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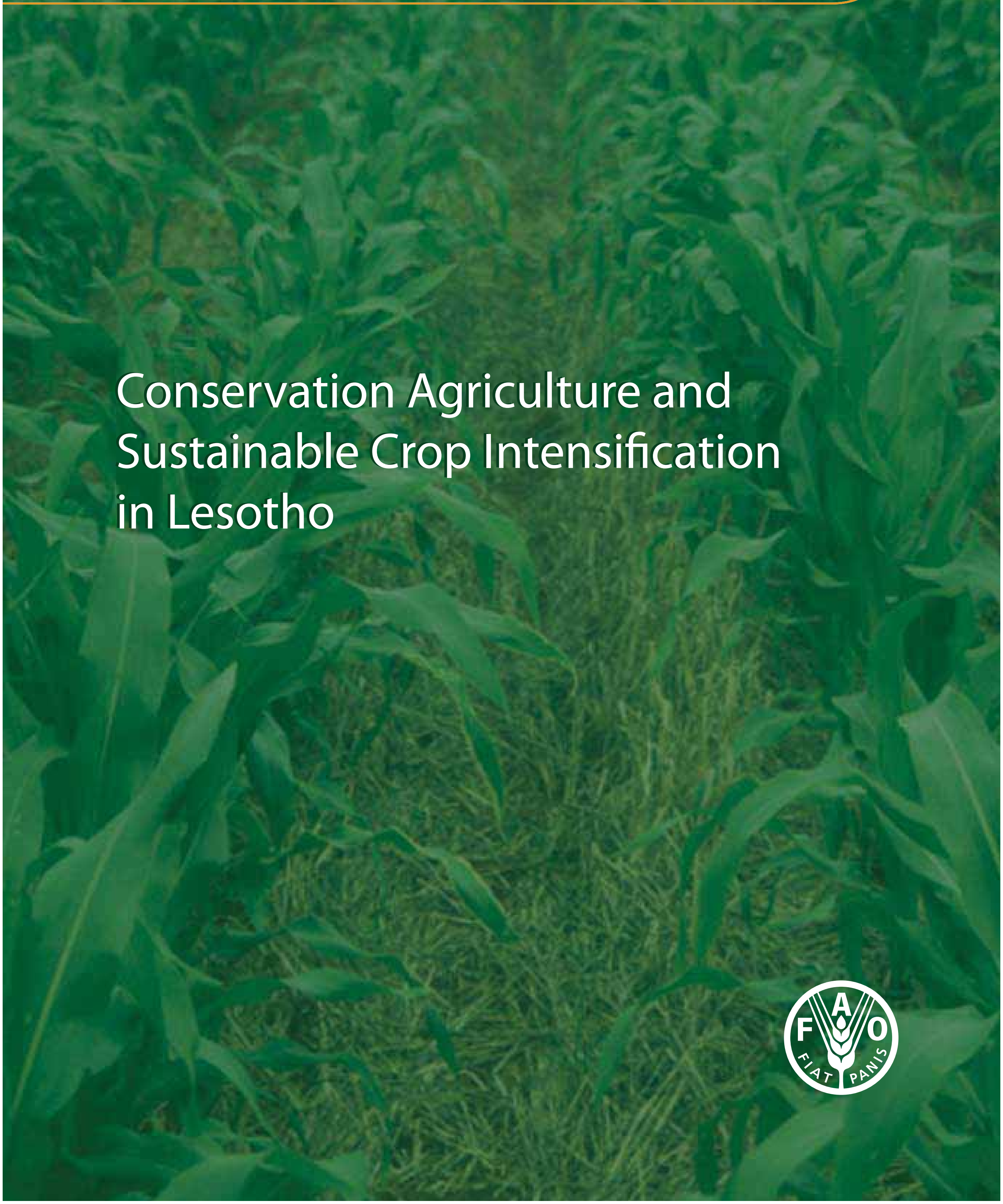

Conservation Agriculture and Sustainable Crop Intensification in Lesotho

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Conservation Agriculture and Sustainable Crop Intensification in Lesotho

Laura Silici
University of Roma Tre, Rome, Italy

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FOREWORD

Lesotho is a small mountainous country characterized by extensive land degradation and erratic climatic conditions. It has a population of 2 million people of whom 68% live below the poverty line. The country is beset with high unemployment rates, rapid spread of HIV/AIDS and low standards of food and nutrition security. This complex interaction of socio-economic factors and environmental constraints has dramatically affected agricultural productivity – maize yields have fallen from an average 1,400 kg/ha in the mid-Seventies to a current 450-500 kg/ha in most of the districts.

