce. The heavy load of domestic work for women and HIV/AIDS increase the burden on women (Scialabba, 2007).

Rigby *et al (*2001) have shown that farmers who convert to organic farming usually have smaller farms, possibly due to the high labour requirements of organic farming. Other case studies have found that the average farm size for smallholder farmers in South Africa is generally two hectares (Thamaga, 2001; Naledzani, 1988), which is probably quite manageable in terms of organics production.

Despite the demands of labour on smallholder organic farming, there is a positive element to this demand. Where unemployment is high (as is the case in South Africa and other African countries), a well resourced organic farming sector can provide a large number of low-skilled people with employment thus contributing to the reduction of unemployment and improving the local economy.

2.3.2 Required organic knowledge and skills

Organic farming is a knowledge-intensive approach to agriculture (Sligh & Christman, 2007). On the other hand, input-based agriculture in conventional systems relies largely on the use of prepared agrochemicals to solve problems. Organic farming demands an in-depth understanding of farms (as entire systems) and farmers (as capable experimenters and innovators with a wealth of experience and knowledge) (von der Weid, 2007). In South Africa, participants in smallholder agriculture tend to be people with no opportunity of moving to the preferred cash-based economy closer to towns due to low levels of education and skills (Aliber, 2006). However, a long-term commitment to building capacity in knowledge related to all elements of organic farming (production, pest and disease control, markets) is critical (Scialabba, 2007). In addition to investing in organic farming skills in Africa, success of organic agriculture requires that other constraints related to infrastructure, marketing and enabling policies gain attention for organic agriculture to be successful. The similarities between organic farming systems and most African farming systems may provide an opportunity in organic agriculture among such farmers. Reflecting on the similarities between African farming systems and organic agriculture emphasises that organic farming is not a recent creation from northern countries but a continuous adaptation of indigenous farming knowledge into science (Sligh, 2002).

2.3.3 Access to organic markets

Farmers need access to markets to generate cash. Institutional arrangements to facilitate market access are crucial (Matungul *et al*, 2001). Export markets for organic products seem to be the focus of developing countries (Sligh & Christman 2007). These markets seem to promise long-term incomes and improved livelihoods. However, both domestic and international markets are important and it must be ensured that local organic markets do not grow at the expense of the export market (Sligh & Christman, 2007). On the other hand, there are many information, institutional, policy and physical challenges that impede smallholder farmers in accessing such markets (Aliber *et al*, 2006). Organic certification is one such challenge that empedes access to organic markets for smallholder farmers and this is expanded in section 2.5.

2.4 Agro-ecological considerations

All sound agricultural practices require a good understanding of agricultural ecosystems. It can be argued that one of the key differences between organic farming and conventional farming is the commercial reliance on external chemical inputs. Unlike conventional farming, which largely relies on external inputs, organic farming emphasises the use of management practices related to agro-ecosystem health, biodiversity, biological cycles and soil biological activity for productivity (Dabert *et al*, 2004). Amongst other aspects, organic production systems aim to enhance biological diversity within the system and increase soil biological activity to enhance long-term soil fertility and pest/disease management (Altieri, 1989, p. 180 and 186).

The reality for most smallholder farmers in South Africa is that they are situated in parts of the country that are of inferior agricultural potential and possess scant information on techniques that could boost production and meet yield demands

(Poulton, 2004). Such areas score poorly in terms of productive soil and favourable climates (Aliber *et al*, 2006). Low rainfall creates water shortage problems in rain-fed agricultural systems.

The natural environment is by far the most important element in fostering the onset of disease. Factors that contribute to the onset of disease include temperature and moisture (Agrious, 2004). Therefore, the location of organic farms is important for successful farming. The choice of crop also influences the likelihood of disease. Some crops, such as tomatoes, should be avoided by organic farmers in humid areas as high humidity renders tomatoes prone to many diseases (Jones *et al*, 1998).

Water use in organic systems must be well managed to avoid runoff, in line with the sustainability principles of organic farming. Lack of irrigation is often cited as a limiting factor in the South African smallholder production systems (Thamaga, 2001). Water harvesting and mulching must be incorporated in organic systems to conserve water and ensure adequate production.

2.4.1 Organic soil fertility and nutrient availability

Many studies have reported initial decreased yields during the first few seasons when switching from conventional agriculture to organic production. Mäder *et al's* 2002's report on a 21 year study on agronomic and ecological performance of biodynamic, bioorganic, and conventional farming systems in central Europe indicated that crop yields decreased by 20% in organic systems. On the other hand, Mäder *et al* (2002) also found that fertilizer and energy input was reduced by 34% to 53% and pesticide input by 97% in organic systems. It is a well established fact that, unlike commercial fertilizers, nutrients in organic sources are not readily available (Magdoff & van Es, 2000). The key to maintaining soil fertility in an organic farming system lies in the increased efficiency of nutrient flow from fixed to soluble states. Soil fertility management is one of the key principles of organic farming to maintain desired yields (Gaskell *et al*, 2007).

The role of organic matter in general soil health is critical (Magdoff & van Es, 2000). High levels of organic matter are associated with reduced soil erosion and better water infiltration, movement, retention and nutrient cycling (Stine & Weil, 2002; Mäder *et al* (2002). Organic sources of soil nutrients contribute more to soil organic matter than commercial fertilisers. Soil organic matter can be improved by crop rotation, tillage systems and manure application rates, even in conventional systems, but these practices are integral to organic farming. Crop yields are further influenced by the effects of treatments, such as mulching, that improve nitrogen levels, water retention and temperature stabilisation (Stine & Weil, 2002). It should be noted that the source of organic matter is important in determining its usefulness as a source of nitrogen.

Stine & Weil (2002) have shown that soil carbon plays a vital role in soil functioning and plant productivity in tropical climate zones when it comes to predicting how organic farming will perform. Organic farmers need to retain nitrogen and soil organic matter at the highest levels possible to ensure maximum soil productivity (Altieri, 1989). The volume or quantity of organic soil matter is also correlated with soil productivity and erosion control, both important considerations in terms of farm system sustainability (Gaskell *et al*, 2007). Increasing soil organic matter is a key aspect of organic production (Gaskell *et al*, 2007). Application of organic fertilisers such as animal manure or compost is essential to complement the primary sources of nitrogen, often fixed by legumes (Gaskell *et al*, 2007). Therefore, the choice of agro-ecological zones is important in achieving productive soils, yet smallholder farmers do not normally have an opportunity to select ideal locations and thus have to make the most of marginal land.

Clearly, organic matter is important for agricultural production and soil fertility, contributing to both soil quality and health (Quiroga *et al*, 2006; Magdoff & van Es, 2000). For farmers who are accustomed to the widespread use of agrochemicals, total elimination of these chemicals may be challenging. Conversion to organic agriculture requires new production and crop management systems. A survey commissioned by the United Kingdom’s Department for International Development (DfID) in 1996 showed that there is little evidence of knowledge and adoption of improved soil fertility management and crop protection of a non-chemical nature among smallholder farmers in sub-Saharan Africa who are accustomed to the application of chemicals (Harris *et al*, 1998). There may be value in reviving age-old, yet declining, indigenous African farming systems that may benefit organic farming today.

Crop diversification plays an important role in the stability of the organic farming system, unlike common mono-cropping practised in conventional farming. Organic farming promotes the planting of more plant species and an abundance of organism groups (Hole *et al*, 2005). Admittedly, many integrated farming systems used in conventional farming systems do incorporate biodiversity principles but still permit the use of agrochemicals.

The volume and type of crops grown organically vary worldwide, with vegetables being the most widely grown crops (Greene & Kreemen, 2001). Many South African smallholder farmers produce crops mainly for subsistence and traditionally plant crops they consume (Aliber, 2006). Organic farmers including African farmers need to increase farm diversity by producing a variety of vegetables, in addition to traditional root, legume and cucurbit crops, to break plant disease and pest cycles (Niggli *et al,* 2007). However, effective management is required to achieve different nutritional needs that the introduction of new crops may pose. Unlike commercial fertilisers, organic nutritional sources provide varied nutrient levels, based on the source and uncertain timing of release of nutrients (Magdoff & van Es, 2000). The stability of the organic production system is based on below- and above-ground biodiversity (Niggli *et al,* 2007).

In addition to the high transaction costs discussed earlier, the elimination of agrochemicals creates higher production risks for organic farmers. Organic farming is more vulnerable to adverse weather conditions and infestation by pests and uncertain and varied nutrient supply, which may reduce yields during the conversion to organic farming.

The organic farming system relies on prevention rather than cure based on crop rotations, resistant crop varieties, maintaining biodiversity and optimum crop health (Soil Association, 2007). Even in the strict and regulated certified organic industry a few pesticides are permitted where no other option exists (Soil Association, 2007). For example, unusual whether patterns may lead to an outbreak of certain diseases and pests, bringing about an imbalance in the biodiversity. The Soil Association allows for such pesticides of simple (sulphur, soft soap, copper and rotenone) chemical form compared to the complex chemicals used on conventional farms to be used in their certified organic farms in the United Kingdom (Soil Association, 2007).

The use of licensed biological control agents is also common and permitted in certified organic farming for the control of disease and pest control (Soil Association, 2007). The concept of biological control has been practiced for a long time even before it could be defined (Yobo, 2005). By definition, biological control in relation to disease control, refers to a mass introduction of one or more antagonistic organism, where the antagonists are referred to as biological control agents (BCA) (Yobo, 2005). These antagonists can be predators or parasites of pests which are released into the crop and have proved to be effective especially in greenhouse/glasshouse production (e.g *Bacillus thuringensis* Bt.).

Biological technology has indeed gained international success in recent years and has been used in organic farming to enhance plant growth and control pest and diseases is also known as Effective Microorganism (EM) use. EM is a complex combination of naturally occurring microorganisms (yeasts, photosynthesis bacteria, lactic acid bacteria and fungi) that function in certain combinations for effectiveness (Chamberlain & Daly, 2005). Through completive exclusion, EM with compete and displace some of the disease causing pathogens (e.g "damping off disease").

A wide range of bacterial and fungal species has been investigated for the control of soil-borne plant pathogens. Nevertheless, there is still a large scope of investigation for potential BCA's. There are several common biological control agents (BCA's) for both vegetable and fruit crops which has been used with success. The following list provides a brief list organisms used as biological control agents for some common crops:

- *Aeromonas caviae* (BCA for *R.solani, S rolfsii, Fusarium oxysporum f.s.p ciceris* in beans) Inbar & Chet (1991).
- *T.viridae G, T. hamatum, T.harzianum* (BCA for *R. solano* in cabbage) Lewis & Lumsden (2001).
- *T.hamatum, Pseudomonus fluorescens, G virens* (BCA for *Fusarium* spp in tomato) Larkin & Fravel (1998).

- *B.pumilus* (BCA for postharvest control of *Penicillium digitatum* in citrus) Huang *et al* (1992).
- *C.globosum, Coniothyrium minitans, T. harzianum, T. virens,T. koningii* (BCA for *Scerotium cepivorum* in onion) McLean and Stewart (2000).

Application methods of BCA range from application to seed as a treatment in beans, incorporation into the growth medium in cabbage, drenching or incorporation into the growth medium in tomato and spraying or injection into fruit wounds in postharvest disease control in citrus.

Not all BCA's are available in South Africa. Many BCA's are foreign products and not registered as local commercial South African products. Such products would out of reach for most smallholders farmers in South Africa. In cases where such products become available, the financially lacking smallholder farmers will not be able to access them.

2.5 Processes involved in organic certification

Organic products are positioned as special products occupying a niche market place. Understating the certification process is important for producers who may wish to trade in organic products to assist their decision making with regards to choosing to trade in organic products or remain conventional.

Unlike conventional commercial farming, marketing of organic produce requires certification of production processes and products by an authorised certification body (OFRF, 2001). The process of certification is lengthy, technical and costly. This may discourage smallholder farmers from entering certified organic farming. Organic certification is the process of determining compliance with standard organic agricultural practice (BDOCA, 2006). There are four reasons why farmers must be certified to market organic produce. First, certification distinguishes between organically-produced products and conventional products. Second, certification informs consumers of the production methods used, especially where consumer premiums exist for organic products. Third, certification protects farmers who adhere to the standards against competition from those who do not follow organic practices. Fourth, certification is a requirement to access high-value niche markets, both locally and abroad.

The process of certification used by BDOCA (one of the certification bodies in South Africa) is outlined in Table 2.2. The process of organic certification begins with the farmer contacting an authorised local certification body. If the farmer's objective is to export to certain markets, the certification body of choice must be recognised and authorised by the importer, as differences in standards exist among countries (Barrett *et al,* 2002).

Table 2.2: Steps to be followed in organic farm certification (BDOCA, 2006)

Steps in the certification process	Activities
1. Application	• Standards and certification cost information is acquired. • History of the farm is recorded.
2. First review	• The certification application is reviewed. • An estimate of the total costs is drawn.
3.Assignment of an inspector	• An inspector is assigned to inspect the farm based on the information provided
4. Inspection	• An inspection is conducted and a report is produced; no recommendations are made at this stage.
5. Second review	• All information is reviewed. • A recommendation is made to the certification committee regarding the application.
6. Recommendation by certification committee	• Several outcomes are possible. Full certification may be granted or refused. Other outcomes of this stage may include a farmer being given a status of 'organic in conversion' with or without conditions.
7. Internal monitoring system	• Once certified, trained internal monitors carry out the inspection in conjunction with a quality control officer. The inspectors use a questionnaire to assess the state of the farm, soil fertility, crops grown, fertilisation regime and pest/disease/weed control. This form is currently written in English. Many African farmers do not speak or write English.

Once certified, trained internal monitors and a quality control officer carry out an inspection. The inspection involves the use of a questionnaire to assess the state of the farm, soil fertility, crops grown, fertiliser regime and pest/disease/weed control. The required form is long, complex and currently written in English. Many African farmers do not read or write English, which may hinder the internal inspection process and block access to certification.

Organic certification standards are generally set by international bodies, such as the International Federation of Organic Agriculture Movements (IFOAM), and are adopted by local certifiers (Hellin & Higman, 2002). There are advantages and disadvantages to using local and international standards (Table 2.3).

Table 2.3: Advantages and disadvantages of local certification programmes

Advantages of local organic certification	Disadvantages of local organic certification
• Lower costs for producers • Better knowledge of local conditions and languages by certifier • Better information flow between certification bodies and producers due to closer proximity • Trust developed between producers and certifier • More possibilities exist for making unannounced inspections • Keeps money in the economy	• Lack of competence and information at start-up phase by local certifier • Difficulties in obtaining international recognition for export opportunities • High initial investment costs may take resources from other activities • Conflicts of interest may lead to power struggles between certification bodies

(Barret *et al*, 2002, pg. 307)

Local certification programmes are of greater benefit to farmers as they are more sensitive to local conditions and culture. Local certification bodies are often cheaper and allow for better information flow between the certification body and farmers during the certification process. Even when local certification programmes conform to required international standards, farmers may experience difficulty in attaining and maintaining these production standards (Barret *et al*, 2002).

Banados & Garcia (2001) have shown that certification standards and legislation from key organic markets, such as those in the European Union, impact negatively on the ability of developing country farmers to trade internationally. For example, agricultural products from developing countries can only be marketed as organic within the European Union if production and inspection systems are considered equivalent to European Union standards. It is estimated that the European Union standards and legislation reduced Chile's organic export produce volumes by 30% between 1998 and 2000 (Banados & Garcia, 2001).

Developing world farmers who want to export to the European Union have two options, as set out in Article 11 of Regulation 2092/91 of the United Kingdom legislation for organic farming. First, the organic farmer's country is required to be listed as having standards equivalent to those of the European Union, as set out under Article 11(1). Currently, most listed countries belong to the developed world. Second, developing countries, with non-equivalent standards, can apply for special permits and import authorisation (Article 11(6)) from the respective European Union control authorities (Barret *et al,* 2002), provided that production systems and inspection standards comply with those stipulated by the European Union (Banados & Garcia, 2001). South Africa does not currently have uniform national certification standards. Unless South Africa and other African countries wishing to benefit from international organic export opportunities formalise and standardise certification procedures, farmers in these countries cannot access or take advantage of international export opportunities.

The complexity of the certification process is increased by the required annual inspections and a rigorous internal monitoring system. Both processes demand capacity development among farmers and/or communities to gain and retain organic certification. Farmers in developing countries face obstacles such as high certification costs and inadequate knowledge of local conditions by foreign certifiers (Barret *et al,* 2002). To export organic produce, developing countries must pay for international inspection costs, which can be very expensive (e.g R 16 000-R 20 000). Local inspection bodies can be accredited by international certifiers, helping to lower the certification and monitoring costs. Small farmers can also group themselves into co-operatives or producer groups for group certification to further lower certification costs (Barret *et al,* 2002). However, internal monitoring systems in group certification must function well. This includes ensuring that a random sample of at least 10% – 20% of the group's farms are inspected annually by the certification body (Barret *et al*, 2002).

Despite the above constraints, an increasing volume of organic produce from developing countries is entering the European Union, but data on imports are currently scarce and unreliable (Barret *et al*, 2002). Many projects that aim to improve organic exports are underway in Kenya, Tanzania and Uganda (Barret *et al*, 2002). These programmes include government programmes, fair trade organisations, business partnerships, and co-operation with certification bodies. An example of such a programme is the EPOPA (Export Promotion of Organic Products from Africa) programme initiated by the Swedish International Development Agency for exporting produce (coffee and cotton) to countries such as the Netherlands (Barret *et al*, 2002).

The International Federation of Organic Agriculture Movements (IFOAM) has a set of principles for organic agriculture, which countries should use to develop their own standards. Table 2.4 contains a list of basic principles that organic production and processing should work towards, according to IFOAM.

Table 2.4: Basic principles of organic farming set by IFOAM
(Hellin & Higman, 2002, pg. 2)

- Organic ecosystems,
- Crop production,
- Animal husbandry,
- Aquaculture production,
- Processing and handling,
- Forest management,
- Labelling, and
- Social justice.

African Farms Certified Organic (AFRISCO) and Biodynamic and Organic Certification Authority (BDOCA) are two South African certification bodies with international affiliations. Several international certification bodies also operate in South Africa, for example Skal from the Netherlands, the Soil Association, Ecocert and Nature's Choice (Callear, 2005). Standards used by local certification bodies in South Africa are adapted from IFOAM principles. These basic principles include provisions for social justice and provide a framework for certification bodies worldwide to develop their own standards (Hellin & Higman, 2002).

2.6 The cost of organic certification

Unlike conventional farming, there is an additional annual cost incurred in organic farming to retain the status for trading organic products. It is important to understand the implications of annual organic certification costs, especially for resource poor farmers. The cost of certification depends on many factors, including the use of local certification bodies versus international bodies; the history of chemical application; farm size; and, the distance travelled by the inspector to the farm. Initial group certification in South Africa can be as high as R16 000, with annual costs ranging from R 16 000-R 20 000 to remain certified (BDOCA, 2006). For example, the Ezemvelo Farmers' Organisation (the first group to achieve group certification in South Africa) paid R9 000 for its first certification, R10 000 for annual certification in 2004 and R15 000 for training internal inspectors in 2003 (Modi, 2004). Without the sponsorship received to cover these costs, this group would not have been able to afford certification in 2003 (Modi, 2004).

Government interventions, such as subsidised organic certification and facilitation of group certification among smallholder farmers, is vital to promote local organic production. Smallholder farmers have an opportunity to implement indigenous farming techniques for commercial purposes. However, government intervention and support is required for the entire supply chain, which includes extension support for organic production, packaging and labelling produce, quality assurance and marketing. Appropriate government assistance with marketing should include extension training in production skills to ensure product quality, market identification, and facilitation of contracts between farmers and buyers. It must be noted that some government interventions should be only on a short term basis to ensure that farmers become self-reliant and that systems are developed to support them without perpetual government involvement.

2.7 The size of the organic market in South Africa

The sale of organic foods in supermarkets was launched formally in South African 1999 by Woolworths Supermarket. Pick 'n Pay, Shoprite Checkers and Spar supermarkets followed suit in subsequent years. Since 1999, South Africa has experienced an increasing consumer demand for healthier foods, including organic foods (Business Times, 2004). In 2004, Woolworths reported sales of R1 million a week (Business Times, 2004). This figure was 20 times higher than the figure of R50 000 reported three years earlier. Two other supermarkets – Checkers and Pick'n Pay reported a doubling of sales in 2003 and a "steady growth", respectively (Business Times, 2004).

The demand for organic food products in South Africa far outstrips supply (Business Times, 2004). In 2004, organic products represented five percent of Pick 'n Pay's total food turnover. Based on international trends, this figure may grow by 10 to 15% between 2005 and 2009. The demand for a larger range of organic products, including clothing and wine, has also increased in recent years. Stellar Organic Winery in Cape Town experienced a 400% increase in sales in the first half of 2005 (Business Day, 2005).

According to Organics South Africa, total land certified as organic in South Africa amounted to 515 000 ha in 2004 but, as is typical in developing countries, this figure was difficult to verify (Willer & Yussefi, 2007). A large percentage (more than 77%) was certified between 2000 and 2004, an indication of the rapid growth of the industry. A large proportion of the certified land is owned by previously conventional large-scale commercial farmers, mostly due to their greater access to start-up costs for production, conversion and accreditation.

A study commissioned by EPOPA (Export Promotion of Organic Products from Africa) on the South Africa organic market survey revealed that information (especially financial records) was difficult to get hold of. However, the study revealed that crop production revenue from the production season of 2004 amounted to R 17 868 896 equivalent to $ 2 179 134 in 2008. Livestock figures were not available (Epopa, 2006).

Despite the great potential for organic farming, very few smallholder farmers participate in the South African market. Matungul (2002) stresses that the reason for the lack of participation in the market is due to a deficiency of assets, market information and training. Mnkeni (2001) asserts that farmers are faced with constraints related to marketing due to the lack of pertinent information. Farmers do not have any information on what type of products to grow, which markets to sell to, what distribution channels to choose, the effects of competition, and how to gain access to markets (Mnkeni, 2001). In addition, farmers are located far from markets and have poor access to infrastructure, which increases their transaction costs (Makhura, 2001).