In recent years a growing number of development agencies have been promoting conservation agriculture (CA) as a means to enhance rural livelihoods through sustainable production intensification. Amongst several initiatives, the CA-based practice that so far has shown the highest potential is a planting basin system, locally called *likoti* (a Sesotho word for "holes"), mostly employed by subsistence farmers in the production of maize and beans. WFP alone estimates that so far about 5,000 households have adopted *likoti* with its support in different districts, covering about 8,163 ha of land under CA (or 2.5% of the total arable land). However, these figures do not include the farmers who have adopted the *likoti* practice with the support of other organizations as well as those who have adopted the practice on their own accord.

Present case study prepared under the AGP's Framework for Sustainable Crop Production Intensification draws on the data collected by FAO in 2006 and illustrates the impact of *likoti* on sustainable crop intensification in the south-eastern highlands of Qacha's Nek district and in the western lowlands of Butha-Buthe and Berea. According to these data, the adoption of *likoti* has brought about significant advantages compared to conventional tillage. The most important are:

(i) Higher agricultural productivity, due to improved efficiency in the use of inputs and other resources.
(ii) Greater environmental sustainability, due to improved soil structure and enhanced fertility.
(iii) Improved livelihoods and social sustainability, due to the accessibility to the technology by all social categories, including the most vulnerable.

The adopters of *likoti* – including the poorest – have thus been able to rehabilitate and strengthen their livelihood capital base, thereby supporting their communities to build system resilience in the face of widespread poverty and increasing vulnerability that affect the country.

Indeed, as this case study shows, the suitability of CA for bringing about improvement in productivity and livelihoods in the different social and economic conditions, even the poorest, is one of the most important benefits associated with its adoption. As one farmer well put it, the main advantage of *likoti* is just that "*Everybody can do it*".

Shivaji Pandey
Director
Plant Production and Protection Division
Agriculture and Consumer Protection Department

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Special thanks go to Pasquale De Muro (University of Roma Tre), Stephen Turner (CIS, Vrije Universiteit), Amir Kassam (FAO) and Theodor Friedrich (FAO) for supervising the work and for their valuable comments and suggestions.

This case study would not have been possible without the goodwill and the benevolent support of the farmers who patiently answered the questionnaire, and shared with us their precious knowledge and experience.

ABBREVIATIONS AND ACRONYMS

AFM	Apostolic Faith Mission
AIM	Africa Inland Mission
AIS	Agricultural Innovation Systems
BOS	Bureau of Statistics of Lesotho
CA	Conservation Agriculture
CFNG	Conservation Farming Network Group
DFID	UK Department for International Development
EIU	Economist Intelligence Unit
FAO	Food and Agriculture Organization
FCS	Food Consumption Score
FFSSA	Forum for Food Security in Southern Africa
FFW	Food for Work
IFAD	International Fund for Agricultural Development
LASR	Lesotho Agricultural Situation Report
MAFS	Ministry of Agriculture and Food Security of Lesotho
NGO	Non Governmental Organization
SARB	South African Reserve Bank
SSA	Sub-Saharan Africa
SWC	Soil and Water Conservation
UNAIDS	The United Nations Joint Programme on HIV/AIDS
UNDP	United Nations Development Programme
WFP	Word Food Programme

CURRENCY EQUIVALENTS
Currency Unit = Maloti
US$1.00 = M7.3687 (exchange rate effective December 5th, 2009. Source: SARB)

WEIGHTS AND MEASURES
Metric System

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CHAPTER 1
Introduction

In recent years, the spread of conservation agriculture (CA) has revealed to be a sustainable way to intensify crop production and sustain rural livelihoods in several African countries. Indeed, the potential benefits associated with the use of conservation farming practices are many. Long-term yield increase and output stability can be achieved while at the same time stopping and reversing land degradation. Larger outputs are often obtained by employing relatively fewer inputs, thereby reducing costs. Compared to conventional tillage methods, CA thus leads to higher net profitability, greater environmental sustainability and – especially important in Africa – higher food security. Furthermore, conservation farming techniques which rationalize the use of labour are particularly helpful in those rural areas where migration and health emergencies have reduced the labour supply and contributed to the increasing "feminization" of the agricultural sector (a comprehensive discussion of the advantages and disadvantages associated with the use of conservation agriculture in Africa is provided in Annex I).