2.8 Decision-making for smallholder organic farming

Decision-making can be defined as the process of choosing a course among alternatives to achieve a desired result. Effective decision-making requires good information, sound judgment and flexibility. Resource-limited farmers in South Africa lack appropriate production information and successful farming experience to make sound judgments regarding production (Poulton, 2004). For farmers to specify realistic alternatives, they must be aware of all aspects of the decision-making process. Risk aversion or risk-taking is informed by the presence of constraints (e.g. available credit) that may limit alternatives. In many parts of the developing world, including South Africa, farmers have limited or no access to alternatives such as credit for the purchase of production inputs, which reduces their choice of alternatives (Sligh & Christman, 2007).

Farmer decision-making is complex and is influenced by on- and off-farm factors, including the availability of off-farm employment, which is often perceived as less risky than farming (FAO, 2006). The need to understand crucial farm management decisions is important for appropriate extension and development strategies to assist in reducing farmer risks, especially when considering adopting and/or scaling up organic agriculture.

Farming is inherently risky, owing to unpredictable factors such as climatic and market factors. Organic farming presents an even more pronounced risk due to the fact that agrochemicals, such as pesticides, are not allowed in certified organic farming. Many decisions will have to be taken in addition to those of conventional farming. Established commercial organic farmers have better structures to support decision-making with regard to organic production. Lack of access to information, particularly information about markets and production, constrain smallholder conversion to commercial organic production. These elements are discussed below.

2.8.1 Access to knowledge and information

Due to the knowledge-intense nature of organic farming, access to such knowledge is critical for the success of organic farming and in creating local critical mass (Scialabba, 2007). Farmers require access to information to expand their current knowledge. There is a need for sufficient and appropriate information to help smallholder farmers make better decisions in farming and risk management (FAO, 2006). Access to knowledge and information is one of the critical stumbling blocks when conversion to organic agriculture is considered (Scialabba, 2007). Lack of experience and appropriate extension and training exacerbate the situation of new organic farmers.

The availability of and access to good information is important in decision-making. Due to historical factors, there is a lack of adequate information to support smallholder farmers (Aliber *et al*, 2006). There is a need for information that allows smallholders to decide if organic production is a sound choice for commercialisation. Critical issues such as markets for organic products and relevant organic farming policy are often absent in developing countries to support the growth of the smallholder organic industry (Willer & Yussefi, 2007).

Only a small proportion of smallholder farmers have access to written information on farming (Bembridge, 1997). There is a sizable volume of printed agricultural information for farmers in South Africa. Despite this, access to such information by smallholders is hindered because many producers of agricultural information fail to meet the true information needs of smallholder farmers in South Africa (Stefano, 2004). Those tasked with the collation and dissemination of agricultural information should consider literacy levels and the appropriateness of information.

Many assumptions are made about what information is required and there is a lack of understanding of how smallholder farmers use information (Stefano, 2004). Most government extension information is not context-specific to smallholder farmers and organic farmers because knowledge is seen as the domain of off-farm experts (Sligh & Christman, 2007). For example, many smallholder farmers engage in multiple cropping systems, whereas most of the printed and verbal information from government extension services is based on mono-cropping and conventional methods of farming.

2.8.2 Use of information by smallholder farmers

Although information exists, it is not always accessible or used, for various reasons. A study by Stefano (2004) discussed information use propositions by smallholder organic farmers. The study explains that information use is dependent on several factors, including need and user awareness. For information to be used, farmers need to be aware of its existence and it should be the kind of information they need. On the other hand, farmers use information because it is accessible, credible and understandable (Stefano, 2004). Non-use of information may be attributed to personal conditions (e.g. lack of motivation); low literacy levels; lack of effort to find what information exists; and, lack of competence in the use of the literature. To support farmer decision-making information should be context-specific, appropriate for the level of literacy, and delivered through the appropriate channels.

In the developed world, government intervention has focused on market facilitation, certification, cost-sharing assistance, funded market research, and subsidised conversion to organic farming systems as a way of facilitating the environmental benefits of organic production (Green & Kreemen, 2003). In most of Africa, transport infrastructure development; relevant training; extension services; skills training; market facilitation; increased local consumer awareness; and, facilitation of access to export opportunities in Europe and the United States are important to support growth in the organic industry.

In summary, organic farming is a young industry with a promising future, driven by a fast-growing international and local demand. African smallholder farmers stand a good chance of benefiting from commercial organic agriculture for the following reasons: lower input costs; similarities in production systems; access to land with limited exposure to agrochemical use; favourable climatic conditions; growing for niche markets; and, organic practices being environmentally sustainable practices. Yet African farmers face production, management, financial, and institutional challenges. Therefore, there is an urgent need to capacitate smallholder farmers to overcome current problems. Long-term investment in capacity building to increase knowledge of organic farming is of paramount importance for the success of organic farming. Practical solutions to overcoming barriers to technical and financial information and institutional barriers, such as accessing loans and meeting certification costs, are also urgently needed for smallholder farmers. However, careful attention should be given to the fact that perpetual external support is not good for sustainable organic farming. Therefore, empowerment of farmers is important so that reliance on external support is minimised.

The elimination of pesticides, fertilisers and herbicides in organic farming poses a challenge for pest and disease management and capacity to meet the required yields, but this may create a much-needed demand for labour in areas of high unemployment. The identification of suitable crops for smallholder agro-ecological conditions could support more profitable farming. Research is required to identify suitable crops with accessible niche markets. Appropriate information and resources are important to minimise risks and to enable better decision-making in order to improve productivity for smallholder farmers.

The growth of the South African and African organic industry requires supportive policies to cultivate a conducive environment for smallholder farmers. Policy considerations may include market facilitation; funded market research; advisory centres; certification cost-sharing; farmer training; extension services, such as information dissemination to users; local consumer awareness; and, access to export opportunities.

CHAPTER 3: STUDY BACKGROUND AND GROUP CHARACTERISTICS

Farming forms an important part of livelihood strategies for most rural communities in South Africa and cannot be ignored in the development of rural areas (Delgado, 1999). Agriculture is promoted widely as a strategy to overcoming poverty and food insecurity in South Africa, and the KwaZulu-Natal province in particular (Hendriks, 2005; Singh, 1999). Moreover, organic production is promoted as a means of income generation among smallholder farmers in the province (Vezi, 2005). Yet, few comprehensive studies have been undertaken to investigate the feasibility of organic production among smallholder farmers in South Africa, including in KwaZulu-Natal.

The Ezemvelo Farmers' Organisation (EFO) was the first group to be certified in organic production in South Africa (Fischer, 2005). Studies conducted among members of this organisation revealed a number of constraints related to production, storage, risk and institutional arrangements. Studies revealed that financial gains from production may be relatively low for several reasons (Hendriks & Msaki, 2006; Molapo, 2006; Ndokweni, 2002; Xaba, 2003). Gadzikwa *et al* (2006) showed that critical elements to the sustainability of organic farming for EFO related to the continued provision of subsidised information, transport, fencing and certification services for its members by external agencies.

Stefano *et al* (2005) found that EFO had poor access to written agricultural information which limited productivity. The risk attitudes of the Ezemvelo Farmers' Organisation were investigated by Lwayo *et al* (2006) who showed that EFO farmers were more risk averse than commercial farmers, implying that opportunities of improved productivity may be hampered by risk aversion.

Alternatives in the organic market chain were investigated by Mushayanyama & Darroch (2006) who indicated that levels of farmer commitment were strongly related to trust between farmers and the marketing agent. An additional study by Phiri & Modi (2005) conducted amongst EFO members, investigated the agronomic potential for new crops in Mbumbulu, where EFO is located. Phiri & Modi (2005) suggested that crops, such as wild mustard (*Brassica spp*), may have agronomic potential and production could be expanded into commercial production. However, Mushayanyama & Darroch (2006) established that although there is scope for increased productivity and planning of new crops, uncertainty around prices and information must be addressed with the group.

This study concentrated on evaluating organic production potential for three farmer groups. Interaction between the researcher and members of the EFO indicated that there was a great desire for information related to crops and production decisions. It is essential that profitability and sustainability of organic production be investigated before promoting the adoption and expansion of commercial organic production among smallholder farmers. Participatory action research was used in the development and testing of a decision-making tool for smallholder farmers considering adoption or expansion of commercial organic production. Two other groups were included to allow for comparison and verification of results.

This chapter outlines the selection of the participating farmer groups, provides background information regarding the location and agro-ecological situation for each of the three areas, and describes the groups' aims and member profiles.

3.1 Group selection

Historically, most smallholder farmers in South Africa are found in rural areas of less favourable agricultural potential (Hendriks & Lyne, 2003). These areas often have harsh climates, poor soils and low rainfall. In addition, such smallholder farmers are often resource-poor. Unless they are beneficiaries of the smallholder irrigation schemes of the former homelands (Aliber *et al*, 2006), smallholder farmers lack supplementary irrigation. Farming under such conditions makes it difficult for them to succeed.

As discussed earlier, EFO (Mbumbulu) members requested sub-problems in this study to be addressed. Interest in organic farming was an important factor to consider in the selection of the two additional groups. It was deemed important to have three groups for the purposes of comparison. In the end, three farmer groups, located in Mbumbulu, Muden and Centocow in rural KwaZulu-Natal, participated in the study.

The three groups were located in three different agro-ecological zones and were at different stages of organic certification. The Mbumbulu farmers obtained certification for the first time in 2001 and had retained certification through annual inspections. The Muden and Centocow groups were both recommended by non-governmental organisations (NGOs) to the researcher as groups who practiced some elements of organic farming but were not certified and still included commercial fertilisers in their practices. The Muden farmers had received training in organic farming and permaculture from an NGO, (The Farmer Support Group) but they were not certified organic producers. Similarly, the Centocow group had received training on organic farming principles and compost-making but had not acquired organic certification status. All three groups were operating at varying levels of formalisation. The following section discusses the characteristics of the farmers and their geographical location.

3.1.1 Geographical location, socio-economic/socio-institutional and soil nutrient characteristics

The three areas occupy different agro-ecological zones and have varied agricultural potential (Fig 3.1). In Table 3.1 a basic climatic comparison of the three areas is presented.

Mbumbulu is a humid area, located in the Mkhambathini municipality, with an average rainfall of 956mm per annum (Camp, 1999). Mbumbulu falls within the Mkhambathini Municipality and is located approximately 50km from Pietermaritzburg towards Durban (see Figure 3.1). Of the three areas, Mbumbulu has the highest rainfall. The EFO farmers practice rain-fed agriculture. At the time of the study, the farmers in Mbumbulu (EFO) had no access to irrigation infrastructure or water storage facilities. Due to the relatively high rainfall (Table 3.1), the possibility for water harvesting exists. Reliance on rainfall limits the choice of crops and expected yield, limiting farmer productivity. At the time of this study EFO members were approximately 250 in number, having grown from 52 certified farmers in 2001 and 161 in 2003. EFO consists of approximately 80% female farmers and 20% male farmers. The organisation includes young members with active roles. Some of the younger members are trained as internal organic inspectors.

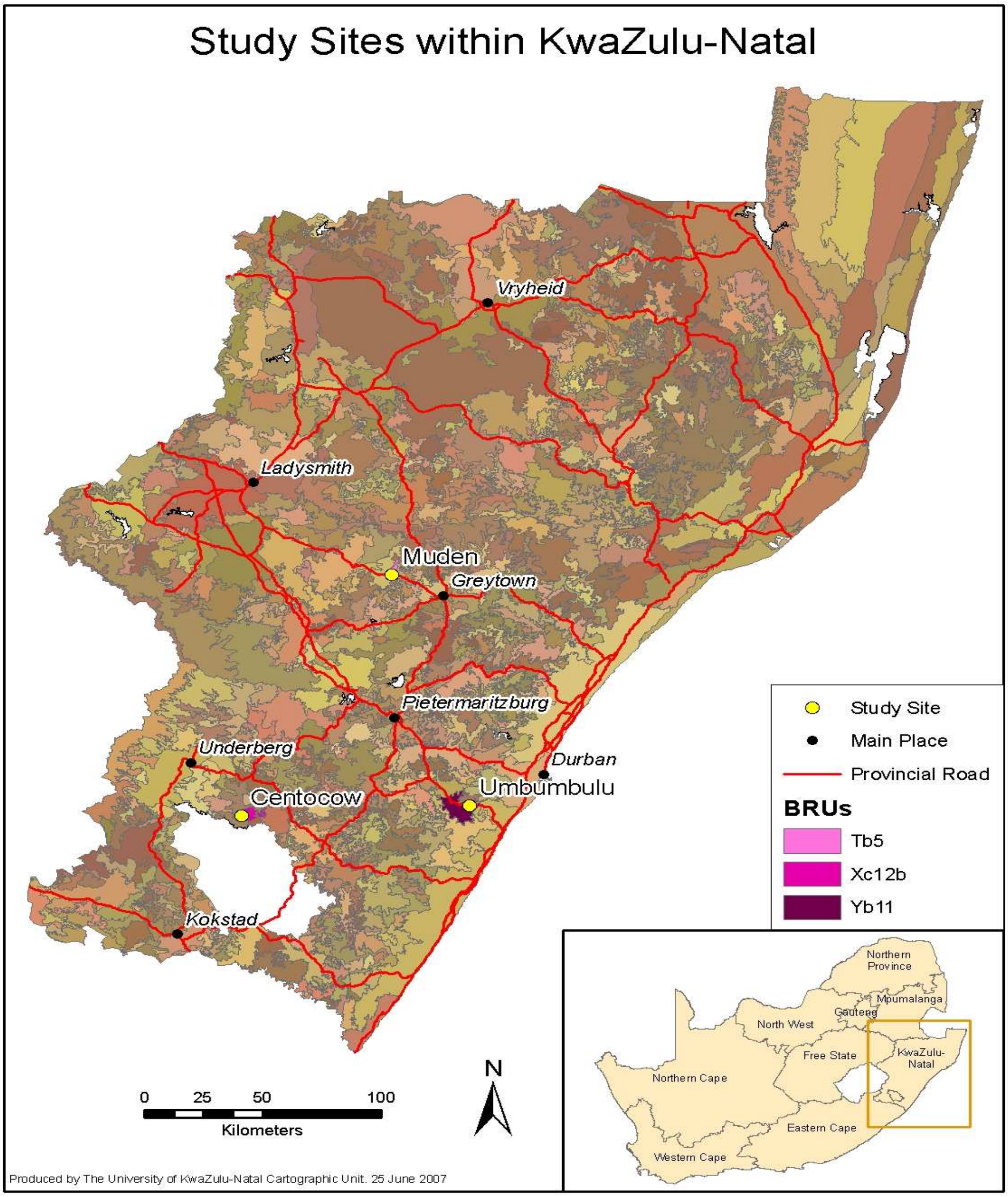


Figure 3.1: Area map indicating Mbumbulu, Muden and Centocow (University of KwaZulu-Natal Cartographic Unit, Pietermaritzburg).

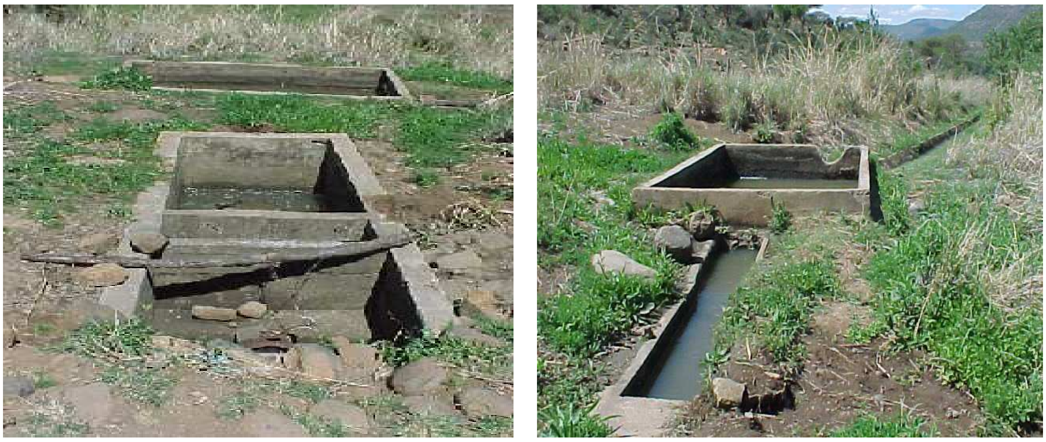
Table 3.1: Comparative climatic data for Mbumbulu, Muden and Centocow (Camp 1999)

Area	Annual average rainfall (mm)	Mean minimum temperature (degree Celsius)	Mean maximum temperature (degree Celsius)	Photoperiod (hours)	Length of rainy season (days)
Mbumbulu	956mm	18.6	24	13	241
Muden	674mm	18.1	24.7	13	181
Centocow	879mm	16.5	23.3	13	211

Muden is a small town situated approximately 25km from Greytown. The Muden farmer group lives in a rural community known as KwaNxamalala in the Msinga Local Municipality. The 109 farmers call themselves the KwaNxamalala farming group. Approximately 90% are female.

The annual rainfall is 674mm and summer is hot and dry. Muden is a low rainfall area (Table 3.1) compared to Mbumbulu and Centocow. Although the Muden farmers farm along the banks of the Mooi River, they are likely to experience water shortages when the river is low due to low rainfall.

Despite the low rainfall in Muden, the KwaNxamalala farmers have access to irrigation infrastructure consisting of pipes, a pump, canals and some sprinklers. The Muden irrigation scheme was developed when the agricultural development trend in KwaZulu-Natal was to establish irrigation schemes. Nevertheless, the Kwa-Nxamalala farmers' group experiences numerous problems with the irrigation infrastructure and availability of water. There is poor capacity among the farmers to repair the broken equipment, which often causes lengthy disruptions in water supply. The farming area of the community is divided into 15 farming sections, also known as blocks. The KwaNxamalala farmers' group utilises blocks 14 and 15 of the farming area.



(A) (B)

Figure 3.2: Sluice gate water supply (A) showing water being diverted (B) into canals in the Muden irrigation scheme (Goba, 2004).

Block 14 and 15 are at the furthest end of the blocks, furthest from the Mooi river dam's point. The Mooi River dam supplies water through a canal system to all 15 blocks. Water is received first by block 1 and last by block 15. The KwaNxamalala group farms for household consumption in the neighbouring village, roadside selling and pension payout days when there are a large number of people with available cash. Goba's 2004 study of water and soil conservation conducted in blocks five and six revealed that, often, the wheel that controls the amount of water that is released into all the blocks is not in working order.

As shown in Figure 3.2, water is released through a sluice gate and distributed through canals throughout the 15 blocks. The fact that the KwaNxamalala farmers occupy blocks 14 and 15 of the farming area is a disadvantage. When water is released to the flood system, blocks 1-13 are first to receive water. Often, blocks 14 and 15 receive little water or none at all. The low rainfall in Muden contributes to the low water level of the river.

3.1.2 Soils nutrient verification

It was important to ascertain the nutritional condition of soils in the three study area so that the decision support tool and its application was based on current soil conditions for the communities. Soil samples collected to analyse for nutrients were taken from the first 20cm of soil using a small spade. In each study area the following was done: three different locations on the farm were sampled, in including the top end, middle and bottom end of each farm (in Mbumbulu and Centocow, the farm refers to participating households (averaged) whereas in Muden the farm refers to one large communal plot). The three samples from each farm were then mixed to make one sample per farm for analysis. The results of the soil analysis, presented in Table 3.2, were used to provide a broad picture of the state of soils as important components of the study. A full analysis of the soil condition is discussed in Chapter 6.

Table 3.2: Soil analysis conducted in Mbumbulu, Muden and Centocow, July 2005

	(P) phosphorous (mg/L)	(P) Reserve (kg/ha)*	(K) Potassium (mg/L)	(K) Reserve (kg/ha)*
Mbumbulu	7.75	-24.5	74.25	-151.5
Muden	5	-30	584	868
Centocow	19	-2	328	356

*[soil analysis value-critical value]*2 = reserve before critical level is reached (Mason , 2006)

Basic socio-economic data on the three groups is presented in Table 3.3. Young people in South Africa are typically not interested in farming, Table 3.3 shows a familiar trend in that the average age of all study participants was at least over 50 years. Similarly, a high percentage of farmers are female, except for Centocow, which is a male only group.

Table 3.3 Mean socio-economic characteristics of the three farmer groups, 2005

	Mbumbulu (n=48)	Muden (n=60)	Centocow (n=11)
Age	53	50	50
Gender	80% female	90% female	100 % male
Household size	9	8	9
Education	Primary school	Primary school	Primary school
Land size (ha)	2.4	2.3	0.72

The findings presented in Table 3.3 are supported by socio-economic data of Integrated Development Plans (IDP's) for the municipal districts where the groups are found. According to the recent Mkambathini (Mbumbulu) Integrated Development Plan (IDP), prepared by Isibuko se Africa Development Planners (2006), Mkambathini consists of five tribal areas and the rest are urban areas. In 2005-2006, about 17% of people in Mkhambathini were skilled and held professional jobs, while about 6.8% of people were employed in commercial agriculture. According to a recent Msinga (Muden) Integrated Development Plan (IDP) prepared by Udidi Development Planners (2005), the district is a low socio-economic status area with high illiteracy levels (68%) and poor access to job opportunities. According to the Ingwe (Centocow) Municipality Integrated Development Plan, prepared by Isikhungusethu Development Planners (2005), the Centocow community is of low socio-economic status. Illiteracy in the region is 50%.

Livestock and small ruminants (cattle and goats) are important economic assets for rural communities. Table 3.4 provides the minimum, mean and maximum numbers of livestock, small ruminants and poultry for manure production. Livestock ownership is important as an economic asset in the communities, especially for organic farmers because livestock (cattle and goats) are the main source of manure.