The present case study reviews and analyses the information collected under a baseline survey, undertaken in Lesotho with the aim to assess the potential costs and benefits associated with the adoption of a planting basins system, locally called *likoti*. The study's main objective is to illustrate the impact of CA on crop production intensification, with a special emphasis given to aspects of sustainability such as social, economic and environmental.

The following section introduces the socio-economic context of Lesotho and stresses the close interdependency between increasing vulnerability and progressive environmental degradation. Section three describes the process through which CA practices have spread in the country. Section four outlines the case study. It provides a technical description of the farming practice and reviews the main characteristics of the surveyed sites and of the sample population. Section five analyses the results of the survey and assesses the impact of *likoti* on crop production intensification with a special focus on the social and the environmental sustainability. The last section synthesises the findings and discusses the lessons learnt on the factors that so far have been mostly determinant to the successful adoption of CA, as well as on the issues that would be worthy of more careful consideration in order to fully exploit the potential of CA in Lesotho.

CHAPTER 2

Lesotho: a Context of Growing Vulnerability

Lesotho is a small, landlocked country of about two million people, of whom 76% are rural[1]. With a GDP per capita estimated at US$1,541 in 2007[2] and 68% of the population living below the national poverty line (UNDP, 2009), it is one of the world's poorest countries. Its economy is based on limited agricultural and pastoral production, light manufacturing (led by export-oriented garment factories owned by East Asian investors) and remittances from migrant labour (albeit declining compared to the past).

Even though social indicators are generally better than the Sub-Saharan Africa (SSA) average, in 2009 the United Nations Development Programme (UNDP) ranked Lesotho as 156th out of 182 countries based on its Human Development Index, and as 106th out of 135 countries based on its Human Poverty Index. The delivery of social services is extremely weak: health personnel are in short supply, health centres are not adequately equipped, and schools lack teaching materials. Over the last ten years, a major health problem has been the increasing spread of HIV/AIDS. According to UNAIDS, in 2008 23.2% of the population aged 15-49 was infected, one of the highest figures in SSA[3].

The spread of HIV/AIDS, along with high unemployment rates, mainly due to the retrenchment of many Basotho miners[4], are among the most important causes of poverty and vulnerability. Along with the migration towards urban and peri-urban areas, and the absorption of many young female workers by the textile industries, these trends are affecting the traditional social structures within the household and at village level. As a result, the social protection mechanisms which so far have helped the Basotho people cope with shocks and stresses are in decline. At the same time, public welfare policies have failed to take over these tasks (Turner, 2005).

1 Lesotho BOS, 2006. *Lesotho Census of Population and Housing, 2006*

2 According to the EIU (2005), since 2003 GDP has substantially risen, but the increase has been the result of the appreciation of the rand against the US dollar, rather than a decrease in poverty levels.

3 UNAIDS/WHO/UNICEF Epidemiological Fact Sheets, 2008 Update

4 Since the end of the 19th century, South African mines have been the main source of employment for Lesotho's labour force, absorbing about 80% of Basotho migrants. In recent years, however, the number of workers engaged in this activity has fallen dramatically (from a high of 127,000 in 1989 to only 62,000 in mid-2004) (Hassan and Ojo, 2002; EIU, 2005).

The economic and social transformations described above occur in a risk prone environment, where the scarcity of natural resources, especially fertile land, is at the same time a cause and a consequence of poverty. Lesotho's ecology is fragile because of its mountainous topography (it lies on a high plateau that rises from 1,500 metres in the west to 3,350 metres in the east), the thin soil layer and the limited vegetative cover[5] (EIU, 2005). Under such unfavourable conditions, the high pressure of human and livestock activities on the land has led to major environmental problems. Forests, as well as pastures, are progressively disappearing. At the same time, the impressive extent of soil erosion increases river siltation and gully erosion[6] (Figure 1 and 2).

FIGURE 1
Soil erosion in a ploughed field

FIGURE 2
Gully erosion

[5] FAO (2003) estimates that in Lesotho the land area covered with forests is of 14,000 ha, or the 0.5% of the total land area (3,035,000 ha). On average, in Africa forests cover 22% of the land area.

[6] According to the Government of Lesotho, in 1988 there were about 6,800 *dongas* (the South African expression for gullies) covering an area of some 60,000 ha and representing a loss of 0.7 tons of soil per annum. (GOL, 1988)

Naturally acid soils with poor contents of phosphorus and organic matter, along with land degradation and extreme climate conditions, have steadily reduced the potential agricultural output. The sector's share of GDP has fallen from 50% to about 15% since the mid-seventies, while yields have fallen by about two-thirds during the same period (EIU, 2005). The agricultural potential is limited not only by the scarce availability of fertile land and by external shocks, but also by the social and economic transformations which are limiting the access to physical as well as social assets.

As highlighted by Boehm (2003), farming in Lesotho is "an activity characterised by a high level of sociality". Since very few farmers own all the necessary assets and means of production, Basotho depend on various forms of co-operation and sharecropping agreements (*seahlolo* or *lihalefote*). In order to successfully achieve these agreements, farmers need to use a number of "social skills", including trust, reliability and reciprocity. In other words, they need to rely on social capital. But, as has been already mentioned, social capital in Lesotho has been increasingly affected by unemployment, the associated increase in income poverty, and the spread of HIV/AIDS. All these factors limit the effectiveness of social assets and sharing mechanisms, thereby affecting the capability to sharecrop and ultimately to farm. Indeed, an assessment of the food security situation undertaken by the Forum for Food Security in Southern Africa (FFSSA, 2004), found that the recent food crises[7] stemmed only partially from crop failures and adverse weather conditions. Rather they reflect long-term, latent food insecurity, in turn caused by poverty (lack of physical assets), deteriorating social capital, and negative social and economic trends due to migrations, retrenchments, and the HIV/AIDS pandemic (FFSSA, 2004).

All the problems mentioned so far are exacerbated by poor governance and inefficient governing institutions. Even though corruption remains low compared to other African countries (EIU, 2005), poor law enforcement, insecure property rights, inadequate delivery of public services, and inadequate local government (including problematic integration of traditional and modern institutions), slow down economic growth and development, and discourage people's participation in civic and political life (Hassan and Ojo, 2002; Turner, 2005). As a result, Basotho live in a context of growing vulnerability, reflected in increasing poverty and inequality, deteriorating health conditions (including low standards of food and nutrition security), and increasing exposure to external shocks and changing climatic conditions (Figure 3).

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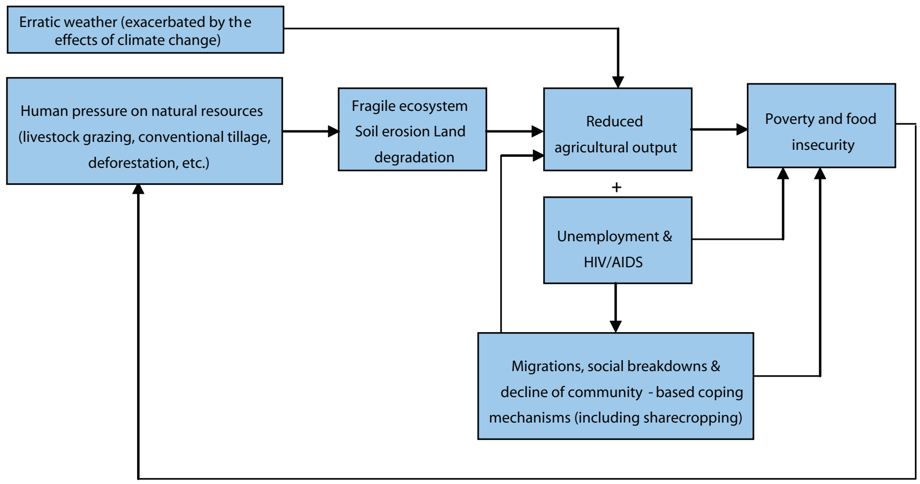
[7] Since 2001, recurrent droughts have lead the government and international donors to set up emergency food relief programmes. After the 2001/2002 food crisis, a state of famine was newly declared in February 2004, when FAO and WFP estimated that about half of the population needed food assistance. Again, in 2007, between 400,000 and 550,000 people were affected by food shortages, according to FAO/WFP estimates.