Table 3.4 Livestock and small ruminant holdings per household

	Mbumbulu (n=48)	Muden (n=60)	Centocow (n=11)
Cattle			
Minimum	10	2	5
Mean	11	8	10
Maximum	12	38	30
Sheep and goats			
Minimum	15	1	3
Mean	35	9	11
Maximum	40	30	50
Poultry			
Minimum	30	-	-
Mean	45	-	-
Maximum	45	-	-

Many farmers in the group hope to make a better living through their involvement in agriculture. However, lack of water and other resources tend to demotivate the majority of group members. Provided that resources (e.g irrigation and fencing) are available, farming has the potential to contribute to livelihoods and income.

Centocow is a small rural mission town en route to Underberg. It is very cold in winter and has an annual rainfall of 879mm (Table 3.1). The rainfall in this area is not low and may be adequate as a source of water for supplementary irrigation if farmers had ways and means of harvesting and storing the water. However, there is no irrigation infrastructure or dam. Smallholder farming in the area is predominantly rain-fed. The farmers involved in this group are from a rural community called Emakhuzeni on the outskirts of Centocow, KwaZulu-Natal. The group calls itself ‘Izwi la Madoda’, meaning ‘the voice of men’. The farmers explained that rural smallholder farming activities are traditionally dominated by women. According to them, there is an urgent need to involve rural men in smallholder agriculture as many of these men have been retrenched and are unemployed.

Figure 3.3: Some of the members from Izwi la Madoda, August 2005.

Izwi la Madoda consists of 15 men, some of whom are featured in Figure 3.3. All of the men hold various leadership positions in the community. Two of the members are the Inkosi’s assistants (*indunas*). Their leadership positions are seen as strategic in influencing members of the community to adopt farming as a way of life (especially organic farming) and to encourage more men to engage in these activities. Traditionally, women dominate farming activities in the area. Izwi la Madoda believes that men have to take the position as head of their families and start providing food and income, since employment opportunities are scarce. The group has worked on many issues with the NGO Valley Trust since 2003, including the role of rural men in agriculture. The Valley Trust has provided training to this group regarding organic farming and compost-making.

Similar to the Mbumbulu and Muden groups, Izwi la Madoda exist within a rural community, Emakhuzeni, which is led by an Inkosi who holds the land in trust for the people, who have communal ownership of the land. It can therefore be expected that Izwi la Madoda members are likely to have similar characteristics as seen in Table 3.3. Naidoo, (2006) showed that one member had attained matriculation-level and education levels varied from high school to primary-level education (n = 11).

Farming takes place on two large farms named Qedindlala and Thembelihle, where the group farms as a collective. Farmers also have smaller units of land at their homesteads where they farm as individuals. The homestead unit is mainly for household consumption and mixed production is practiced. The joint farms are for large-scale, commodity-based production. When rains are good, the larger plots are utilised to capacity.

3.1.3 Group institutional arrangements and activities

There are similarities and differences in how the groups are organised and managed. The Mbumbulu (EFO) and Muden groups are managed by an annually elected committee, which constitutes a chairperson, a treasurer and a secretary. Mbumbulu (EFO) is the first group in South Africa to gain organic certification (Fischer, 2005). EFO has a well-developed constitution that details the role of the internal approval committee, which reviews applications from prospective members and makes decisions. The constitution sets out the role of the internal control system and determines the ramifications for EFO members who violate the rules. External members, including an official from the Department of Agriculture and a Researcher from the University of KwaZulu-Natal (UKZN), form part of the internal approval committee (Fischer, 2005). The UKZN staff member plays an important role in ensuring quality, adhering to standards and establishing and maintaining links with other stakeholders on behalf of the group. The Department of Agriculture has not played an active role in this group.

The Muden and Centocow groups have an elected leadership but they do not have an elaborate constitution, such as that of the EFO, that they abide by. However, they do have basic constitutions and rules of engagement. The chairpersons of both groups provide leadership and serve as the contact person for stakeholders.

The current production methods of the groups differ. EFO has for decades been using traditional farming methods similar to that of organic production methods although they received organic certification in recent years. Within the EFO organisation 52 farmers are fully certified, while the rest are partially certified (in conversion). On the contrary, the Muden and Centocow groups are essentially using conventional farming methods with the inclusion of livestock manure (also known as kraal manure) as a fertiliser.

EFO organised itself into a formalised farmers' organisation in 2000 and received organic certification in 2001. Although not certified as organic, the Centocow group formalised itself as a farming group in 2000. Muden was formalised in 2004. The KwaNxamalala farmers' group is currently using conventional farming practices although some organic farming practices, such as the occasional use of manure, are included in their production system. The group is at the initial stages of investigating organic farming methods. Although it has received training in organic farming principles, it is still largely using conventional methods. EFO has enjoyed ongoing assistance from researchers at the University of KwaZulu-Natal and other NGOs (Makhanya, 2006). In contrast, the Centocow group cited a lack of assistance from government extension workers or other parties. The Valley Trust was the only external party working with the group at the time this study was conducted.

EFO's original aim was to alert smallholder farmers to the importance of indigenous crops and help farmers realise the economic value of indigenous knowledge and practices (Modi, 2004). EFO has since expanded and adjusted its traditional farming system to include certified organic farming and is producing for the market. EFO members are organic producers who sell green beans, potatoes, sweet potatoes and *taro* (a*madumbe)* to the Woolworths supermarket chain in South Africa. EFO also sells to other markets, including the local community and merchants from urban centres who visit the area. Although EFO appears to be the most developed group of the three, because it has access to formal markets, Gadzikwa *et al* (2006) have shown that EFO will only survive if it continues to receive subsidised information, transport, fencing and certification services for its members and synchronises harvesting and delivery. In contrast, the Muden group of farmers formalised itself into a collective to share resources and conduct group marketing (Dludla, 2005). The Centocow group formalised itself with the purpose of setting the example that men can also play a role in rural agriculture and are able to provide for themselves and their households (Vezi, 2005). All groups aim to produce for both household consumption and markets. However, they do not always succeed in producing surpluses for sale. The Muden group frequently produces garlic (a non-traditional crop for its members) for commercial purposes. On the other hand, the Mbumbulu group is committed to supplying Woolworths and attempts to increase yields. The Muden group sells to neighbours and also targets monthly pension payout points where there are a large number of people with available cash.

All three groups farm communally owned land held in trust by the Inkosi (Traditional Authority Chief) of the Embo-Timuni Traditional Authority (TA) in Mbumbulu, Bomvu TA in Muden and Amakhuze TA in Centocow. Due to communal tenure and weak traditional institutions, there is no land market. Unlike commercial farmers, who traditionally farm privately-owned land, smallholder farmer members in these areas cannot use their land to secure finance/loans.

Farming activities are vital for food security and have the potential to unlock the potential of a rural economy. In South Africa, farming has been shown to play a small but important role in buffering households against poverty (Aliber *et al*, 2006). Therefore the importance of pioneering agricultural groups, such as EFO, cannot be overstated. Cash in hand rather the ability to produce food which is still the single most important determinant of food security in South Africa (Kirsten *et al*, 2003). Efforts to commercialise subsistence farming are important and should be fully engaged and supported.

CHAPTER 4: PARTICIPATORY ANALYSIS OF ORGANIC PRODUCTION CONSTRAINTS

4.1 Introduction

Organic farming is a topic that dominates international food production and food security debates (Scialabba, 2007). Organic farming is also viewed by both developed and developing countries as a plausible food production system for environmental sustainability (Hellin & Higman, 2002). Despite the success of organic farming in other parts of the world, there is not enough evidence that organic farming can have the same success in the context of smallholder farming in South Africa. Smallholder agriculture in South Africa is faced with many historical constraints that are still present some 10 years after the establishment of a new, democratic government (Aliber *et al*, 2006). These range from poor technical skills of farmers, poor agro-ecological location, inadequate extension services, high transaction costs and an unsupportive government policy environment (Aliber *et al*, 2006).

On the other hand, many farmers in developing counties have farmed along organic farming principles for decades, mostly due to a lack of funds to purchase agrochemicals. Due to the apparent similarities in production methods between organic and traditional farming in respect of the non-use of agrochemicals, it seems that there is an opportunity for farmers in developing countries to tap into this fast growing niche market area of organic farming. Nevertheless, there is not enough scientific information to assist developing countries and farmers to explore and make sound decisions on organic farming to meet production demand (Scialabba, 2007). Modern organic farming is a knowledge intensive farming system where thorough knowledge of the organic production system replaces the use of agro-chemicals (Sligh & Christman, 2007). Smallholder organic farmers in developing countries (including those in South Africa) face many constraints in production, marketing and institutional issues. It is against this background that it became imperative to analyse constraints that the three groups in the study were facing and respond by providing a tool to assist farmers to make informed production decisions about possibilities of organic production in their areas.

As stated in Chapter 3, the initial interaction between the researcher and members of EFO indicated a need and desire for information related to crops and production decisions, among others. From the outset, a participatory action research methodology was deemed important so that the study's outcomes would provide satisfactory results that are relevant to the farmers' identified problems. The methodology used for the study includes qualitative and quantitative research from the investigation and analysis of the organic production constraints, conceptualisation of the decision-making tool to testing the developed tool. Organic production constraints were identified through initial participatory focus group discussions, participatory workshops, followed by ranking of constraints by the groups. The purpose of this chapter is to present current constraints faced by the groups and an analysis of the identified constraints.

4.2 Initial interaction with farmer groups and identification of the study sub-problems

After making initial contact with the farmers through their leaders, dates were set for the first meetings in 2004, during which an analysis of the groups' composition, objectives and knowledge of organic production was carried out. These initial meetings involving the researcher, farmer groups and other professionals who had links with the groups (NGOs and extension officers) were informal and focused on 'getting to know one another'. Group leaders were contacted by telephone to establish suitable dates for the meetings which coincided with the days when the groups would normally meet (e.g. first Monday of each month for EFO). All meetings were conducted at the study sites (Mbumbulu, Muden and Centocow). The first group visited was the EFO for reasons detailed in Chapter 3. Common organic production problems identified in the Mbumbulu sessions were verified by the Muden and Centocow groups.

All farmers who were present at the meetings participated. For example, the Muden group comprises more than 100 farmers but approximately 30 participated in the meeting. Similarly, 25 out of 48 certified farmers from Mbumbulu, and 11 out of 15 members from Centocow were present at their meeting. The researcher was assured by the group leaders that the pending workshops were well publicised through announcements made at the monthly meetings of each organisation. In addition to the farmers in the Muden group, an extension officer was present throughout the study. No extension officers were present at meetings of the Mbumbulu and Centocow groups because none had been assigned to groups at the time of this study. Efforts of the researcher to establish links with the responsible extension officers proved fruitless.

At these initial meetings, farmers generally voiced their main issues (both positive and negative) regarding smallholder and organic farming. The outcome of these 'getting to know one another' sessions informed the research question. The steps that followed the initial sessions are discussed below.

Two key participatory research methods were used to engage with the farmers. Three participatory focus group discussions were conducted with farmers at their sites by the researcher and a graduate student, using a question guide relating to resource verification and organic production constraints (Appendix A). Questions were posed to the group and answers were recorded after consensus was reached among the farmers. Occasionally, it was necessary to encourage or facilitate further discussion among farmers in order to reach consensus. If there was no consensus after further discussion, more than one answer was recorded. Figure 4.1 shows the steps followed during the group survey workshop.

The three main areas of the focus group questionnaire guide related to organic production (including natural disease control) and access to resources for successful farming and marketing. According to de Vos (1998, pg 313-326), focus groups can be used for a variety of reasons, including exploration and confirmation of issues. In this study, all three groups participated in identification of the problem and in the research process that sought to confirm these and present possible solutions. The Mbumbulu (EFO) farmers were key in identifying the organic production problems while the Muden and Centocow farmers verified the importance of these problems. de Vos (1998, pg 405-408) explained that participatory action research should be a knowledge-raising process that empowers people to become involved in their own development. In this study, focus groups were indeed used to explore production issues in organic farming and to confirm identified problems with a view of re-directing research efforts.

Step 1: Breaking the ice

First, greetings were exchanged between farmers and the researcher. This action ensured that everybody was relaxed and could ease into the plan of the day.

Step 2: Setting up the stage

A flip chart was set up at a central place where it was visible. Chairs were organised in a half-moon shape around the flip chart. Pens of different colours were laid out for use.

Step 3: Introduction of the study and setting of objectives

Objectives of the study were explained. Expectations of the farmers and the researcher were clarified. Previous telephonic conversations between the contact person and the researcher regarding permission to conduct the study were referred to. Consensus was sought on the objectives of the study and the day's proceedings.

Step 4: The workshop

The question guide was used to table the questions to the group. Explanations were given when sought. The answers were discussed by all farmers in a participatory manner, facilitated by the researcher. Important details of the discussion were written on the flip chart using a large font for visibility and further discussion.

Step 5: Clarification

The final answers to questions were recorded by the researcher. Lists were developed and tabled on the flip chart for more discussion (e.g. list of constraints).

Figure 4.1: Steps followed in focus group methodology at the first meetings with farmers in Mbumbulu, Muden and Centocow in August 2005

The questionnaire guide ensured that the same questions were used for all three groups. Due to the fact that the questionnaire guide consisted of many open-ended questions, the respondents had room to explain and elaborate on their responses. In this study, the researcher guided the participants throughout the discussions to make it easier for participants to recall information. The researcher also paid attention to controversial responses given to questions and requested clarity before recording the responses.

Questions were repeated and clarified when requested to ensure that all the respondents understood the question. At times respondents helped to rephrase questions when these were not understood by fellow farmers. The researcher ensured that the meaning was not lost during rephrasing by being attentive, while giving space to farmers to assist one another. For the purposes of this study, a decision was taken to concentrate on production constraints and subject those constraints to further analysis.

The second qualitative tool used in this research was the Force Field Analysis (FFA). The FFA is a management and analysis tool that uses a creative process for forcing agreement about facets of any desired change (Lewin, 2005). Issues identified during focus group sessions were brainstormed into two categories as the driving and restraining forces pertaining to organic farming. The process of how the study developed emanating from the FFA exercise is illustrated in figure 4.2.

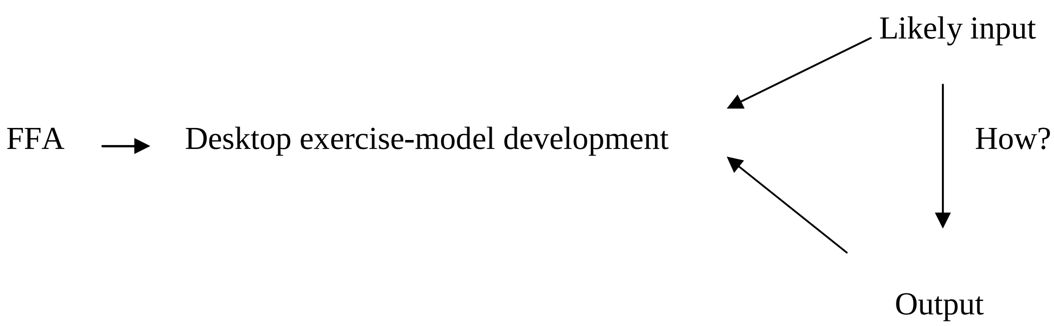


Figure 4.2 The process followed in the development of the decision support tool

Driving forces included elements such as actions, skills, equipment, procedures and culture that facilitate movement towards the goal, whereas restraining forces inhibit achievement of the desired goals. In this case, the aim was to identify forces for and against certified organic farming. An example of a FFA is presented in Figure 4.3. Once the farmers had listed the positive and negative forces for organic farming, these were ranked from strongest to weakest in terms of supporting organic farming. The strongest negative force was placed first in the negative force box. The strongest positive force was placed first in the positive box.

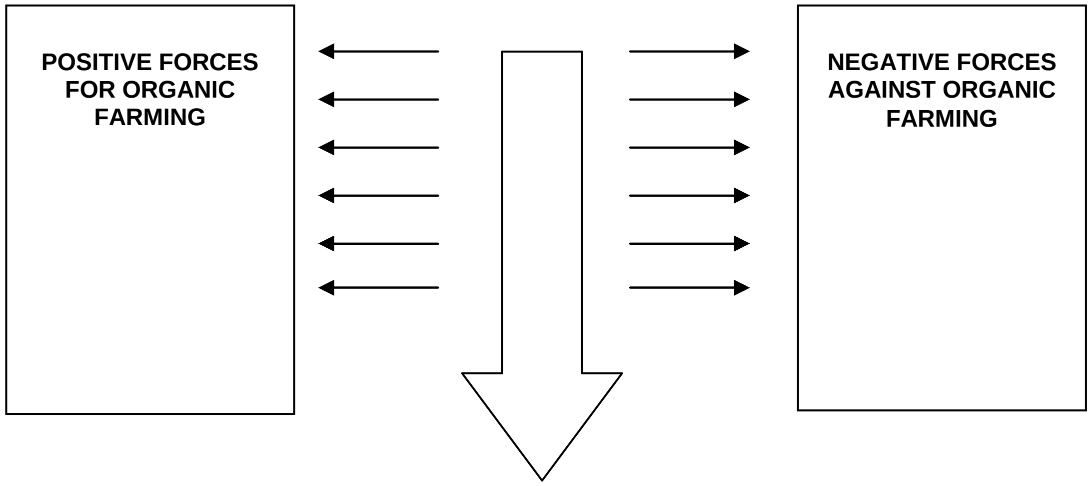


Figure 4.3: Outline of a force field analysis

Both methodologies (focus groups and FFA) were participatory, enabling farmers to engage actively in clarifying problems and finding solutions to problems relating to organic crop production. These methodologies assisted to prioritise key problems and develop and prioritise possible solutions within their means.

The FFA identified critical constraints in organic production, after which farmers requested that action be taken to resolve the constraints so that they could be more productive. They expressed strongly that they often are faced with decisions relating to organic production but did not have a way of solving them, so the idea of a tool to guide production decisions was initiated.

4. 3 Results and discussion

The results of the prioritisation of constraints in figure 4.3 was used to inform the model development stage with regard to which outputs of the model were important to consider in the decision-making tool. As expected, a varied mix of constraints was listed by farmers. However, due to scope limitations of the study, only constraints related to production and regarded as key among the negative forces were selected from all three groups with the view of creating model outputs.

The results of the Force Field Analysis (FFA) are presented in Appendix B. A comparative analysis of the prioritised constraints identified in Appendix B is presented in Table 4.1. It is evident from the FFA illustration (Appendix B) that smallholder farmers in the rural communities of Mbumbulu, Muden and Centocow face numerous constraints which can be grouped into four main categories: organic production, resources, marketing and policy (Table 4.1)

Table 4.1: A comparison of agricultural constraints identified from Force Field Analyses of Mbumbulu, Muden and Centocow groups, August 2006

	Mbumbulu	Muden	Centocow
Production			
Lack of irrigation	✓	✓	✓
Lack of organic compost-making skills	✓	✓	✓
Shortage of animal manure	✓	✓	✓
Poor knowledge of natural pest and disease control	✓	✓	✓
Resources			
Lack of finances	✓	✓	✓
Lack of fencing	✓	✓	✓
Marketing			
Lack of formal markets	-	✓	✓
Policy			
Lack of knowledgeable extension officer	-	✓	✓
Illiteracy	✓	✓	✓

4.3.1 Production constraints

All three groups are faced with production constraints, including lack of irrigation, lack of compost-making skills, shortages of manure and poor knowledge of natural pest and disease control. The Mbumbulu and Centocow farmers have no irrigation infrastructure or water storage facilities (e.g. a dam). Consequently, their production is predominantly rain dependent. On the other hand, the Muden farmers have access to irrigation infrastructure but experience several problems that affect water availability. This is related to the fact that the Muden farmers occupy the furthest farming blocks along the canal. Consequently, the farmers report that the water is used up before it reaches blocks 14 and 15. This may be attributed to the low water levels and the small capacity of the dam. The low water levels may also be attributed to a faulty sluice gate that allows water to escape, and high temperatures causing high evaporation rates (Goba, 2004). Furthermore, Muden has low rainfall (Table 3.1). The lack of technical skills and accountability for funds to pay for repairs of the pump are contributing factors in this ongoing problem. Matungul (2002) also found that the lack of finance, limited farm expansions and investment contrained smallholder farming. Increased finances from improved production or finance from governments and NGO's may assist the Muden farmers pay for maintenance of the irrigation system.

Although the Mbumbulu (EFO) farmers experience higher rainfall, the lack of water harvesting techniques and storage results in water shortages in drier periods. The lack of irrigation impacts negatively on attempts to improve yields through the introduction of new crops in Mbumbulu and Centocow. Ortmann & Machete (2003) have pointed out that historically smallholder farmers have not had the opportunity to produce high value crops due to limited resources.

All three groups stated that there was a shortage of manure due to the low numbers of livestock that they own or that are available in the community to supplement their manure production. The livestock available to them is insufficient to supply their manure requirements (the number of wheelbarrow loads indicated by the model). Furthermore, increased manure usage may increase the labour demands of smallholder farmers. Kalinda *et al* (2000) showed in their study in southern Zambia that labour and livestock were important for expansion in smallholder production.

All groups stressed that the lack of compost-making skills was a major concern in organic farming. Currently, only farmers in Centocow have received theoretical training in compost-making but they have not actually developed skills in this respect. Scialabba (2007) emphasised that organic farming is a knowledge-intensive farming system. Clearly, a lack of an important element for organic production, such as compost, will have a negative impact on productivity. Stefano (2004) explains that farmers use information because it is accessible, credible and understandable. It is therefore important that appropriate and practical information, such as 'on-the-job' training, is provided for smallholder farmers and not only theoretical information that the farmers will not recall when required. The Centocow farmers said that they urgently need practical compost-making demonstrations so that they can begin to improve their soils.

All three groups expressed concern about their poor knowledge of natural pest and disease control, which is critical in certified organic farming. They agreed that farmers in their communities once had knowledge of natural pest and disease control but that this knowledge has been lost. Juma (2007) suggests that knowledge loss occurred as a result of the Green revolution, which promoted the use of agrochemicals to the detriment of local knowledge. Aliber *et al* (2006) further explains that the historical removal of African people from rural agricultural areas as a means of providing cheap labour to urban South Africa contributed to the neglect of agricultural development in these areas.