FIGURE 3

Complex relationships between socio-economic factors and environmental constraints affect living standards in Lesotho

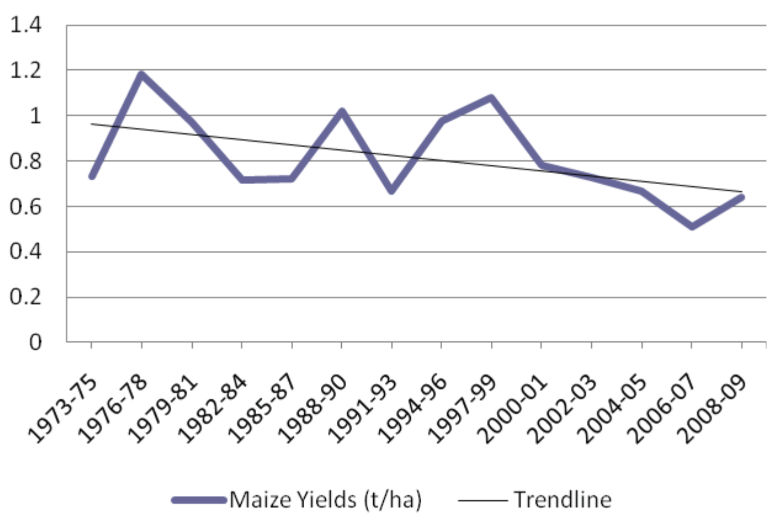


CHAPTER 3

The Diffusion of Conservation Agriculture as an Innovative Process to Cope with Vulnerability and Food Insecurity

In Lesotho, agriculture consists primarily of maize and (to a much lesser extent) wheat mono-cropping. In spite of abundant and irregular rains, rainwater harvesting methods are rarely practised (Gay and Hall, 2002). Agricultural productivity is highly variable (especially due to erratic precipitations), and it has steadily declined over the latest 30 years – maize yields have fallen from an average 1,200 Kg per hectare in the mid 1970s to a current 450-500 Kg per hectare in most of the districts (Figure 4). Nonetheless, agriculture remains a source of livelihood for the vast majority of the population, most of which is engaged in subsistence farming.

FIGURE 4
Maize yields trends (t/ha), 1973-2009



Source: Authors' elaboration on FAOSTAT and FAO/GIEWS data

In spite of recent attempts to strengthen the involvement of the private sector and encourage diversification into high-value export products (such as the Agricultural Sector Adjustment Programme assisted by the African Development Bank in 2000) progress has been limited by the poor prospects of profit as well as by ineffective agricultural development policies. The livestock sector provides a significant proportion of rural income (usually for better-off households) and is well integrated in the national and the regional economy through the export of wool and mohair. However, the importance of livestock has also started to decline due to the recurrent droughts, poor animal quality and inadequate disease control.

The potential opportunities for the agricultural sector to develop and contribute to the country's economic growth are contested. This is in part due to contradictory figures on agricultural production (in the latest seasons, estimates of the cereal gap varied by over 300% depending on the source). Whatever the precise data, it is hardly contestable that agricultural production is in sharp decline. Shortage of arable land, mainly due to land degradation, and erratic climate are commonly mentioned as the most determinant factors. However, these problems have affected the country since it was a British protectorate in the nineteenth century. Therefore, it is most likely that the main causes of this decline depend on the farmers' limited or inadequate capability to deal with and adapt to the environmental conditions.