The farmers in Mbumbulu have been organically certified for approximately five years but listed lack of adequate knowledge of natural pest and disease control as a serious constraint. They also said they were confident about producing traditional crops such as *amadumbe*, sweetpotatoes and potatoes because they were familiar with natural pest and disease control regimes pertaining to these but did not have the confidence to try new crops. They viewed the introduction of new crops as risky due to their lack of knowledge of natural pest and disease control for these crops. The farmers in Muden and Centocow stated that their lack of natural pest and disease control knowledge may be a deterrent for considering venturing into certified organic farming. It is therefore paramount that farmers have access to appropriate information and technical skills relating to natural pest and disease control. However, the farmers will have to make an effort to seek information on new crops. Stefano (2004) indicated that sometimes farmers do not have the required information because of a lack of effort on their part to seek this out. However, Stefano (2004) also admits that lower literacy levels and lack of competence in the use of literature by farmers may impact on existing information not being used.

4.3.2 Resource constraints

The Mbumbulu, Muden and Centocow farmers listed finances and fencing material as the most important resources for improved success in farming but these are currently very scarce. Lack of finances was identified as the top resource constraint by all three groups (Table 4.1). In his study on the contribution of soil and water conservation to rural livelihoods in Muden, Goba (2004) found that farmers in blocks 5 and 6 also stressed the importance of fencing in preventing crop loss. Good fencing keeps livestock out and restricts crop damage and loss. All groups stated that fencing was expensive and that they would need external financial assistance to purchase external inputs to improve production. All the farmers said that, unlike commercial farmers, they have to finance farming operations from household income. Historically, smallholder farmers did not receive financial assistance from the government (Ortmann & Machete, 2003). Although there are programmes to address this imbalance, many smallholder farmers have not received assistance. Furthermore, most smallholder farmers in South Africa farm on communal land and as such they lack collateral for loans. This situation leads to inadequate resources to buy farming implements, inputs (eg. fertiliser, seeds and manure), labour and irrigation infrastructure. The farmers stated that farming suffers from low productivity and yields. Furthermore, accessing resources was a problem because they reside in poor rural areas and are unable to access assistance for rural farmers, such as via financial institutions, even when it exists. The farmers in Centocow expressed the view that they have been forgotten by Government authorities. While they have heard via the radio of special farmer-targeted programmes offered by the Government, they do not know how to access such programmes.

4.3.3 Marketing constraints

The farmers in Muden and Centocow do not access formal markets due to several barriers. Mthembu (2007) identified the marketing barriers as those related to resources, information and high transaction costs in the three study areas. Lack of access to markets and market intelligence for a niche market, such as organics, is detrimental to the growth of smallholder certified organic farms (Makhanya, 2006). The Muden and Centocow farmers expressed the view that they are currently incapable of identifying and retaining such niche markets due to a lack of experience in marketing. The Mbumbulu farmers were assisted in accessing formal markets by a researcher from the University of KwaZulu-Natal. However, these farmers faced many problems, such as a lack of understanding of how the formal market works, pricing information and payment structures. The Muden and Centocow farmers are not certified organic farmers yet, but they also face similar marketing problems. These shortcomings in marketing increase the risk of exposure to dishonest middlemen who can take advantage of this situation.

4.3.4 Policy and institutional constraints

The lack of policies governing organic farming in South Africa is a problem for those who are certified and for those who wish to acquire certification (BDOCA, 2006). Although there are some South African organic certification bodies, South Africa relies on foreign standards, which does not help develop local capacity and often foreign companies do not have a full understanding of local conditions (Barret *et al*, 2002; Banados & Garcia, 2001). The lack of policy and legislation for organic agriculture in South Africa makes it difficult for the industry to develop and translate into programmes (e.g. mainstream organic farming training in agriculture degrees). Scialabba (2007) stressed that a conducive policy environment is key to the development of organic agriculture worldwide. All groups expressed the need to have access to experienced extension officers who can assist with providing relevant organic farming information. Many extension officers in South Africa, including the ones at Mbumbulu and Muden, are not trained in organic farming and find it difficult to support organic farming. One of the critical areas in organic farming is natural pest and disease management (stated as a production constraint) which is not addressed due to the lack of skills and information by extension officer.

Only one of the groups is organically certified. The Mbumbulu group was assisted by a researcher from the University of KwaZulu-Natal in the process of preparing for and acquiring certification. Arranging organic certification can be expensive and complex. The farmers in Mbumbulu reported that certification costs were high and they are concerned about annual inspection costs. Modi (2004) agrees that the Mbumbulu farmers would have found it very difficult to acquire organic certification had they not received external funding and assistance. The Muden and Centocow groups have had no access to such assistance prior to this study.

4.4 Summary

The participatory nature of the study assisted farmers to identify constraints that were categorised into production, resource, marketing and policy constraints. As per the farmers' desire, the study focused further analysis and development of the decision support tool required to address identified production constraints. Production constraints were given priority because farmers felt that this was the one area where they were required to make many decisions. Further engagement with farmers had revealed that they wanted to be more productive and prosper in organic farming but lacked information on what crops were suitable to grow organically in their areas. Other sub-problems related to the farmers' opinion of the organic production decision-support tool and threats to the commercialisation of organic farming were developed and addressed in chapters five and six.

CHAPTER 5: THE DEVELOPMENT OF THE DECISION SUPPORT MAKING TOOL - RESPONSE TO ORGANIC FARMING PRODUCTION CONSTRAINTS

5.1 Introduction

The developed and developing countries have, in recent times, demonstrated a growing interest in improving the livelihoods of smallholder farmers, using organic agriculture, among other approaches and technologies (Duram, 1999). The complexity of organic farming management demands a well-developed knowledge system that promotes biological harmony encompassing biodiversity, biological cycles and soil biological activity, while discouraging the use of off-farm inputs (NOSB, 1995). This complexity is exacerbated by the fact that organic agriculture also encompasses other non-agricultural factors, such as those related to the social, economic and institutional dimensions (Scialabba, 1999). Decision-making for smallholder farmers is characteristically complex because of the close interactions between household and farming decisions (FAO, 2006). Decision-making so complex and can be a big challenge for smallholder farmers in poor countries who, not only have poor access to resources and information, but are also faced with literacy constraints. The need for a decision support tool for organic production is crucial to support both the evaluation of potential for organic farming in South Africa and to support decisions of aspirant organic farmers.

Introduction of new technologies, including organic agriculture, in situations of need, such as in many poor African countries, can be viewed as answers to a wide variety of problems (Freyer *et al*, 1994). There are many studies that have investigated adoption of different technologies but studies that relate to the adoption and successes or failure of organic agriculture in Africa are not easily available. Nevertheless, it is important that any technology should be appropriate to the context within which it is intended.

This chapter presents the components of a farmer-oriented decision support tool (Appendix C) by presenting and discussing the stages that were followed during the development of the tool.

5.2 Components of the decision support tool

The analysis of organic farming constraints (Chapter 4), led to the development of a decision support making tool to provide farmers with crucial information to guide organic production decisions. The farmers' main desire was to improve productivity and prosper in organic farming. However, they needed to establish what was required to achieve this goal. Vigorous engagement with the farmer groups led to their main question being expanded into four sub-problems. These four questions were adopted as the study's sub-problems. As emphasised earlier, the tool's development was limited to organic production but recognised that other areas of organic farming, such as marketing, are important. The production related sub-problems were as follows:

Sub-problem 1: What crops can be grown organically in the three chosen areas based on climatic data?
Sub-problem 2: Do farmers concur that these are the most suitable potential organic crops?
Sub-problem 3: How useful do the farmers find the decision making tool?
Sub-problem 4: What constraints threaten commercial production of the identified crops for these farmers?

It was agreed that the tool needed to be as simple as possible for the end-user. Consequently, the computer programme used was Microsoft Office Excel (version 2003) instead of a complex programme that would require the user to be well versed in computer usage as this could be a deterrent. Due to the multidisciplinary nature of the study, a team of experts from various agricultural specialisations was consulted at various stages of the model development to verify that the approach and stages of development of the model were sound. The methodology applied during the expert workshops is discussed later in this chapter (results and discussion).

The decision support tool produces a two-page printout. The first page contains the output for high moisture-induced crop diseases. The low moisture-induced crop diseases are listed on the second page. Ideally, both high moisture and low moisture-induced diseases should be on a single page printout. However, the Excel program is not sophisticated enough for this. The model could thus be developed further to suit field conditions, using a higher level of computing and programming with the support of computer programming specialists (Voges, 2006). This can be undertaken in the future. Descriptive headings are used for the output to keep the tool simple. Detailed results of the tool are presented later in this chapter. In chapter six, an application of the decision support tool is presented. The following section discusses how the model, upon which the decision support tool is based, was developed. A presentation of results and discussion follows and concludes this chapter.

5.3 Development of the model

The decision support tool was developed in two main stages subsequent to the FFA process. A desktop exercise using existing primary data for calibrations and the development of the user interface in three steps was the first action undertaken. Several important assumptions were made in the development of the model and they are:

- It is assumed that for satisfactory crop growth to take place, minimum climatic conditions have to be met.
- Crop nutrient needs were based on maximum quantity to fulfil the argument that organic nutrient needs (based on manure) are based on the most limiting nutrient.
- It was further assumed that rainfall was a correlate of moisture.
- An assumption that rainfall can be predicted was made.
- Rainfall based moisture was used to predict onset of disease.

These rainfall-related assumptions were based on the confidence from graphical correlation of predicted and observed rainfall values as demonstrated in chapter 5 (figure 5.5). Graphical depictions of this assumption, in Figure 5.5, show a very high correlation, yielding confidence that the assumption made is sound. All farmers largely practice rainfall-dependent agriculture with no effective irrigation. It is acknowledged that humidity and mist may play a role in disease onset, but lack of data on these two factors for the study areas resulted in the use of rainfall as the sole source of moisture data.

The initial step in the conceptualization of the model was to decide what output a user may want from the model (i.e. the desired output). Based on the FFA results, it was decided that the model should answer sub-problem 1; namely what crops can be grown in the three chosen areas based on climatic data?

Numerous sources of information were consulted to aggregate the relevant information in answering the study's questions. Table 5.1 summarises the various sources of primary data consulted in a quest to answer the second sub-problem namely; what crops can be grown in the chosen areas?

5.2.1 Stage 1: Selection of climatic data and loading of agro-ecological information per crop into specially created Excel spreadsheets (see Appendix C-decision support tool)

The first sub-problem was mainly concerned with what crops could be grown in the three chosen areas. The following steps were taken to respond to this sub-problem:

- Creation of a manageable list of crops.
- Identification of normal physiological growth conditions for crops on the list.
- Use of various computations to link physiological growth conditions and other data located in different Excel spreadsheets.

The first activity in stage one of the decision support tool development involved creating a list of crops from which to identify suitable crops using the Natural Resource Database from the Department of Agriculture and Environmental Affairs in KwaZulu-Natal (DAEA) (Camp, 1999). Since organic farming is a growing niche market with opportunities for smallholder farmers (Barett *et al*, 2002), it was important to establish which crops were in demand. Therefore, a list of sought-after organic crops was obtained from Woolworths' buying division as a market leader in retailing a wide range of organic vegetables, fruit and dry products in South Africa (Ferreira, 2004).

Table 5.1 Summary of key sources from which primary data were collected for the desktop calibrating exercise

Sub-problem two	Model development stage	Key references
What crops can be grown in the three chosen areas based on climatic data?	Stage 1: loading of agro-ecological data	Ferreira (2004). Camp (1999). Food and Agriculture Organisation of the United Nations (2003).
	Stage 2: loading of crop nutrition requirements	Hygrotech (2005). Naylor *et al (*1966). Manson AD (2006). Van Averbeke & Yogananth (2003).
	Stage 3: loading of crop disease data	American Phytopathological Society (2000). Agrious (2004). Ogawa (1995). Yobo (2006).

The DAEA (Camp, 1999) list was used to establish which crops were suitable for the three agro-ecological zones and the Woolworths' list was used to eliminate vegetables and fruit crops that were not sold by Woolworths at the time of the study. This process led to a list of 18 crops. Two crops (*amadumbe* and maize) were added to the list because as they are grown widely by households in the study areas. The final list had 20 crops. It is recognised that this list of 20 crops is not exhaustive but suitable and manageable for this empirical test.

Figure 5.1 illustrates a decision support process employed to respond to the first sub-problem. A consequential series of questions was posed for each crop to assess if agro-ecological conditions met crop requirements. The four conditions were set as the minimum and essential requirements for the normal physiology of plants (Bidwell, 1974, pg. 3-4). These are the annual rainfall (mm); the length of the rainy season (days/annum); mean annual temperature (minimum and maximum) and photoperiod, all of which were sourced from FAO's (2003) Ecocrop website. The first two questions in figure 5.1 were related to water requirements because water is a critical element for plant growth (Bidwell, 1974).

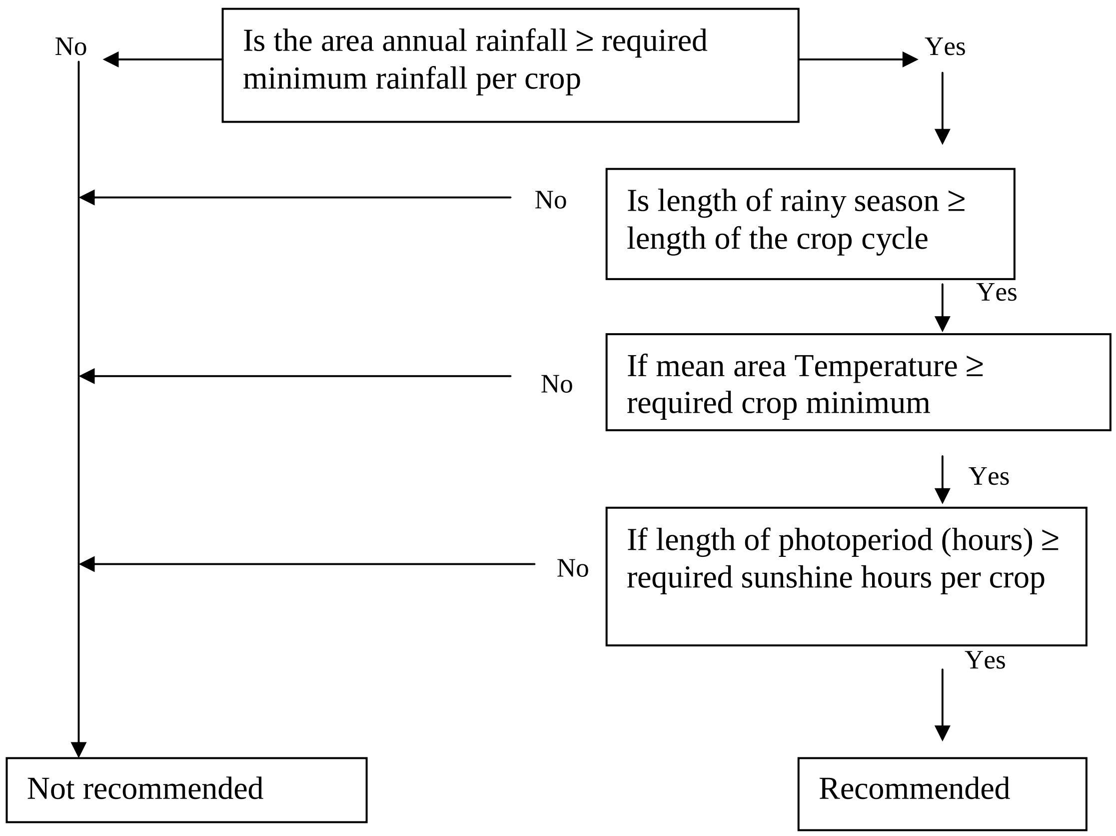


Fig 5.1: Illustration of the decision support process used to identify suitable crops

The area's mean annual rainfall was compared to the minimum rain requirements for each of the 20 crops. In the case where the area's mean annual rainfall did not meet a crop's minimum rainfall requirements, the crop was deemed unsuitable for rain-fed agriculture and thus was not selected. Other requirements were that:

- the length of the rainy season must be equal to or longer than the growth cycle of each crop so that the crop would have enough water during its physiological development;
- the minimum growth temperatures required by each crop had to be fulfilled; and
- there had to be adequate sunshine during the photoperiod. A positive answer to all four questions in Figure 5.1 meant that the crop could grow, given optimal conditions. The output at this stage was to list all crops that had potential to grow in the chosen area.

The main assumption in this sub-problem was that for satisfactory crop growth to take place, minimum climatic conditions had to be met. However, it is accepted that a certain level of growth that will lead to a certain level of yield will take place but the decision support tool cannot quantify this variation. This is because mean values of climatic parameters were applied. Therefore, it is accepted that climatic value below the mean may lead to some crops being rejected by the model as not being suitable.

5.3.2 Stage 2: Loading of crop nutrition requirements

Agrochemicals in conventional agriculture have two main roles, which are disease and pest control and crop nutrient supply. On the contrary, organic farming, according to the OFRF (2001), is the exclusion of all external inputs of agrochemicals (pesticides and fertilisers) in agricultural production and related activities. This definition underpins the second sub-problem, which questions whether farmers can grow the selected crops organically. In the case of smallholder farmers (including groups participating in this study), livestock manure is the most common source of soil and crop nourishment (Kuepper, 2003; van Averbeke & Yoganath, 2003).

Various government extension sources were consulted to obtain soil nutrient requirements for each crop, including the Guide for Extension Officers (Smith, 1998); the Vegetable Production Manual (Alleman & Young, 2001) and the Fruit Production Manual (Sheard & Jele, 2002). Other sources including Chadha and Shimansky (1999), Salunke and Kadam (1998) and Salunke & Kadam (1995) were also consulted. Lastly, telephonic communication was held with vegetable and fruit specialists and research papers were consulted for crop nutrition information.

Crop nutrient removal norms also indicate how the soil would be depleted further if no soil nourishment plan is in place. Hygrothech's (2005) vegetable production guide was used to obtain vegetable nutrient removal norms, which were used to calculate NPK requirements. Furthermore, Manson (2006), Conradie (2005), Kilby (1998), Salunke & Kadam (1995), Agata (1992), Askew (1992) and Kabeerathumma (1992) were consulted to obtain the nutrient withdrawal norms of vegetables, fruit, root and maize crops using equation 1.

$$NRR = CY \times NRN \qquad \text{Equation 1}$$

Where: NRR=Nutrient Removal Rate (T/ha)

CY=Crop Yield (T/ha

NRN=Nutrient Removal Norm (kg/T).

The number of wheelbarrow loads of manure required to meet the removal norms for each crop was calculated for N, P and K in turn, yielding three quantities based on equation 2. A load of a wheelbarrow is assumed to be 75kg (van Averbeke & Yogananth)

$$\text{No of WB} = NRR/ANCM \qquad \text{Equation 2}$$

Where: No of WB=Number of Wheelbarrows of Manure

NRR=Nutrient Removal Rate

ANCM=Average Nutrient Content of Manure (N, P or K).

These quantities of wheelbarrows were then compared for N, P and K. The highest number of wheelbarrow loads for N, P or K was then chosen (see equation 3) as the required manure input per crop, ensuring that all nutrient requirements are met.

Manure input = Max (M_n, M_p, M_k) Equation 3

It was also important to estimate the amount of manure that could be produced by one animal (beast, sheep or goat). The number of animals is directly related to the availability of manure and thus crop yields. Equation 4 illustrates a series of formulae used to calculate the amount of manure from one animal, the area that can be fertilised and the possible yield for each crop per annum based on one grazing beast. Using this element of the model, it is possible to evaluate available manure or potential for manure production based on the number of animals accessible to the farmers. Manure was calculated using the formula in equations 4, 5 and 6. The assumptions made in equations 4, 5, and 6 were based on USAD (1996) & van Averbeke & Yoganath, (2003).

Faeces output = (1-D) x I Equation 4

Manure deposited in the pen =FO x 0.5/MDM Equation 5

Wheelbarrows of manure = MDK/75 Equation 6

Where: D=Digestibility coefficient of the diet and was assumed to be 0.5

FO= Faeces output

MDK= Manure deposited in the pen

I= Dry matter intake assumed to be 6kg/day

Assumption 1=Half the faeces are deposited in the pen as manure

Assumption 2=MDM is the manure dry matter assumed to be 0.8 and

Assumption 3= One wheelbarrow is assumed to hold 75kg of manure.

It was further assumed that the most limiting nutrient between NPK was used as a basis for the calculation of manure requirements. The number of wheelbarrows of manure was based on this nutrient. However, it was expected that some level of soil nutrients will be available, even though nutrition may not be optimum. The decision support tool indicated a very large number of wheelbarrows of manure which cannot be practically applied due to the large volumes, health contamination and nutrient imbalances that may be caused by large applications of certain nutrients. It is doubtful that even the most astute management, including crop rotations, can overcome such nutrient accumulation due to the sheer volumes of manure indicated by the model. It is critical to note that other organic nutrient provision methods, such as compost, may have to be considered as a strategy of supplying required nutrients if organic farming is to succeed in the study areas based on soil nutrient and manure analysis.

5.3.3 Stage 3: Loading of crop disease information

The purpose of this third stage was to ascertain if the climatic conditions of the study areas were conducive or detrimental to organic farming. Both temperature and moisture are important for disease occurrence (Agrios, 2004). It was not necessary to program temperature into the decision support tool because summer temperatures are conducive for onset of disease. However, moisture plays a critical role in disease setting (e.g. spore germination and penetration) and disease spreading. As a result, moisture was deemed the single most important indicator of disease risk in this study. The choice of moisture as an environmental risk factor was based on the premise that the presence or lack of moisture at a satisfactory level is a key requirement for diseases to initiate (Agrios, 2004). Rainfall was used because it is a correlate of moisture.

In order to determine the risk of disease occurrence, monthly rainfall levels (source of moisture) were modelled over twelve months using equation 7. A reference database of diseases that could affect each of the listed crops and their corresponding predisposing climatic conditions was created. The disease database consisted of three most important diseases associated with moisture and three others associated with lack thereof. The importance of the disease was based on economic importance and extent of devastation. The diseases were separated into two categories: those that set due to moisture presence and abundance (Appendix D, high moisture diseases) and those that set due to low moisture or lack thereof (Appendix D, low moisture diseases).

It was recognised that the mean annual rainfall reported in the Bioresource Database of the KwaZulu-Natal Department of Agriculture and Environmental Affairs (Camp, 1999) includes rainfall distribution. However, it is an over-expectation of any one without records to know the monthly rainfall and, even when these are available, provision of input area in the user-interface will render the interface very cumbersome. So the use of a single entry of mean annual rainfall is preferred. The mean annual rainfall should then be distributed using the following distribution function as proposed by (Naylor *et al*, 1966, pp. 92–93) in Equation 7.

$$X = \sigma_x (12/K)^{1/2} (\Sigma r_i - K/2) + \mu_x \qquad \text{Equation 7}$$

Where: X= random proportion

σ_x = standard deviation

K= total of estimated random value (120)

r_i= random value

u_x= mean proportion of rainfall per month.

In order to determine parameters in this function (mean annual rainfall) the mean annual rainfall values from five random locations of varying agro-ecologies in KwaZulu-Natal were used to develop a deterministic pattern based on the monthly rainfall and its variation across locations. The monthly rainfall in each of the five locations was expressed as a proportion of the annual rainfall. The mean proportion (u_x) and its standard deviations (σ_x) were calculated for each month. Random values (120) ranging from 0 to 1 were generated using a random Excel function.

The estimated random proportion was multiplied by the mean annual rainfall to derive a rainfall estimate for each month. The monthly risk of disease onset risk was based on how much rainfall was predicted per month. The following rainfall ranges were used to define the degree of diseases' risk in Table 5.2.

Table 5.2 Rainfall ranges and degree of diseases' risk

Rainfall range (ml)	Risk level (high moisture)	Risk level (low moisture)
≤ 50	Low (L)	High (H)
50-100	Medium (M)	Medium (M)
>100	High (H)	High (L)

Each month was assigned a disease risk profile based on the range of rainfall (Table 5.2). This information could function as an early warning system to determine planting periods for various crops by checking which prevailing moisture level (low, moderate or high) was applicable per month. The decision support process employing rainfall effect to determine the risk of disease is illustrated in figure 5.2.

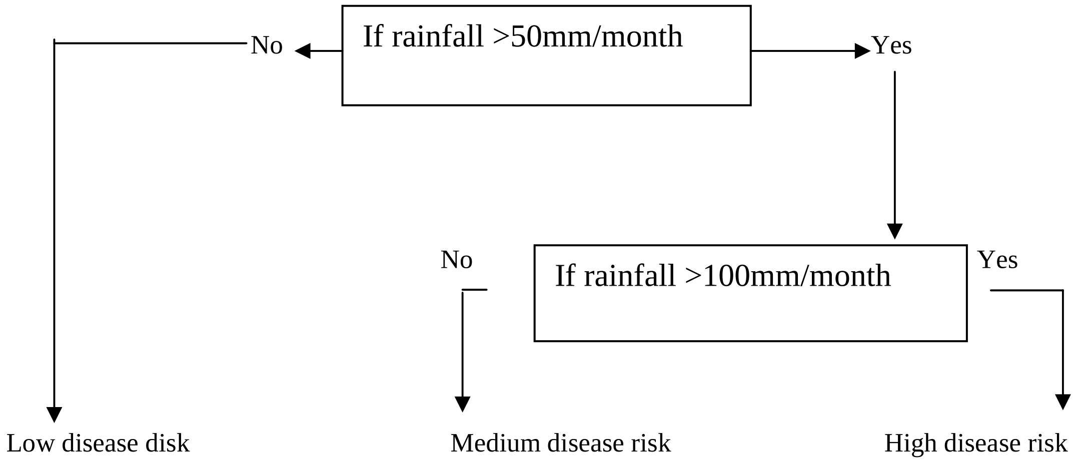


Figure 5.2: The process followed in determining the risk of disease onset based on crop choice

The decision support process was then employed to assign an appropriate disease risk profile (L, M or H) to each month depending on whether the predicted rainfall values were less than 50ml, between 50–100ml and more than 100ml.

The last of the assumptions related to production made in this study related to the fact that rainfall can be predicted and that the rainfall based moisture can determine the onset of disease. However, it is accepted that rainfall is not the only contributor of moisture where diseases are concerned. Humidity and condensation, among other factors, are important determinants of moisture for different environments. However, rainfall data was easier to access and apply in the development of the decision support tool.

5.4 Validation of model inputs

Due to the study's multidisciplinary nature, which involved the use of data from disciplines such as Horticultural Science; Agronomy; Soil Science; Plant Pathology; Simulation Modelling; Sustainable Livelihoods; Extension; Rural Development and

Community Development, a large number of experts from the University of KwaZulu-Natal, the KwaZulu-Natal Department of Agriculture and Environmental Affairs and the Institute of Fruit Technology (IFRUTEC) in the Western Cape were consulted in the development and testing of this model and its outputs.

Three seminars were conducted at the proposal, model input development stage and output stage. The objective of the first seminar was to receive critical analysis and input on the proposed design, methodologies and sources of information for the model. Once the proposal for the study was developed, the expert panel was invited to participate in the consultative process of this study, interrogate the proposal and to make an input. They provided inputs on the type of model proposed and relevant outputs, and verified relevant science included in the model. The second seminar's objective was to critically review the identified inputs for the model. Once the decision support tool development took shape, the experts gave their input on the model development approach chosen and verified statements, assumptions and explanations provided through the overall approach. The last seminar's objective was to discuss the output and receive critical review of the tool. The experts also guided the researcher by pointing out areas of potential concern, such as ensuring that the decision support tool can be applied to any location.

This innovative approach to trans-disciplinary research ensured the experts were able to verify their inputs in the presence of specialists from different disciplines. This reduced gaps in knowledge and interpretation, and cut down on inaccuracies. Their input contributed to an integrated design and holistic approach to the study. The researcher also consulted experts individually during the course of the study when necessary. Farmers also had an important role in the validation of desired outputs and the developed tool. Their experiences and impressions of the tool are separately reported in Chapter 7.

5.5 Results and discussion

In stage one, once the list of crops was finalised twenty crops, growth conditions for each crop on the list was established. A decision was made that single values instead of ranges would be used when capturing plant growth data as it was easier to work with a single entry during data-capturing. In the case of rainfall, absolute values relating to rainfall were used because many smallholder farmers practice rain-fed agriculture and are found in low rainfall areas. Aliber *et al* (2006) explains that many smallholder farmers in South Africa are located in poor parts of the country (former homelands), which are also less favourable agricultural areas. On the other hand, using optimal ranges is supportive of obtaining better yields. Nevertheless, currently smallholder farmers is South Africa do not experience optimal conditions which is likely to result in difficulties in organic production. In the case of temperature, mean values for temperature were used due to the variation related to the nature of temperature.

In the first sub-problem absolute values relating to rainfall were used because many smallholder farmers practice rain-fed agriculture and are found in low rainfall areas. Mean values for temperature were used due to the variation in the nature of temperature. On the other hand, it is accepted that the use of mean means that certain crop growth will occur for values that fall below the mean.

In stage two, several decisions on crop nutrition requirements and soil analysis were applicable. One of the most important factors in organic farming is soil fertility. In organic farming, the practices for improving soil fertility must be aligned with approved organic standards (BDOCA, 2006). The use of commercial inorganic fertiliser to provide crop nutrients is prohibited in certified organic farming.

Crop nutrient requirements and soil analyses were based only on three key nutrients, namely, nitrogen (N), phosphorous (P) and potassium (K), as these are the basic nutrients required by all plants in high quantities for good growth (van Averbeke & Yoganath, 2003). It was assumed that all other nutrients were in adequate supply. Adequate water and good maintenance of soil health is also important for good organic production (OFRF, 2001).

A ‘one-size-fits-all’ soil nutrition programme would be misleading due to variation in soils and local climates. Soil nutrition improvement recommendations would need to be farm-specific. Due to the apparent lack of uniformity and the generalised nature of the soil fertility data, a decision was taken to use nutrient removal norms to indicate the amount of nutrients removed from the soil per ton of product. Plant material is analysed for level of nutrients, which is then attributed to the soil's condition (Maynard & Hockmuth, 1999). Nutrient removal norms also indicate how the soil would be depleted further if no soil nourishment plan is in place (Bertling, 2006).

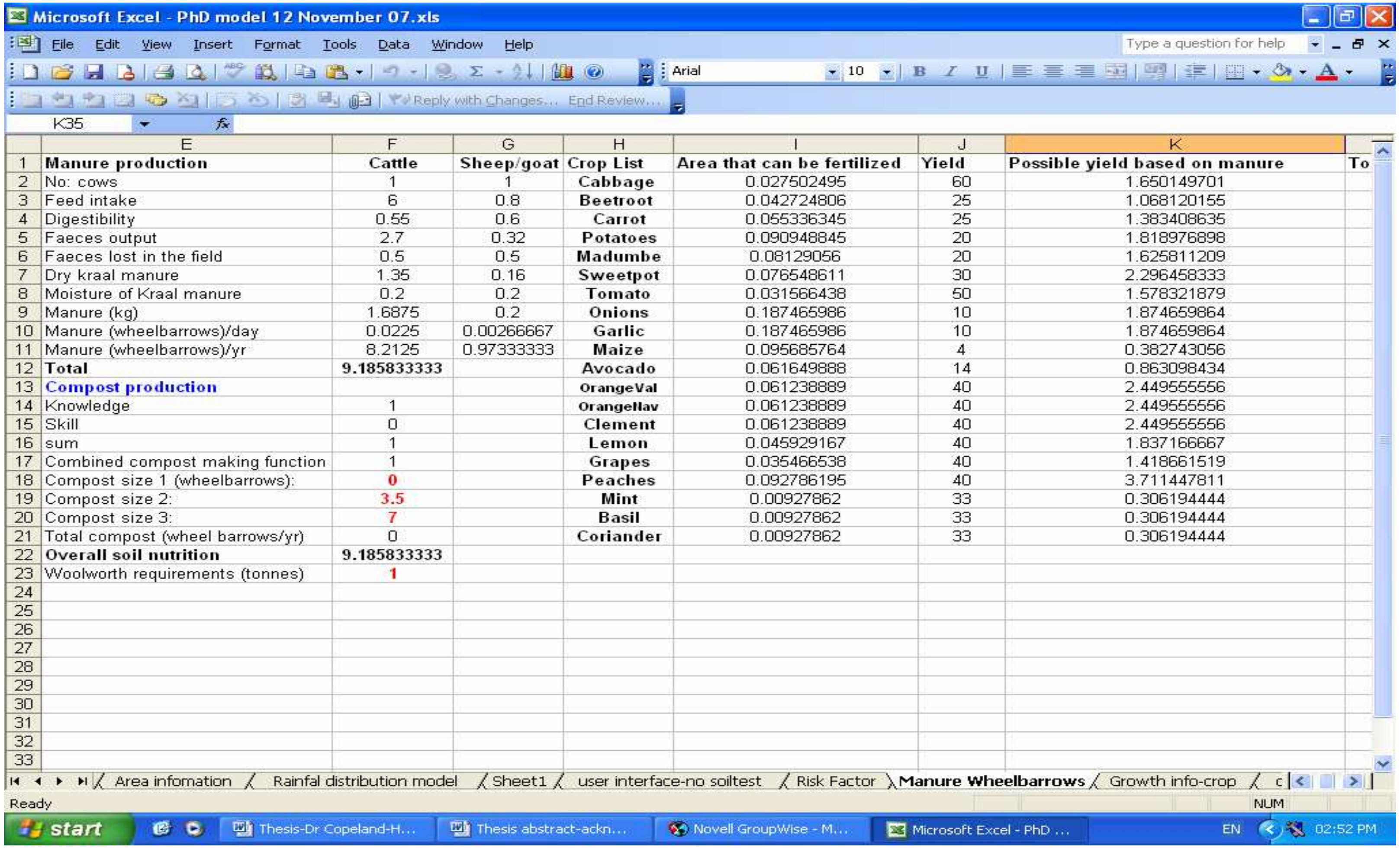
As some nutrients are required in higher quantities than others, it is quite possible that a particular nutrient could accumulate and perhaps reach an undesirable concentration in the soils, causing an imbalance and affecting the availability of other nutrients. Raw manure use is frequently associated with imbalances in soil fertility because manure is often rich in specific nutrients such as phosphate (Kuepper, 2003). Continued applications of manure may lead to a detrimental nutrient build-up. Excessive nutrient levels affect the uptake of other minerals in the soil. This may be avoided by conducting continuous soil analyses, crop rotation, cover-cropping and addition of other natural fertilisers (Kuepper, 2003).

Manure produced by one beast and one sheep/goat can total 8.85 wheelbarrows per annum. The calculation below demonstrates how the amount of manure was calculated by the model. Depending on the crop, this can fertilise varying parcels of land ranging from 0.01 ha to 0.3 ha resulting in yields ranging from of 0.6 t/ha (mint, basil and coriander) to 6.4 t/ha (peach) respectively as illustrated in figure 5.3. The method of storage and application of the indicated manure is important in determining the quality and level of nutrients available.

The study recognised that although manure is the common organic nutrition source, other sources such as compost are relevant. Therefore, total nutrition from available organic sources was calculated by adding animal manure and compost.

Large amounts (7–10 ton/ha) of manure would be required to obtain near-maximum yields. This may pose a real challenge for farmers who do not have livestock, as is the case with many smallholder farmers. Even those with livestock will require unrealistically large amounts of manure to meet yield demands. This may not be sustainable if livestock numbers drop from current tables (Table 3.4) the few there currently are. Farina (2005) argues that it is barely possible for farmers to make up their nitrogen inputs using only organically-acceptable manures or compost.

According to Farina (2005), the effect on productivity of exclusive reliance on organically-accepted sources is likely to be counter productive. The use of crop rotation with legumes will supply



	Manure production	Cattle	Sheep/goat	Crop List	Area that can be fertilized	Yield	Possible yield based on manure
2	No: cows	1	1	Cabbage	0.027502495	60	1.650149701
3	Feed intake	6	0.8	Beetroot	0.042724806	25	1.068120155
4	Digestibility	0.55	0.6	Carrot	0.055336345	25	1.383408635
5	Faeces output	2.7	0.32	Potatoes	0.090948845	20	1.818976898
6	Faeces lost in the field	0.5	0.5	Madumbe	0.08129056	20	1.625811209
7	Dry kraal manure	1.35	0.16	Sweetpot	0.076548611	30	2.296458333
8	Moisture of Kraal manure	0.2	0.2	Tomato	0.031566438	50	1.578321879
9	Manure (kg)	1.6875	0.2	Onions	0.187465986	10	1.874659864
10	Manure (wheelbarrows)/day	0.0225	0.00266667	Garlic	0.187465986	10	1.874659864
11	Manure (wheelbarrows)/yr	8.2125	0.97333333	Maize	0.095685764	4	0.382743056
12	**Total**	**9.185833333**		Avocado	0.061649888	14	0.863098434
13	**Compost production**			OrangeVal	0.061238889	40	2.449555556
14	Knowledge	1		OrangeNav	0.061238889	40	2.449555556
15	Skill	0		Clement	0.061238889	40	2.449555556
16	sum	1		Lemon	0.045929167	40	1.837166667
17	Combined compost making function	1		Grapes	0.035466538	40	1.418661519
18	Compost size 1 (wheelbarrows):	0		Peaches	0.092786195	40	3.711447811
19	Compost size 2:	3.5		Mint	0.00927862	33	0.306194444
20	Compost size 3:	7		Basil	0.00927862	33	0.306194444
21	Total compost (wheel barrows/yr)	0		Coriander	0.00927862	33	0.306194444
22	**Overall soil nutrition**	**9.185833333**					
23	Woolworth requirements (tonnes)	1					

Figure 5.3: Manure and compost production potential or organic production

only about 45kg of N/ha which is low compared with the much higher removal norms. It is accepted that manure and compost have far lower concentrations of N, P and other minerals that may not meet commercial yields. Nevertheless, the role of manure as a source of plant nutrients, especially N and P, in the smallholder production system cannot be ignored (Mkhabela, 2006).

Many studies have been undertaken to validate the potential benefits of manure application as a means of sustaining soil fertility and have shown improvement in soil structure and water retention in the smallholder farming environment (Mkhabela, 2006). It is accepted that cattle and chicken manure cannot be used as a substitute for inorganic N fertilisers but these manures can be helpful in augmenting nitrogen supply to crop production and thereby reduce the cost of purchasing inorganic fertilisers (Mkhabela, 2006).

It is a known fact that most smallholder farmers in South Africa do not use large amounts of commercial fertiliser due to the cost (Mkhabela, 2003). The economics of manure usage versus no usage of manure among smallholder in KwaZulu-Natal was studied by Mkhabela (2003) and revealed that for smallholder farmers, there was improved profitability in using manure compared to no manure usage. The study further indicated that although manure usage was beneficial to smallholder farmers, greater benefit was derived when manure was supplemented with inorganic fertiliser. This finding is supported by Farina (2005) who proposes that organic inputs alone may not meet crop nitrogen needs.

Stage three was concerned with ascertaining if the climatic conditions of the study areas are conducive or detrimental to organic farming. It was important to check how close the observed and the predicted rainfall moisture values were as a way of validation of the rainfall distribution function. Computations of the rainfall distribution for the three study areas are illustrated in Figure 5.4 while rainfall patterns are given in figure 5.5.

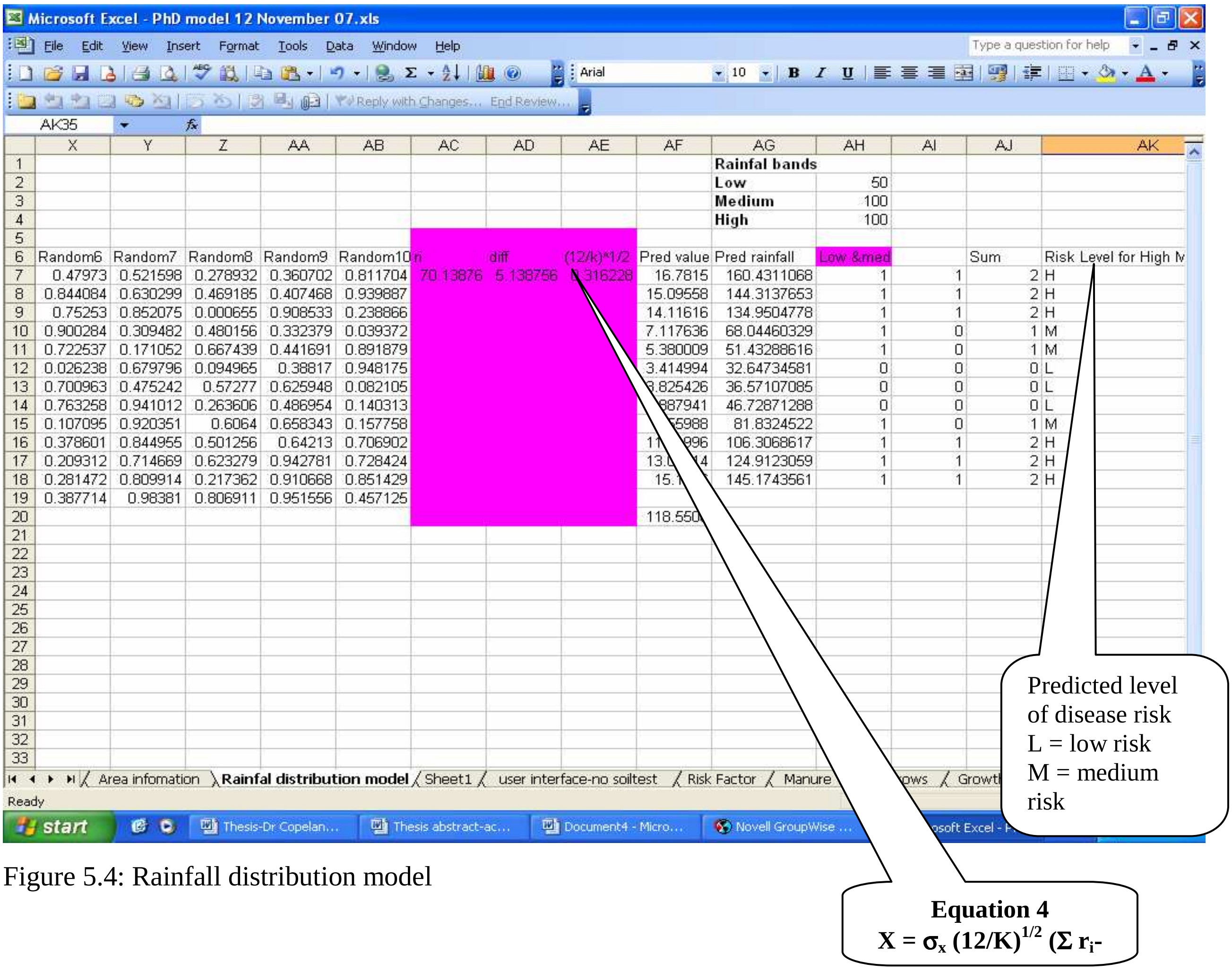


Figure 5.4: Rainfall distribution model

The observed rainfall values and the predicted rainfall values are strongly correlated. With the exception of Muden, the correlation is strong throughout most of the year. This suggests that given the mean value, the rainfall distribution can be predicted with reasonable accuracy over 12 months.

Evidently, risk is low during low-rainfall months (winter). However, with the increase in rainfall (moisture), the risk of disease also increases. It is to be noted that rain is not the only contributor of moisture but that mist and humidity can also play a role in disease development. Nevertheless, data on mist and humidity levels of rural areas is hard to find. According to the geographic location of the study areas, Mbumbulu is closest to the sea and is located in a humid area compared to Muden and Centocow, which are drier, although Centocow's higher rainfall than Muden and Centocow may lead to a higher presence of moisture.