The abandonment of the fields by migrant workers, and the consequent scarce investments, have limited the adoption of products and technologies suitable to the local conditions, and ultimately hampered the growth of productivity. At the same time, the use of conventional tillage methods and of intensive agricultural practices, often promoted by development assistance programmes, have contributed to increased land degradation and lower soil fertility. More recently, the poor performance of agriculture has been linked also to the high rates of poverty and vulnerability (discussed above) which affect the economic as well as the social capabilities needed to farm. Finally, in some cases, poor crop production has been the paradoxical outcome of policies aimed at encouraging food production – such as subsidies and emergency interventions – which resulted in late plantings or disincentives to plant.

Of course, none of these factors, alone, is the unique or main cause of the dramatic decline of yields and output. A complex combination of interrelated factors has contributed to the current situation. With regard to the future, some see the agricultural sector as a disaster, while others recognise the potential for increasing agricultural productivity and stress the role of agriculture in combating poverty and enhancing food security (Gay and Hall, 2002; FFSSA, 2004). Those who support the potential role of agriculture in development recognise the need to face – and overcome – several challenges. Among the most important of these is the need to foster agricultural development through the promotion of more sustainable, ecologically friendly practices, such as soil and water conservation, reclamation of limited areas of degraded land for intensive food production, and mixed and low external input farming (Gay and Hall, 2002; Turner, 2001).

Even if, at least in the medium term, it seems unlikely that agriculture will be the driver of economic growth and provide significant numbers of jobs, proper policy options and interventions aiming at enhancing the availability of food could stimulate local agricultural markets, and contribute to creating employment and increasing wage rates through higher productivity (FFSSA, 2004). In order to boost agricultural yields and stabilize outputs, however, appropriate solutions should especially focus on environmental as well as social sustainability. In fact, in such a risk prone natural environment, conventional tillage methods impose a severe stress to the soil and decrease crop productivity. Furthermore, practices which rely on expensive purchased inputs and mechanical implements increase farmers' vulnerability to external shocks. On the other hand, conservation agriculture (CA) can provide an effective solution to reversing the spiral of declining productivity caused by land degradation and extreme environmental conditions. In addition, some CA practices are particularly suitable to small-scale and poor resource farmers (see Box 1 for a brief introduction to CA and Annex I for a comprehensive discussion of the advantages and disadvantages associated with the adoption of CA in Africa).

BOX 1 **Conservation Agriculture in brief**

CA is a concept for resource-saving agricultural crop production that strives to achieve acceptable profits together with high and sustained production levels while concurrently conserving the environment. CA is based on enhancing natural biological processes above and below the ground. Interventions such as mechanical soil tillage are reduced to an absolute minimum, and the use of external inputs such as agrochemicals and nutrients of mineral or organic origin are applied at an optimum level and in a way and quantity that does not interfere with, or disrupt, the biological processes. CA is characterized by three principles which are linked to each other, namely:

1. Continuous minimum mechanical soil disturbance (i.e. no tilling and direct planting of crop seeds).
2. Permanent organic soil cover.
3. Diversification of crop species grown in sequence and associations

It has generally been demonstrated that CA allows yields to increase while improving soil and water conservation and reducing production costs (FAO, 2001. *The economics of conservation agriculture*; Kassam et al., 2009). In addition, CA has been shown to work successfully in a variety of agro-ecological zones and farm sizes. Indeed, further advantage associated with CA is that it can be applied to different farming systems, with different combinations of crops, sources of power and production inputs.

Based on: www.fao.org/ag/ca

Since 2000, a growing number of local and international actors – including, among the others, the Food and Agricultural Organization (FAO), the World Food Programme (WFP), the National University of Lesotho (NUL) and several NGOs – have started to promote conservation agriculture in Lesotho. The adoption of conservation farming as a strategic means to increase and stabilise agricultural production as well as to prevent and reverse soil erosion has been explicitly mentioned in the *Lesotho Food Security Policy and Strategic Guidelines* (Ministry of Agriculture and Food Security (MAFS), 2005) and in 2006 the FAO Representation in Lesotho launched a Conservation Farming Network Group (CFNG) to encourage the adoption of water and soil conservation technologies, facilitate the exchange of knowledge among different actors and provide them with updated information about the CA practices that were promoted in the country and the associated outcomes.