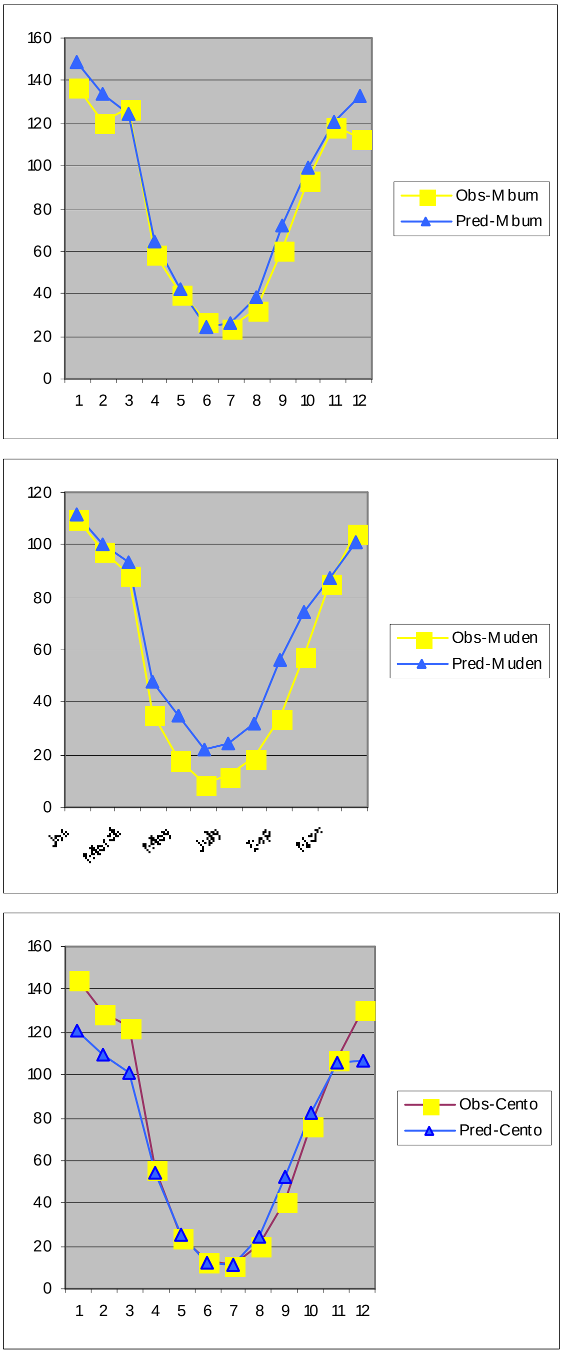


Figure 5.5: Observed and predicted monthly rainfall at Mbumbulu, Muden and Centocow

5.5.1 The user interface

The user interface as the interactive element of the model is the 'visible' element. Other cells are locked to prevent interference with data. The model was developed with the aim of establishing a user interface that farmers and other users (extension staff) can use with ease. An example of a user interface is presented in Figure 5.6. The output was demonstrated in figure 5.7 and 5.8 as illustrated earlier. This is the screen that allows the user to supply the inputs and obtain a printout. Other sheets responsible for the computation are protected to discourage inadvertent manipulation.

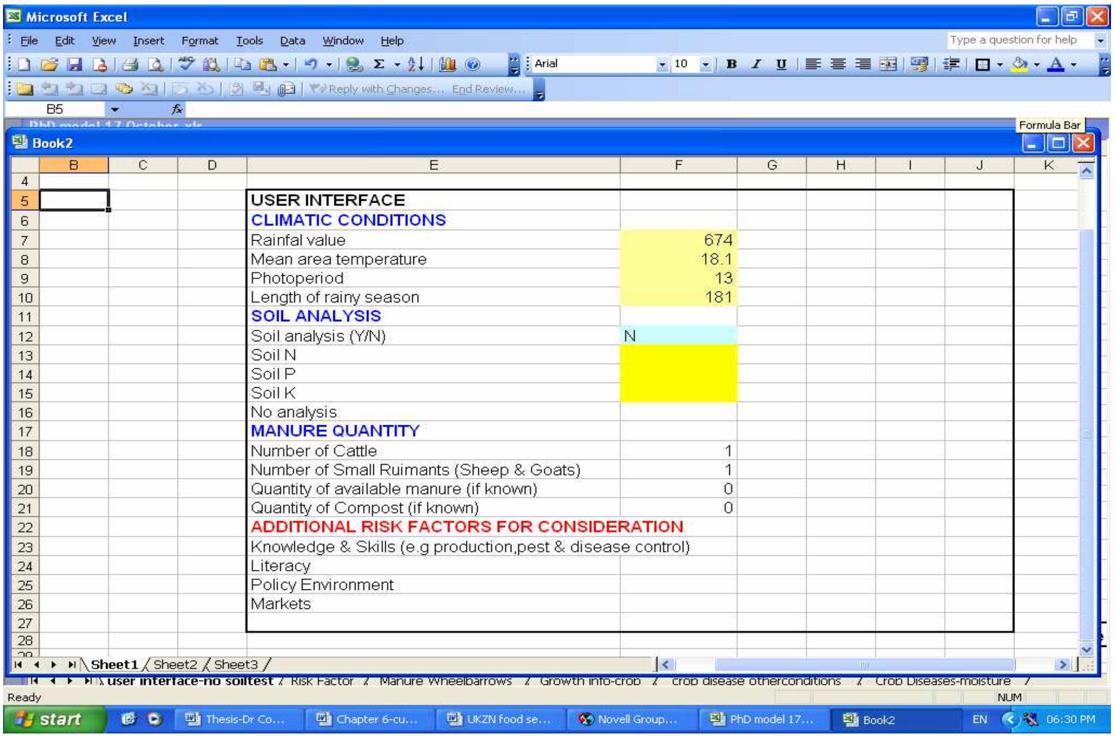
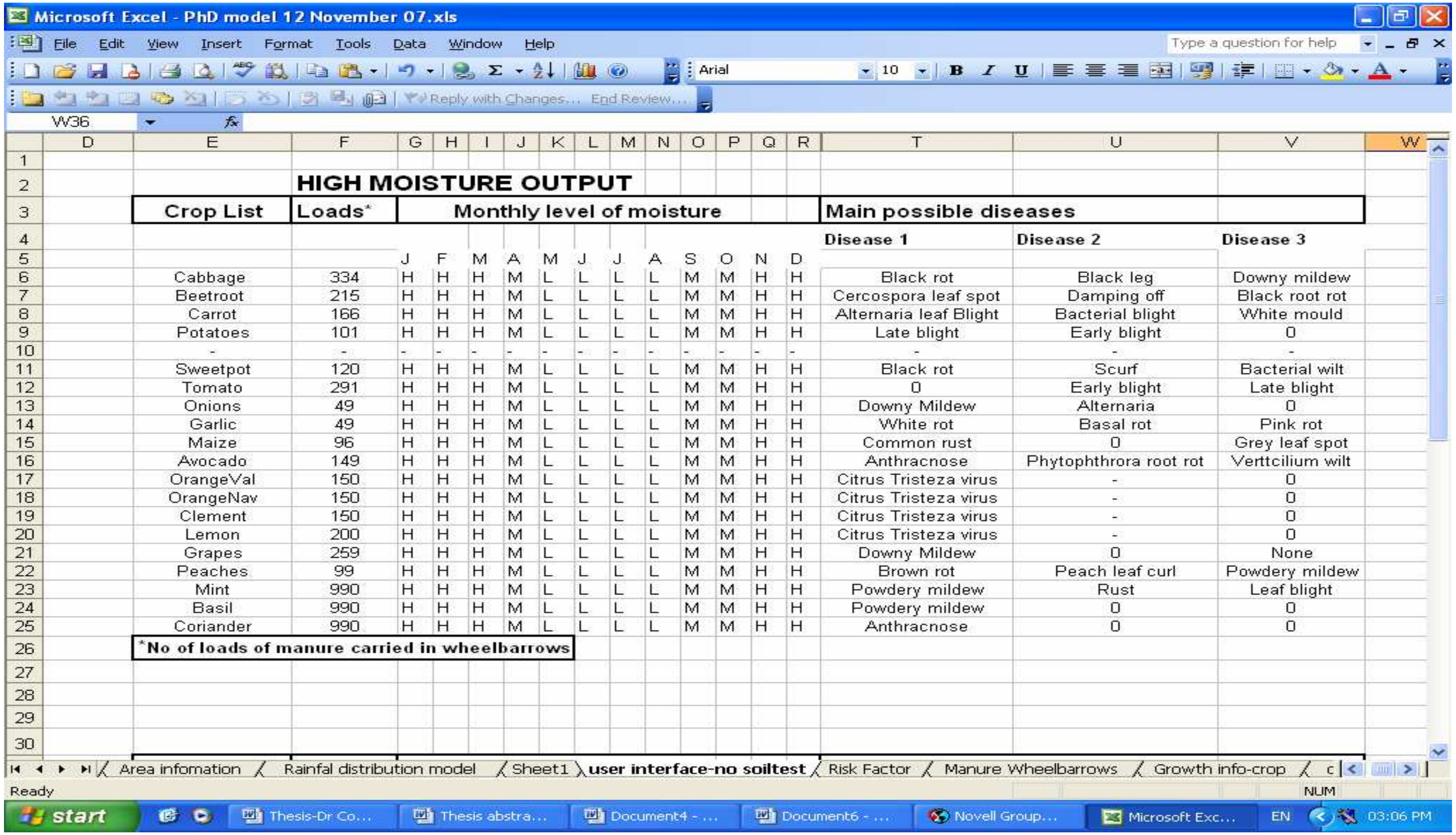


Figure 5.6: An example of the user interface.

The screen of the user interface had four sections. The user needs to provide data for three areas to receive input. They are climatic data (annual rainfall in mm); area mean temperature (degree Celsius); annual number of rainfall days and the length of the photoperiod (hours); conducted soil analysis (yes or no); and, manure quantity (number of animals or quantity of manure if it is known or quantity of compost if it is known). The decision support tool can either predict the quantity of manure based on the number of animals for a specified list of crops or a list of specified crops based on the quantity of manure or compost provided. These two outputs cannot be produced simultaneously. This allows one to be sure of which nutrient source the output is based on. In cases where a user desires output based on number of animals, manure and or compost, the output will have to be generated separately. The interface also lists additional factors that are important to consider in organic production including which are: knowledge, skills and literacy (Sligh & Christman, 2007) and an enabling policy environment (Scialabba, 2007). The intention of including these additional risk factors in the user-interface is to inform the decision-maker that it is not only the production elements of organic farming that are important but that other factors have a serious role to play. No output can be generated for these additional factors.

Model outputs are displayed to the right of the user-interface once the required data is filled in (Figures 5.7 and 5.8). The output lists crops that can grow; the number of wheelbarrows (loads* i.e. number of loads of wheelbarrows of manure) required to provide the required amounts of nutrient for each crop; monthly moisture levels and important diseases that are triggered by high moisture presence; and, for disease triggered by low moisture presence.

The use of the tool is simple because once the required information is entered into the Excel spreadsheet, output can be received at the push of the ‘enter’ button. Ideally, the outputs should be displayed on separate screens once the desired input user interface has been loaded. However, that will require extensive computer programming specialist input and time (Voges, 2006). Nevertheless, this step can be carried out in the future. The interface is simple to use and can be used by any literate person, provided they have the required information as specified above. Furthermore, the tool may appear complex to illiterate farmers, but given training it is fairly simple to use for an extension officer or anyone in an advisory role to farmers.

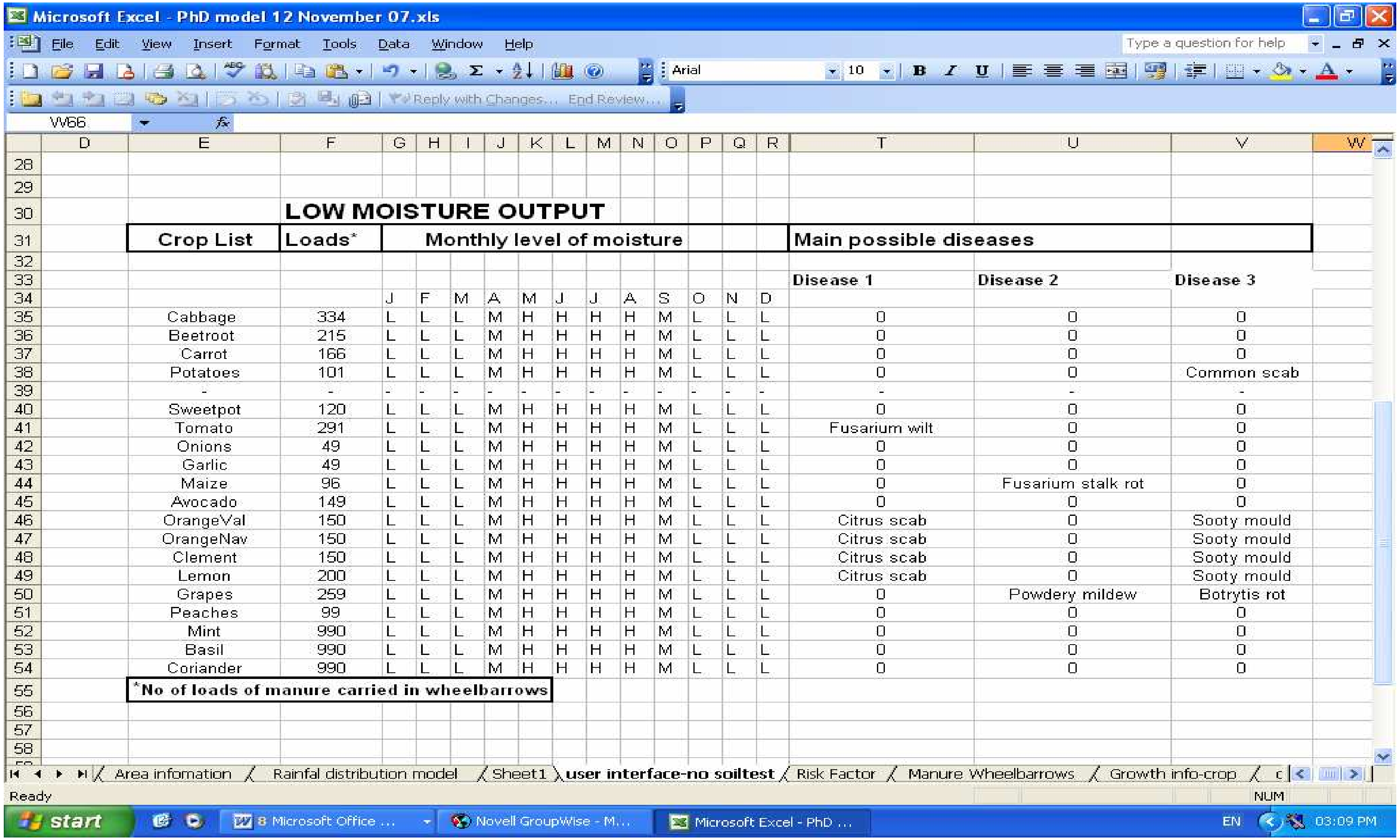


HIGH MOISTURE OUTPUT

Crop List	Loads*	Monthly level of moisture												Main possible diseases		
		J	F	M	A	M	J	J	A	S	O	N	D	Disease 1	Disease 2	Disease 3
Cabbage	334	H	H	H	M	L	L	L	L	M	M	H	H	Black rot	Black leg	Downy mildew
Beetroot	215	H	H	H	M	L	L	L	L	M	M	H	H	Cercospora leaf spot	Damping off	Black root rot
Carrot	166	H	H	H	M	L	L	L	L	M	M	H	H	Alternaria leaf Blight	Bacterial blight	White mould
Potatoes	101	H	H	H	M	L	L	L	L	M	M	H	H	Late blight	Early blight	0
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sweetpot	120	H	H	H	M	L	L	L	L	M	M	H	H	Black rot	Scurf	Bacterial wilt
Tomato	291	H	H	H	M	L	L	L	L	M	M	H	H	0	Early blight	Late blight
Onions	49	H	H	H	M	L	L	L	L	M	M	H	H	Downy Mildew	Alternaria	0
Garlic	49	H	H	H	M	L	L	L	L	M	M	H	H	White rot	Basal rot	Pink rot
Maize	96	H	H	H	M	L	L	L	L	M	M	H	H	Common rust	0	Grey leaf spot
Avocado	149	H	H	H	M	L	L	L	L	M	M	H	H	Anthracnose	Phytophthrora root rot	Verttcilium wilt
OrangeVal	150	H	H	H	M	L	L	L	L	M	M	H	H	Citrus Tristeza virus	-	0
OrangeNav	150	H	H	H	M	L	L	L	L	M	M	H	H	Citrus Tristeza virus	-	0
Clement	150	H	H	H	M	L	L	L	L	M	M	H	H	Citrus Tristeza virus	-	0
Lemon	200	H	H	H	M	L	L	L	L	M	M	H	H	Citrus Tristeza virus	-	0
Grapes	259	H	H	H	M	L	L	L	L	M	M	H	H	Downy Mildew	0	None
Peaches	99	H	H	H	M	L	L	L	L	M	M	H	H	Brown rot	Peach leaf curl	Powdery mildew
Mint	990	H	H	H	M	L	L	L	L	M	M	H	H	Powdery mildew	Rust	Leaf blight
Basil	990	H	H	H	M	L	L	L	L	M	M	H	H	Powdery mildew	0	0
Coriander	990	H	H	H	M	L	L	L	L	M	M	H	H	Anthracnose	0	0

*No of loads of manure carried in wheelbarrows

Figure 5.7: An example of the first page of the decision support tool showing output for high moisture-induced crop diseases



LOW MOISTURE OUTPUT

Crop List	Loads*	J	F	M	A	M	J	J	A	S	O	N	D	Disease 1	Disease 2	Disease 3
Cabbage	334	L	L	L	M	H	H	H	H	M	L	L	L	0	0	0
Beetroot	215	L	L	L	M	H	H	H	H	M	L	L	L	0	0	0
Carrot	166	L	L	L	M	H	H	H	H	M	L	L	L	0	0	0
Potatoes	101	L	L	L	M	H	H	H	H	M	L	L	L	0	0	Common scab
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sweetpot	120	L	L	L	M	H	H	H	H	M	L	L	L	0	0	0
Tomato	291	L	L	L	M	H	H	H	H	M	L	L	L	Fusarium wilt	0	0
Onions	49	L	L	L	M	H	H	H	H	M	L	L	L	0	0	0
Garlic	49	L	L	L	M	H	H	H	H	M	L	L	L	0	0	0
Maize	96	L	L	L	M	H	H	H	H	M	L	L	L	0	Fusarium stalk rot	0
Avocado	149	L	L	L	M	H	H	H	H	M	L	L	L	0	0	0
OrangeVal	150	L	L	L	M	H	H	H	H	M	L	L	L	Citrus scab	0	Sooty mould
OrangeNav	150	L	L	L	M	H	H	H	H	M	L	L	L	Citrus scab	0	Sooty mould
Clement	150	L	L	L	M	H	H	H	H	M	L	L	L	Citrus scab	0	Sooty mould
Lemon	200	L	L	L	M	H	H	H	H	M	L	L	L	Citrus scab	0	Sooty mould
Grapes	259	L	L	L	M	H	H	H	H	M	L	L	L	0	Powdery mildew	Botrytis rot
Peaches	99	L	L	L	M	H	H	H	H	M	L	L	L	0	0	0
Mint	990	L	L	L	M	H	H	H	H	M	L	L	L	0	0	0
Basil	990	L	L	L	M	H	H	H	H	M	L	L	L	0	0	0
Coriander	990	L	L	L	M	H	H	H	H	M	L	L	L	0	0	0

Column groups: Monthly level of moisture (J–D); Main possible diseases (Disease 1–3).

*No of loads of manure carried in wheelbarrows

Figure 5.8 An example of the second page of the decision support tool showing output for low moisture-induced crop diseases

In summary, the model provided three desired outputs, these being a list of suitable crops in the chosen areas, an answer as to whether the suitable crops can be grown organically in the chosen areas and possible diseases associated with each crop. Each stage of the model aimed to solve a sub-problem of this study and was described and critiqued. Several assumptions relating to each sub-problem were made. In the first sub-problem a decision was made that single values, instead of ranges, would be used when capturing plant growth data. Absolute values relating to rainfall were used because many smallholder farmers practice rain-fed agriculture and are found in low rainfall areas. Mean values for temperature were used due to the variation in the nature of temperature. On the other hand, it is accepted that the use of mean that certain crop growth will occur values that fall below the mean.

Crop nutrient requirements calculations were based on the most limiting nutrient between N, P and K. It is also accepted that some yield (although below optimum) can be achieved. Other assumptions were related to the use of rainfall as a correlate of moisture for both crop growth and disease onset. Nevertheless, it is accepted that other sources of moisture (mist and humidity) and environmental factors, such as slope, can play a role in moisture levels that can influence disease onset.

Large numbers of wheelbarrows indicated by the model show that organic production based on manure does not lead to optimum yields. The challenge for smallholder farmers is the large number of livestock that is required to produce the manure which is not likely to be possible for poor farmers. Even those with livestock will require unrealistically large amount of manure. This may not be sustainable if livestock numbers drop. Other technologies such as composting and the use of EM are important to consider.

Risk was based on moisture and disease occurrence. Risk is expected to be lower in winter but higher in summer which poses a problem for rain-dependent farmers, therefore the need for supplemented irrigation is heightened. Furthermore, rain is not the only contributor of moisture, but that mist and humidity can also play a role in disease development.

CHAPTER 6: COMPARATIVE APPLICATION OF THE DECISION SUPPORT TOOL

6.1 Introduction

In conventional research people are the subjects of research (Tilakaratna, 1990). In this study people were active participants in the collection and processing of the data. The creation and ownership of knowledge and technology in participatory research is aimed at those who are the ultimate beneficiaries of that knowledge (de Vos, 1998). Advances in technology related to smallholder farmers are seen as a solution to many of their problems (Duram, 1999; Freyer *et al*, 1994). However, technology should be appropriate for the environmental, cultural and economic situation it is intended for (NCAT, 2007). Creation of brilliant technologies, without consideration of appropriateness to their beneficiaries, is futile. Participation of beneficiaries in generation of knowledge and/or technology cannot be over emphasised.

One of the constraints in smallholder farming is access to appropriate information (Stephano *et al*, 2005). Farmers require information to make sound decisions related to production and other areas of farming. Factors such as form, medium of delivery, language and literacy play a role in access to information (Stefano, 2004). Therefore, development of technologies that focus on overcoming these constraints are important.

Previous chapters relating to the model addressed the need for a decision support tool and the development of the decision support tool to address identified production constraints. The purpose of this chapter is to present an application perspective of the decision support tool that was created in partnership with farmers. Actual answers on what crops can be grown organically in the three study areas or whether the farmers agree that the selected crops can be grown organically or not in their areas, are provided for in each case, using a comparative approach. A farmer's critique of the tool is also presented.

6.2 Methodology

Agro-ecological conditions for each area (being annual rainfall in mm); length of rainy season (days/annum); mean annual temperature (minimum and maximum) and the photoperiod) were entered into the decision support tool (user-interface) to produce output printouts. A stepwise comparison and analysis of the three outputs was conducted, based on each sub-problem.

6.3 Results

6.3.1 What crops can be grown organically by the participating farmers?

As explained in Chapter 5, the list of suitable crops resulted from matching the lists of sought-after organic crops from Woolworths (Ferreira, 2004) and agronomic data from the Bioresource Database from the Department of Agriculture and Environment in KwaZulu-Natal (Camp, 1999). Vegetables, fruit and herbs were included in the crop list. The list was used as a base for generating the model outputs. Table 6.1 shows a comparative list of crops per area from model outputs. The list in Table 6.1 was used as a base to match the agro-ecological data (mean annual rainfall, mean area temperature, the photoperiod and the length of the rainy season) supplied in the user interface for the crop requirements of each plant for adequate plant growth. The crops that the model deemed suitable for each area appear in the two-page printouts, per area in Appendix D (Mbumbulu), E (Muden) and F (Centocow).

It must be emphasised that instead of using optimal plant growth conditions, absolute plant growth conditions and means were chosen in the development of the model. This reasoning was based on the fact that, due to historical reasons, many smallholder farmers are located in agro-ecologically inferior parts of South Africa (Aliber *et al*, 2006). In addition, means were used for temperature values due to the naturally large variance in temperature across days and seasons. Due to the use of absolute growth conditions, it was expected that lower yield scenarios would be presented by the decision support tool as opposed to higher yield scenarios, if optimal conditions were used. Nevertheless, the modest yield scenario presented is more likely to be experienced by most smallholder farmers, which may have negative effects on marketability and profitability for farmers.

Table 6.1: Model output of suitable crops for three agro-ecological zones of Mbumbulu, Muden, Centocow, generated from Appendix D,E and F

Crop	Mbumbulu	Muden	Centocow
Cabbage	✓	✓	✓
Beetroot	✓	✓	✓
Carrot	✓	✓	✓
Potatoe	✓	✓	✓
Amadumbe	–	–	–
Sweetpotato	✓	✓	✓
Tomato	✓	✓	✓
Onions	✓	✓	✓
Garlic	✓	✓	✓
Maize	✓	✓	✓
Avocado	✓	✓	✓
Orange Valencia	✓	✓	✓
Orange Navel	✓	✓	✓
Clement	✓	✓	✓
Lemon	✓	–	✓
Grapes	✓	✓	✓
Peaches	✓	–	–
Mint	✓	–	✓
Basil	✓	✓	✓
Coriander	✓	✓	✓

Note: Where ✓ means the crop grows and – means the crop does not grow in the area.

According to the model, Mbumbulu's climatic conditions meet almost all growth requirements for the crops, except for those of *amadumbe (taro)*. *Amadumbe* was rejected by the model for all three areas due to its high rainfall requirement (FAO, 2003). On the contrary, *amadumbe* is a popular crop in the area and it is widely grown for consumption and for commercial purposes. A closer look at the reason for this outcome revealed, according to the model, Mbumbulu's mean annual rainfall was 956mm, as indicated by DAEA's Bioresources Database (Camp, 1999). On the other hand, the minimum water requirement for *amadumbe* according to FAO 2003, is 1000mm (FAO, 2003). A shortfall of only 44mm has resulted in the model indicating *amadumbe* to be unsuitable in Mbumbulu. Due to the shortfall being small, it is reasonable to conclude that *amadumbe* is suitable for growing in Mbumbulu. However, this small shortfall also highlights the fact that without supplementary irrigation, Mbumbulu farmers face a significant risk if the rains do not come as expected. Furthermore, the model itself required a wider range of data to be more inclusive to avoid crops being rejected on small margins.

Four crops in Muden (including *amadumbe*, lemon, peach and mint) were deemed unsuitable for organic production for growth by the model. Only *amadumbe* and peach were rejected by the model for the Centocow area. Peach was also rejected by the model for both the Muden and Centocow areas due to their relatively short rainy season (Muden 181 days and Centocow 211 days), thereby not meeting the minimum requirement of 240 days for peach's growth cycle (FAO, 2003). Lemon was rejected by the model on the grounds of the rainy period being too short to fulfil adequate growth in Muden. Fruit trees have a longer growth cycle (and constantly need available water) and take time to bear fruit. Mint was deemed unsuitable for growth in Muden due to shortfall in annual rainfall need (FAO, 2003). It is clear that Muden, compared to Mbumbulu and Centocow, is agro-ecologically less supportive of rain-fed smallholder agriculture. Additional irrigation or improvements and the introduction of water harvesting technologies should have a positive impact on crop performance, provided all other important elements are met.

Table 6.2 shows the crops currently grown by the three groups. There is a discernible difference between what the farmers are currently growing and what is suitable for growth according to the model. It is to be noted that the Mbumbulu farmers (EFO) focus on only three root crops, potatoes, sweetpotatoes and *amadumbe* and green beans (not root crop and new crop), when the area in fact has the potential to support 19 other crops. The Mbumbulu farmers currently have no supplementary irrigation, which may explain why their farming does not include leafy vegetables, as these crops would require supplemented irrigation. The Mbumbulu farmers stated that they would like to include more vegetables in their production but they were limited by many factors, including organic pest control and a lack of new markets. The Muden farmers' production focus is currently on vegetables and garlic. Interestingly, garlic is their main cash earner. Although the Muden farmers have supplemented irrigation, they have expressed frustration regarding the inefficiency of the irrigation system (Goba, 2004; Mthembu, 2005). The Centocow farmers focus mainly on three crops despite the potential for many other crops; the farmers revealed that other vegetables were grown in home gardens but not consistently. The farmers expressed a desire to grow more maize and vegetables, such as cabbage, but they are limited by a lack of water and fertiliser.

Table 6.2: Current crops grown in Mbumbulu, Muden and Centocow collected in a group survey in 2004 (Mthembu, 2005) and in 2006 (Naidoo, 2006)

Crop	Mbumbulu	Muden	Centocow
Cabbage	–	✓	–
Beetroot	–	✓	–
Carrot	–	✓	–
Potatoes	✓	✓	✓
Madumbe	✓	–	–
Sweetpotato	✓	–	✓
Tomato	–	✓	–
Onions	–	✓	–
Maize	✓	✓	✓
Garlic	–	✓	–
Green Beans	✓	–	–

Note: Where ✓ means the crop grows and – means the crop does not grow in the area.

The second part of solving sub-problem one was to ascertain what the organic production requirement was for suitable crops and whether farmers in these areas can meet these requirements. According to van Averbeke & Yogananth (2003) it is common knowledge that small-scale farmers in rural areas of South Africa use livestock manure for soil nourishment. Key nutrients for plant growth required in larger quantities for most plants are N, P and K. Manure provides these minerals but only in small quantities. It is important to note that manure's nutrients are slowly released and subsequent crops would benefit from previous applications. The farmers included manure in varying qualities in their soil nourishment programmes. The Mbumbulu farmers used pen manure exclusively due to certified organic requirements. The Muden and Centocow farmers used manure in conjunction with commercial fertilisers. Both Muden and Centocow farmers expressed a wish to be certified as organic producers but are faced with many constrains with regards to meeting the requirements for organic farming certification. Unless these constraints are addressed, Muden and Centocow do not meet organic certification.

When calculating the amount of manure required for the soil to improve from being nutrient depleted, the nutrient removal rates per crop were used as detailed in Chapter 5. Table 6.3 shows a comparison of the amount of nutrient (kg) removed by crops to produce one ton of harvest when using a commercial inorganic fertiliser (Hygrotech, 2005). The number of wheelbarrow loads of manure required to provide the equivalent nutrients removed is indicated (van Averbeke & Yogananth, 2003). The strength (nutrient concentration of manure vs. fertilizer) of the commercial fertiliser versus manure is also indicated in Table 6.3.

It is evident from Table 6.3 that the strength of commercial fertiliser is incomparable to manure due to the concentrated form of commercial fertiliser. The current rate of manure application by the Mbumbulu farmers (EFO) is 8998.716 kg/ha or 120 wheelbarrow loads per hectare per annum. One needs comparatively less commercial fertiliser to produce one ton of a crop (Table 6.3). For example, 3.34kg of N is required to produce one ton of cabbage compared to 334 wheelbarrow loads of manure per hectare. As per the decision support tool, indicating the output for all three areas (Appendix C), cabbage production would be limited by inadequate N. It can be unequivocally stated that organic production based on manure as the source of nutrients would be difficult to maintain and crops would perform poorly. It is important to note that there would be value in a comparison between organic and conventional production systems for participating farmers, taking into account the current resource-poor farmer context. However, that comparison, although valuable, does not form the scope of this study.

Table 6.3: NPK requirements for optimum growth (withdrawal norms) vs equivalent from manure (Hygrotech, 2005; van Averbeke & Yogananth, 2003 and Conradie, 2004)

Predetermined Plant List	N (withdrawal norms on commercial fertiliszer kg/tTon)	N (number of wheelbarrow loads of manure)	Strength of commercial fertiliszer vs manure	P (withdrawal norms commercial fertiliszer kg/tTon)	P (number of wheelbarrow loads of manure)	Strength of commercial fertiliszer vs manure	K (withdrawal norms on commercial fertiliszer kg/ton)	K (number of wheelbarrow loads of manure)	Strength of commercial fertiliszer vs manure
Cabbage	3.3	334	100.0	0.6	189	300.0	3.6	270	75
Beetroot	2.9	120	41.0	0.5	215	430.0	6.9	56	8
Carrot	4.0	166	41.0	0.7	93	124.0	4.8	150	31
Potatoes	3.0	101	33.0	0.3	20	66.7	4.0	100	25
Madumbe	3.4	113	33.0	0.4	45	100.0	3.2	80	25
Sweetpotato	2.4	122	49.8	0.4	67	148.9	3.2	120	37.5
Tomato	3.0	29	9.7	0.3	87	248.5	4.67	250	53.5
Onions	2.85	47	16.5	0.6	49	77.8	3.88	31	8
Garlic	2.85	96	33.7	0.3	49	77.8	3.88	25	6.44
Maize	11.92	397	33.3	3.0	1192	397.0	5.2	298	85
Avocado	5.70	133	23.0	1.0	70	70.0	8.2	148	18
OrangeVal	2.0	133	66.5	0.5	100	200.0	3.0	150	50
OrangeNav	2.0	133	66.5	0.5	100	200.0	2.0	150	75
Clement	2.0	133	66.5	0.5	100	200.0	3.0	150	75
Lemon	3.0	133	66.5	0.5	100	200.0	3.0	150	75
Grapes	3.89	259	66.5	0.7	144	205.0	3.1	122	40
Peaches	1.39	93	66.9	0.2	50	200.0	2	99	50
Mint	4.0	220	55.0	6.0	990P	165.0	0.5	33	66
Basil	4.0	220	55.0	6.0	990P	165.0	0.5	33	66
Coriander	4.0	220	55.0	6.0	990P	165.0	0.5	33	66

*Formulae used to calculate strength of commercial fertiliser vs strength of manure
Strength of commercial fertiliser = (2)/(1)
Removal rate (T/ha) = crop yield (T/ha) X nutrient removal norm (kg/T) equation (1)
No of wheelbarrow loads = removal rate/average nutrient content of manure (N, P, K) equation (2)

The least number of wheelbarrow loads required to grow crops on the predetermined list is 29 wheelbarrows per hectare. The farmers conveyed that even this relatively low number of wheelbarrow loads would be difficult to obtain due the small number of animals being available. As shown earlier in Figure 5.4., manure produced from one cow amounts to only 7.92 wheelbarrow loads per annum (USDA, 1996). Table 3.4 illustrated livestock and small ruminant numbers per household in the study areas. It was important to determine if the current numbers of animals owned by the farmers were producing adequate manure to meet crop nutrient requirements. Table 6.4 presents manure availability based on current stock levels as informed by the decision making tool. The mean number of animals (cattle and small ruminants) was used in the decision support tool to find out manure availability.

Table 6.4 Manure availability based on current livestock and small ruminants measured in wheelbarrow loads

	Mbumbulu	Muden	Centocow
Minimum	97.72	47.14	43.98
Mean	124.5	74.46	92.87
Maximum	137.4	341.28	295.04

Evidently, it is not possible for the farmers to have an adequate load of manure given their current livestock level because the mean wheelbarrow loads indicated in table 6.4 are lower than those indicated by the model for crops in appendix D, E and F. The concentration of nutrients in manure depends on several factors. The most important factors that affect the concentration of nutrients in manure are the levels of moisture and its soil content (van Averbeke & Yogananth, 2003). Uncomposted manure kept in an animal enclosure (pen), known as a kraal in rural South Africa, constitutes significant soil (van Averbeke & Yogananth, 2003). It is common practice for manure to be left to accumulate in the animal enclosure where it mixes with soil as animals walk on it. The higher the soil content, the lower the nutrient concentration. All calculations of wheelbarrows of manure in this study were based on a soil content of 60% in manure as shown in the extensive study of manure by van Averbeke and Yoganath (2003). Table 6.5 presents the results of the manure analysis.

Table 6.5 Manure analysis, July 2005

	Nitrogen (N) %	Phosphorous (P) %	Potassium (K) %
Mbumbulu	1.64	0.30	0.58
Muden	0.91	0.6	0.2
Centocow	1.73	0.82	0.27

As shown in table 6.5, the manure sample contained low proportions of N, P and K nutrients. In comparison, most commercial fertilisers contain between 20% and 30% of N, P and K nutrients per 100kg of fertiliser (van Averbeke and Yogananth, 2003). Mkhabela's (2006) study in the KwaZulu-Natal midlands indicated that: N = (2%), P = (1.5%) and K = (2%), are low, as they are in this study, although the potassium results vary noticeably between the study areas. Nevertheless, it is questionable (especially in Mbumbulu (EFO)) whether farmers can continue to use kraal manure as the sole source of soil nutrition for reasons that include soil fertility imbalances, weed problems, pollution hazards and produce quality.

The number of wheelbarrow loads of manure required to meet crop needs, as shown in Table 6.3 is excessively high. Excessive manure application is prohibited in certified organic farming and may lead to an oversupply of nutrients in the soil, which may lead to imbalances in the soil and contamination by pathogens (BDOCA, 2006; Kuepper, 2003). Nutrient imbalances in the soil may lead to difficulties in absorption of some minerals, especially micronutrients (Titshall, 2006). Soil samples were collected from the three farmer areas and analysed to assess the state of fertility. As noted previously, the study was concerned only with three nutrients: nitrogen (N), phosphorous (P) and potassium (K). However, the soil results presented in Table 6.6 bear reference only to phosphorous and potassium (K) because nitrogen is unstable in soil due to rapid soil environmental changes that affect the availability of this mineral. Furthermore, nitrogen also has high leaching tendencies.

The soil analysis presented in Chapter three (Table 3.5) indicates a general deficiency of P in the three study areas. Plants that require large amounts of P will not perform well in such soils without corrective soil nutrition strategies. On the other hand, with the exception of Mbumbulu, all areas have high levels of K. The following three examples are used to evaluate whether areas would be able nutritionally to support new crops if these were to be introduced, given the current nutritional status. Three crops were used for this purpose and they included a leafy crop (cabbage), a root crop (*amadumbe*) and a fruit tree (Valencia orange).

Table 6.6: Evaluation of soil nutrient status in study areas

	(P) (Reserve (kg/ha)*		(K) (Reserve (kg/ha)*	
Mbumbulu	-24.5	*Nutrient required (kg/ha)	-151.5	Nutrient required (kg/ha)
Cabbage (*yield = 60T/ha)		37.8		216
amadumbe (yield = 20T/ha)		9		6.4
Orange (yield 40T/ha)		20		120
Muden	-30		868	
Cabbage (yield = 60T/ha)		37.8		216
amadumbe (yield = 60T/ha)		9		6.4
Orange (yield = 60T/ha)		20		120
Centocow	-2		356	
Cabbage (yield = 60T/ha)		37.8		216
Madumbe (yield = 60T/ha)		9		6.4
Orange (yield = 60T/ha)		20		120

*Nutrients required by plant = withdrawal norm *yield.

As indicated in Table 6.6, the Mbumbulu soil samples do not currently meet the nutrient requirements of the three examples of crops used, because the reserve nutrient values are lower than crop requirements. This situation is likely to affect yields.

Due to the fact that farmers in Mbumbulu (EFO) were certified organic producers, the demonstration in Table 6.7 presents an important case. Evidently crops such as cabbage would be of limited yield due to the deficit in crop nutrient requirement (NPK). On the other hand, nutrient requirements for salad vegetables, such as tomatoes, onion and garlic, are met except for K in the case of tomatoes. Information presented in Table 6.7 is critical for farmers because it provides a clear picture of which crops would be uneconomical to plant due to possible poor yield because of deficit in nutrient requirements.

Using information from Table 6.3, cabbage requires 189 wheelbarrow loads of manure/ha to provide 38kg/ha of P and 270 wheelbarrow loads of manure/ha to provide 216kg/ha of K. With the restrictions on manure available and possible oversupply of N, P and K it is evident that pen manure cannot meet the nutrient requirements of the crops. The soil at Muden and Centocow not only does not meet the P requirements but also has an oversupply of K.

It is important to state that corrective soil nutrition plans must take into account the current availability of minerals and soil type. For example, in clay soils, most soil P is not available to plants, even when it is indicated as high in the soil test. Therefore, budgeting for P is more difficult in such soils. Furthermore, the absorption of nutrients by plants is affected by the availability of other minerals in the soil. The mode of application of manure is also an important factor to consider because the method of manure application has a direct relationship to nutrient availability (Magdoff & van Es, 2000). These findings show that farmers need to understand or have access to an extension officer who is able to interpret such soil test results and assist them in designing appropriate soil nutrition improvement plans that take into account their current practices. These plans may include crop rotation and the use of compost.

Three questions were posed and discussed with a view to answering the first sub-problem of this study, i.e. what crops can be grown organically by the participating farmers? Mbumbulu met the agronomic requirements of 95% of the crops on the model list. Centocow met the agronomic requirements of 90% of the crops on the model list. Muden met only 80% of the agronomic requirements of the crops on the model list. The popular *amadumbe* was rejected as a suitable crop for all areas (although by only a small margin for Mbumbulu) due to its very high minimum water requirement. Peach was deemed unsuitable to grow satisfactorily in Muden and Centocow due to its deficit in minimum water requirement and a short rainy season that may not sustain the full crop cycle.

Table 6.7 Analysis of manure availability (wheelbarrows) in Mbumbulu

Predetermined Plant list	Mean manure availability in wheelbarrows	N (number of wheelbarrow loads of manure)	P (number of wheelbarrow loads of manure)	K (number of wheelbarrow loads of manure kg/tTon)
Cabbage	124.5	334	189	270
Beetroot	124.5	120	215	56
Carrot	124.5	166	93	150
Potatoes	124.5	101	20	100
Madumbe	124.5	113	45	80
Sweetpotato	124.5	122	67	120
Tomato	124.5	29	87	250
Onions	124.5	47	49	31
Garlic	124.5	96	49	25
Maize	124.5	397	1192	298
Avocado	124.5	133	70	148
OrangeVal	124.5	133	100	150
OrangeNav	124.5	133	100	150
Clement	124.5	133	100	150
Lemon	124.5	133	100	150
Grapes	124.5	259	144	122
Peaches	124.5	93	50	99
Mint	124.5	220	990P	33
Basil	124.5	220	990P	33
Coriander	124.5	220	990P	33

Muden deemed unsuitable for both lemon and mint crops due to an inadequate rainy season for grape's crop cycle and due to low water requirements. The systematic evidence provided by the comparison of commercial fertiliser and pen manure, in relation to crop nutrient needs, showed that all three groups do not meet organic nutrient requirements because of the poor concentration of nutrients in pen manure. In all three areas, the farmers do not have adequate livestock to produce the required number of wheelbarrow loads of manure. Organic production would be difficult to sustain based on the current manure availability. The poor nutrient condition of their soils (Table 3.2) in relation to current crop nutrient requirements is an unsustainable and unbalanced condition which can only contribute to accentuate soil deterioration. Evidently, the current farming practices of all three groups do not meet organic nutrient requirements and are not sustainable. The continued 'harvesting' of already-depleted soils without proper soil enrichment will have a detrimental effect for all three groups.

The following section provides an account on the farmers' experience of the tool, including testing of the model, group discussions, opinion, impressions and usefulness of the tool.

6.4 Threats to commercialisation of organic farming

Agriculture makes a small but important contribution to household food security in the poor former homelands of South Africa by functioning as a buffer against hunger and poverty. Despite the fact that there are indications that organic farming may offer smallholder farmers opportunities to realise commercial goals that may not be possible through conventional agriculture, this study has shown that smallholder farmers are faced with a lack of resources to realise commercial goals. The purpose of this section is to crystallise constraints that threaten the commercial production of identified crops.

Exclusive organic farming is based on total elimination of synthetics inputs in production and processing of agricultural products. The definition of production risks for this study is based on the risk related to the elimination of agrochemicals in managing crop diseases and relying on a knowledge-based system for crop diseases management and soil nourishment.

Table 6.8 is a summary of presents elements that present a threat to the commercialisation of organic farming. Evidence presented in section 3.1 and Table 3.1 indicates that all the groups studied are essentially practicing rain-fed agriculture due to a lack of irrigation or effective irrigation. Shortage of water is detrimental to productivity and improved yields. All three farmer groups are unable to solve their irrigation or lack thereof on their own. External assistance in the form of providing irrigation infrastructure is essential.

Table 6.8: Elements that threaten organic production drawn from FFA and group discussions with Mbumbulu, Muden and Centocow groups, August 2006

Risk element	How it affects organic production
Fencing	Crop losses
Irrigation	Poor yields, limited choice of crops
Knowledge and information (production, soil nourishment and disease control)	Threat to growth of organics, losses, unproductive soils, soil erosion, lack of access to organic market
Appropriate extension	Lack of support for farmers, poor chance of building critical mass of knowledgeable farmers, poor learning opportunities
Illiteracy	Limits access to information and understanding of important information such as regulations and laws
Non-conducive policy environment	Halts industry growth and critical macro-scale elements, opens up room for abuse of farmers, lack of legal protection for wronged farmers.

Lack of effective irrigation is a threat to organic production and or expansion thereof for participating farmers. Lwayo *et al* (2006) discovered that EFO farmers have not introduced new crops due to the risk aversion associated with rain-dependent agriculture. With the exception of EFO (Mbumbulu), participating farmers are found in low rainfall areas and essentially all practice rain-fed agriculture.

Poor knowledge of organic farming and disease control among all three groups is a major threat for organic agriculture, especially for EFO who are certified organic producers and are prohibited from using agrochemicals. As most crop disease is prevalent when there is water, participating farmers are likely to experience most diseases during the most productive period, threatening yields and livelihoods.

Mean annual rainfall data was used to determine the availability of water during the summer months for the three areas. A special rainfall distribution model, as explained in Chapter five, section 5.2.3, was used to determine the monthly rainfall. The probability of disease onset was based on water availability and warm summer temperatures. The availability of moisture (rainfall) was used as a basis for setting the disease risk profile and is presented in Table 5.2. The disease risk profile is delivered in three ranges, as low, medium and high risk of development. Appendix D, E and F present model outputs for the three areas where the annual disease risk is detailed. A summary of the disease risk output derived from Appendix D, E and F, which relates to periods of high moisture (summer months), is presented in Table 6.9.

Table 6.9 : Disease risk profile for high moisture periods for Mbumbulu, Muden and Centocow

	October	November	December	January	February	March
Mbumbulu	H	H	H	H	H	H
Muden	M	M	M	H	M	M
Centocow	M	H	H	H	H	H

*Range 1 ≤50 mm (low = L)
*Range 2 50-100 (medium = M)
*Range 3 >100 (high = H)

It is evident from Table 6.9 that periods of high moisture (November to March) are related to high risk of disease occurrence. Mbumbulu is the most risky area for disease onset. Mbumbulu has higher humidity levels compared to the other areas due to the proximity to the coast and a high rainfall (Camp, 1999). Muden can be associated with medium risk for disease onset.

According to Table 6.9, October is associated with the onset of the period of increased risk of disease, but these months are also those that the farmers look forward to because of their rainfall. During October to March, farmers are faced with disease management decisions. As stated earlier, agrochemicals are forbidden in certified organic farming. Organic farmers require adequate knowledge of natural disease control. The lack of knowledge of natural disease control was reported as one of the production constraints for all groups. This is a serious problem that will continue to hamper success for the Mbumbulu (EFO) certified farmers and may deter the Muden and Centocow farmers from practising certified organic agriculture.

Lack of extension services, as stated by the Centocow group and EFO, is a threat to information needs of farmers. Stefano (2005) reiterates that access to agricultural information is problematic to rural farmers. Furthermore, extension officers are mostly trained in conventional farming techniques and would find it challenging to support organic farmers.

Translation of the disease names into indigenous languages would require the assistance of extension officers or through the use of a professional translator. A production manual with coloured photographs showing images of the diseases, to assist farmers in recognising these diseases and methods of disease controlhow to control them, would be of great assistance. An extension officer can play an important role in this regard. An extension officer is a crucial link for farmers, as is the use of the decision support tool. The Centocow and Muden groups reported a lack of extension support and inappropriate extension, respectively. Extension services for the Centocow area were poor. The Centocow farmers reported in section 6.1.1 that they had not been visited by a Government extension officer for four years and they did not know where to turn to for help to improve their resources. Although the Muden farmers were not deprived of an extension officer, he was not trained in organic production and could not assist them effectively in adopting organic production. A lack of knowledge can halt the development of organic production farming. Farmers need a thorough understanding of the agro-ecology and comprehensive knowledge of the farming system (Scialabba, 2007) to devise effective management plans for crop diseases and soil nutrition. All farmers reported (section 6.1.1) that their lack of knowledge in these areas was a risk. This dearth of knowledge of organic production has been attributed to the Green Revolution (Juma, 2007). Poor knowledge in organic farming has a negative impact on the growth of the organic farming industry because few people would be successful. Chances of crop losses are high if farmers do not know how to manage diseases and other resources such as water. The lack of knowledge may also lead to unproductive soils, affect yields negatively, and lead to soil erosion and degradation. Poor knowledge of the organic industry may be linked to illiteracy and can lead to a lack of access to the organic market.

Farmers verified the usefulness of the monthly disease risk information in production planning. They stressed that knowing when to avoid risk with regards to planting certain crops was indeed useful. The farmers also verified whether the moisture categories (low, medium and high) matched what they already knew about certain diseases. It was difficult for them to match the moisture categories to exact millimetres of rain; instead they used ‘little’, ‘enough’ and ‘much’ rain as broad categories. All farmers agreed that there was much rain in the summer months and that December and January were months of high rainfall.

Lack of fencing is a serious threat to production and is presented in Table 6.9, along with other risks identified through the constraints based on the FFA analysis and group discussion during the study. Crop damage and losses can be high when livestock have access to farm fields. This may impact negatively on food insecure and poverty-stricken households. Households trying to start businesses through farming are at risk if effective fencing is lacking.

The lack of irrigation limits the choice of crops that can be planted due to a deficit in water requirements. Crops yields are also negatively affected by poor water availability. Poor irrigation infrastructure, or lack of irrigation infrastructure, is detrimental to production and may discourage participation among members, as stated by the Muden farmers.

Access to finances is a key constraint identified by all of the farmers. Among other roles, financial assistance may solve the fencing problem. However, due to the low levels of education and geographical location of participating groups, accessing finances for smallholder farming is difficult. In the case of EFO, who received some funding when they started (Modi, 2004), external guidance from a university resulted in EFO receiving financial assistance. Furthermore, Gadzikwa *et al* (2006), in their study, revealed that EFO's future sustainability is dependent on continued external support for fully subsidised information, transport, fencing and certification services. This level of external support will be difficult to maintain and EFO members need to be able to provide these resources themselves for sustainability. It is therefore not surprising that Muden and Centocow are not certified organic producers, despite practising some elements organic farming for years, due to the lack of the external support.

A poor policy environment can arguably be said to be the main contributor to most problems identified. The lack of legislation addressing organic farming in South Africa exposes the industry to several problems, including slowing organic industry growth, opening up the way for farmers to be overcharged by private overseas certifying companies; failure to promote the development of local organic farming standards; and, allows for abuse of farmers due to the non-existence of legal protection for wronged farmers. The lack of an organic farming policy has macro level impacts that affect extension education, country training needs and local and export market facilitation. The farmers in Mbumbulu reported (section 6.1) that certification costs were high and they are concerned about annual inspection costs. The high cost of certification can be attributed to the lack of organic farming policy and legislation in South Africa, which has allowed private companies to charge unregulated fees driven by profit.

6.5 Farmer critique of the decision support tool

Farmers were critical partners in the study. It was, therefore, important to present the farmers' critique, opinions and feel of the decision support tool. All farmer groups welcomed the idea of having a list of crops that match their climatic conditions to consider for organic production. All expressed a view that the list will provide new choices and ideas about crops they did not know were compatible with their environments and/or had a market demand. The farmers wanted to know why some crops were rejected by the decision support tool. In the case where a crop was rejected by the model, when farmers knew from experience that it was compatible, there was disbelief and mistrust of the 'computer'. However, promises by the researcher to investigate further were welcomed. The Centocow farmers also said that the model affirmed what they already knew about which crops were agreeable but they were surprised that other crops were also considered agreeable. For example, Centocow farmers were pleased that the plants they currently grew are listed by the model but were surprised that fruit trees (which were never considered) were listed by the model (Appendix D, E and F).

6.5.1 How useful do the farmers consider the model to be as a decision-making tool?

With the exception of a few highly-educated farmers in Mbumbulu, all farmers felt that they would not be able to use the model or to read the outputs due to their low levels of education and poor knowledge of the English language. The farmers suggested that the model should be translated into isiZulu to make it more accessible to them. However, the farmers conceded that they would still need the knowledge of an extension officer to help them acquire some of the prerequisite information to enter into the user interface and receive the outputs. They would also need the extension officer to show them how to use the model. In Muden, the extension officer, who was part of this study, agreed that indeed the farmers would need help, especially with regard to the four initial requirements for receiving the output. It is encouraging that extension officers have access to the Bioresources Database from which they can obtain the required inputs.

The farmers groups verified that they were able to calculate the length of the rainy season by counting the months during which it rains but not the annual rainfall in millimetres, with the exception of one farmer in Mbumbulu who has a rain gauge on her farm. They also stated that they did not know the minimum temperatures of their area and the crop photoperiods, making the role of an extension officer critical when using the decision support tool.

The farmers agreed that it was important to know the manure requirements of each crop for organic production as indicated by the third model output. All groups expressed disbelief at the very high number of wheelbarrow loads of manure required. There was consensus that, based on the manure indications, farmers could not farm organically on a sustainable basis using their current soil nutrition practices. All farmers emphasised the need for compost making skills. The Centocow farmers expressed the view that there was a clear need to continue to use agrochemicals for better yields since they did not have enough animals to meet the manure requirements. However, they stated that commercial fertilisers were expensive so the need for compost making know-how was key to improving soil nutrition. The three groups said it was important to know when to watch out for diseases, but a dilemma was that the diseases were most prevalent during the rainy season, which is also planting time. All groups agreed that the lack of know-how on natural pest and disease control was a serious constraint and threat to organic farming. If this know-how was improved, they would feel less at risk.

The Mbumbulu (EFO) farmers expressed the most disbelief when shown that, according to the model, *amadumbe* was not suitable for organic production. They said that they have always grown *amadumbe* without supplemented irrigation and had a good harvest. The researcher explained that she would go back and investigate why *amadumbe* was rejected based on inadequate rainfall. One farmer stated that she has a rain gauge on her farm and was well aware that the rainfall in Mbumbulu was more than 1000mm per annum. She also stressed that as she was born in Mbumbulu, she knew without a doubt that the rain was adequate for *amadumbe* as it always has been. Although the disparity between the two criteria was small (44mm) and may not make a significant difference, this raises the issue of the uniformity and credibility of sources of information versus farmer knowledge. Clearly, farmers (in this case) know better and should not be discounted in research as recipients of an outsider's knowledge but need to be embraced more as research partners.

The farmers in Muden and Centocow did not oppose the model's rejection of peach since they said that orchard farming was not common in their area. All groups were most vocal with regard to the crops that were rejected and less vocal about those that were indicated as suitable. Nevertheless, all groups said that it was useful to have a list that could be used as a guide to provide possibilities rather than planting only what was common. This may provide new opportunities and new markets for farmers provided that the required support is available. Farmers were most intrigued by the suitability of uncommon crops, such as herbs. All of the farmers groups said that the provision of supplementary irrigation would make the list of suitable crops even longer. They all placed great emphasis on irrigation as a key factor in improving the natural suitability of an area. The farmers in Mbumbulu further stated that they farmed only the *amadumbe*, sweetpotato and potatoes as these crops have adapted to rain-fed agriculture and seemed to do well. An introduction of new crops would demand supplementary irrigation and would mean new challenges in terms of agronomic knowledge, including crop rotation, natural disease and pest control mechanisms.

All three groups indicated strongly that they faced a shortage of animals and were doubtful that they would meet the manure requirements indicated by the model. Even if the farmers had enough animals to produce the manure, it was stated earlier that they would face limitations regarding how much manure could be applied. In certified organic farming, manure usage must be controlled due to possible problems with excess nitrogen (European Union Organic Standards, 2004). This limitation poses an important element for smallholder farmers to consider in organic farming. Farmers who are interested in certified organic farming are therefore compelled to have compost-making skills, ensuring permitted fertiliser inputs, which include plant material.

CHAPTER 7: SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

7.1 Summary

Despite the success of conventional farming, there is evidence that conventional agriculture has been detrimental to the environment and there is a need to find more sustainable ways of farming. One of the systems viewed as environmentally sustainable is organic farming which has had some success in other parts of the world. Organic farming is also often promoted as a suitable farming system for smallholder farmers in Africa for cultural factors, similarities in production, enhancing indigenous knowledge systems and profit opportunities. Despite the success of organic farming in other parts of the world, it is not known if the same success and sustainability can be experienced in the context of smallholder farming in South Africa. Given the serious shortage and requirements of manure in South Africa for smallholder farmers, technologies such as composting and essential microorganisms (EM) are possible solutions that should be investigated for the current situation.

There are many uncertainties with regard to production techniques, choices of crops, pest and disease control and markets that make decision-making in organic production difficult for smallholder farmers. Although there is great value in comparing organic and conventional productions for rural farmers in developing countries to establish the merits of each production system, this was not within the scope of this study. This study focused on evaluating the potential for organic production based on agro-ecological suitability and nutritional needs through the development of a decision support tool that would assist farmers to address the following sub-problems and they are:

Sub-problem 1 What crops can be grown organically in the three chosen areas based on climatic data?

Sub-problem 2 Do farmers concur that these are the most suitable potential organic crops?

Sub-problem 3 How useful do the farmers find the decision making tool?

Sub-problem 4 What constraints threaten commercial production of the identified crops for these farmers?

Initial interaction between the researcher and the members of EFO indicated a need for organic production information decisions on crop choices. Two additional groups were included in the study to provide a comparison. Force Field Analyses were conducted with the groups to identify and prioritise organic production constraints. The tool's focus was to ensure that prioritised production constraints were solved. The desired outputs are also the study's sub-problems. Participatory focus group discussions were conducted to determine the need for and usefulness of desired model outputs.

Primary agro-ecological data was loaded onto an Excel spreadsheet for each study area. Mathematical calibrations and computations were used in the development of the decision support tool. Due to the trans-disciplinary nature of the study, a panel of experts verified the model data input, outputs and the approach of the study, which reduced information gaps and minimised errors. The tool's user-interface was developed during participatory engagement with farmers. The final tool was presented to the farmers' groups, who critiqued and provided suggestions for improvement. The first sub-problem investigated which crops could be grown, (based on climatic data) according to the decision support tool at the three study locations. Minimum criteria for crop growth, which included agro-ecological area rainfall, photoperiod, the number of rainy days and crop minimum temperature requirements, were used to identify the potential crops. Four crops in Muden, including *amadumbe*, lemon, peach and mint, were deemed unsuitable due to their high water requirements and short rainy periods that were unable to sustain the crop cycle. Only *amadumbe* and peach were rejected by the model for the Centocow area. *Amadumbe* was rejected by the model in all three areas due to its high water requirement of an absolute minimum of 1000mm. However, evidence shows that *amadumbe* is grown widely in Mbumbulu. The rejection was based on a small difference (44mm) in the water requirement compared with the rainfall figures. This is evidence that the model's basis of information may need to be broadened with a wider range of data.

The second sub-problem investigated whether the identified crops could be grown organically using manure as the only source of soil nutrition. Organic farming prohibits the use of agrochemicals (inorganic fertilisers, pesticides, etc). Therefore it was important to establish what the risk of this factor was for smallholder farmers. Nitrogen, phosphorous and potassium nutrient removal norms for optimum growth were used to compare nutrient concentration in pen manure versus commercial fertiliser. As expected, commercial fertiliser had much higher concentrations of nutrients compared to pen manure. Due to the fact that pen manure is the main source of nutrients for smallholder farmers, they would require an impossibly large amount of pen manure to meet crop nutrient needs. Soils were already depleted of nutrients, which exacerbates the situation. Continued cultivation and introduction of new crops with different and/or higher nutrient needs is not advised without taking corrective strategies such as composting and EM to improve soil health. Therefore, organic production would be very restricted based on shortages of manure and extremely high volumes of manure required to meet basic crop nutritional needs.

The risk of disease onset was highest for organic farming during periods of high moisture (rainfall). However, farmers could not avoid farming during this period as they all depend largely on rainfall for irrigation. Farmers would therefore battle with disease control during this period. All three groups faced the added risk of losing crops due to diseases because they lacked knowledge and skills needed for natural disease control. As certified organic farmers, EFO does not have the option of using agrochemicals when the threat of disease is heightened. A lack of knowledge in natural pest and disease control is a serious added risk for EFO.

Although there was an instance of disagreement with regards to the fact that *amadumbe* can grow in Mbumbulu, farmers appreciated the tool. However this disagreement demonstrated that, the model was precise in providing answers through the use of single and absolute crop growth values as opposed to using a range of values. The disagreement on *amadumbe* also demonstrated the farmers understood that rainfall varied and was not absolute, demonstrating that farmers' knowledge is just as important as scientific tools.

In addition to identified production-related constraints in the potential for organic production among smallholder farmers in the three groups studied, the commercialisation of smallholder organic farming is threatened by lack of: fencing; adequate irrigation; knowledge and skills; trained and adequate extension services;

illiteracy; and, an enabling organic policy environment. Until smallholder farmers are able to overcome most of these constraints, without total dependence on external agents, successful organic production will remain an unreachable dream.

7.2 Conclusions

Many traditional research studies with a component of marketable products are concluded at the product development stage. This study involved farmers in the identification and analysis of production constraints. The study went further to respond to the identified constraints by developing a practical tool. The tool was tested by the participants who were involved in its conceptualisation and validation. Farmers found the tool useful.

It can be concluded that, although a number of agronomically-suitable crops grow in the study areas, organic production is restricted by manure shortages, lack of compost-making skills and soil depletion. Organic production of agronomically-suitable crops is further threatened by an environment conducive to crop disease during the rainy seasons and non-production related constraints that are critical in providing an enabling environment for smallholder farming.

The participatory research process followed in this study included using science to extend ideas into practical tools, to use as informed by the intended users. The participatory research methodology involving the researcher, farmers and experts in a multidisciplinary study of this nature is critical for research that is aimed at providing practical solutions in development.

7.3 Recommendations

Recommendations related to development of the decision support tool include the use of a range of values instead of only absolute and mean crop growth values would be more appropriate so that different yield scenarios can be available to the user. Other factors that contribute to moisture levels could be included to predict disease occurrence subject to data availability. Recommendations for the improvement of the tool include full development of the user-interface into a proper field tool that extension staff can carry to the field to assist farmers in making decisions although this may cost a lot of money. Without interfering with the processes involved in the model development, the Excel spreadsheet should be developed to a higher level of sophistication so that the user sees the user-interface and output separately.

Ways to address the non-production related constraints to commercialisation of smallholder organic and conventional farming are required. The provision of essential resources, such as fencing, is recommended for all farmers. This could be achieved through current capital project funding aimed at smallholder farmers through joint projects with Departments of Agriculture and local Municipalities. The involvement of the private sector, such as commercial farmers, financial institutions, corporate social foundations, produce markets and retailers is important since the Government cannot perform this task alone. Organic farming is a knowledge intensive production system. Farmers require support with regard to production knowledge and continued updating of this knowledge when new crops are introduced and when pests and diseases are a threat. Appropriately trained extension personnel, plus knowledge and information-sharing with other smallholder farmers are important elements that can be facilitated at a local level.

The growth of organic farming in South Africa and in Africa requires intensive training to capacitate farmers' new production knowledge that replaces synthetic input driven agriculture. Information gathering and building on local knowledge systems is important for productivity. Information sharing could be linked to innovative rural information technology centres such as those used in rural India. Such centres can house the study's model coupled with other relevant information needs that rural communities need. South Africa has multipurpose centres in rural communities which can be used for this purpose.

The lack of policy on organic farming has far-reaching effects locally and internationally (e.g. export) for South Africans and the organic farming industry. Locally, established policy can facilitate organic farming training and extension support to provide the critical skills-base required. The lack of a conducive policy environment in South Africa is a major hindrance for aspirant new smallholder farmers who want to enter certified organic farming and for established commercial farmers who may want to convert to organic farming. The lack of advisory support for new entrants can be a deterrent. The lack of organic farming policy relating to inspection fees in South Africa has led to inconsistent inspection charges, leading to farmers being charged exorbitantly by unregulated private companies.

Recommendations for future research include a comparative study between organic farming and conventional farming merits (including economical viability) in the context of the current smallholder farming situation in South Africa is critical. Such a study can inform policy related to advocacy and promotion of each production system. In addition, investigation into and documentation of organic farming knowledge (production, soil health improvement and processing) in South Africa, to establish what is known so that improvements can be based on this information. The impact of organic farming on local rural economies versus conventional farming is worth further investigation. Once the merits of each system are ascertained, further research is required to establish ways of improving local organic food demand, while maintaining an enabling environment for those interested in exporting. Due to the fact that organic farming is a niche market, efforts to enter into this industry should be supported by all relevant stakeholders, such as government, financial institutions, researchers, retailers and media. Existing programmes for smallholder farmers, such as those housed by the Land Bank and Khula Enterprise, need to be more accessible to smallholder farmers. However, external support by government and private sector partners should be carefully planned to include farmer empowerment to aid future sustainability of assisted farmers.

Future improvement of the tool may include an adaptation of the tool to factor in conventional crop nutrition elements. Some work in this regard has already been done in the thesis, although the decision support tool is not developed to provide conventional nutrition output. The study has created a table that compares the strength of commercial fertiliser and manure. Further development of the tool could also include advice on optimal combinations of manure and commercial fertiliser, depending on farmers manure volumes and crop choices.

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