According to the information collected through the CFNG[8], several different CA practices have been implemented in Lesotho in the latest years. Between 2005 and 2006, the MAFS set up field trials to support the adoption of animal and tractor-drawn no-till planters under "block farming" agreements, while FAO organized training and demonstration sessions to teach farmers to use simple no-till equipment such as jab-planters[9]. Furthermore, some NGOs were committed to (re)introduce sustainable agricultural practices such as the Machobane Farming System.[10] However, all these efforts have achieved mixed results. The conservation farming practice that so far has shown the highest potential is a planting basin system, locally called *likoti*.[11] The practice was introduced in Lesotho mainly due to the commitment of two Christian organisations: a local association called Growing Nations, supported by Africa Inland Mission (AIM), and Rehoboth Christian Church. Up to today, *likoti* has been by far the conservation technique most adopted countrywide and the reason of this success largely lies on the inspiration and motivation of its promoters.

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[8] The information was synthesised in a "CA Map" which is available for consultation at FAO Representation Lesotho (tel: +266 22315585, e-mail: FAO-LSO@fao.org)

[9] No-till machineries are more suitable for commercial oriented production while jab-planters – simple devices operated by hand that place a controlled number of seeds and amount of fertilizer directly into the soil – are meant for smallholder farmers.

[10] The Machobane Farming System is an intensive cropping system developed by James Machobane during the 1950s, using crop rotation, relay cropping, and specific inter-cropping practices. It follows some of the principles of CA such as mulching, crop rotation and inter-cropping though still encourages farmers to till the soil using techniques as double digging and ploughing every fifth year.

[11] Since the Nineties, planting pits have been successfully used in many African countries. They are known as *tassa* in Mali, *zai* in Burkina Faso, *demi-lune* in Niger, *potholing* in Zambia, and *matengo* pit system in Tanzania.

CHAPTER 4

Introduction to the Case Study: the Practice of Likoti

4.1 ORIGINS AND SPREAD OF THE TECHNIQUE

Rev. August Basson is an AIM missionary who moved with his family to the harsh mountainous area of Tebellong, in Qacha's Nek district, in 1993. For many years, he was trying to improve local agriculture by investing donors' money in tractors, greenhouses, and inputs, but the yields never repaid his investments. Furthermore, most Basotho people could not have afforded such equipment. The Pastor then switched to testing farming practices that relied on low external inputs, which were more suitable to the local socio-economic conditions. He also realized that the tillage methods that were in use in Lesotho were exacerbating soil erosion and land degradation. Eventually, in 2000, Rev. Basson went to South Africa to learn more about conservation agriculture.

Back to Lesotho, he developed a planting basins system adapted to the local conditions and started to promote it with a Sesotho name, *likoti*, which means "holes". According to the *likoti* method, pits are about 15x30cm large in diameter and 15-20cm deep (or smaller), and they are dug in a 75x75cm grid (Figure 5 and Figure 6). A small quantity of fertilizer (either inorganic or organic) and seeds (the number depends on the desired crop density) are placed in each basin and covered with soil. Additionally, farmers should leave crop residues on the field as mulch and practise crop rotation and inter-cropping. The next season farmers can plant in the same pits without turning the soil up. The *Likoti* method was originally deployed in the production of maize and beans. However, innovative farmers have used it also to produce other crops such as sunflowers, sorghum, potato and tomato.

FIGURE 5
Two farmers digging the basins

FIGURE 6
CA trainer covering the soil with mulch

In order to diffuse the conservation farming technique, Rev. Basson founded a Lesotho based charity, Growing Nations. He hired fields to set up demonstration plots and organized several training sessions. It took a couple of years for the first group of *likoti* farmers to become confident with the new practice. In the meanwhile, Pastor John Mokoena and Rev. Pete West, from Rehoboth Christian Church, also started to promote CA in the northern district of Botha-Bothe. In 2001, Brian Oldrieve, a pioneer of the planting basin system in Zimbabwe and other african countries since the Eighties, came to Lesotho to provide training both in Tebellong and Makhoakhoeng. Since 2002, the practice has captured the interest of more NGOs and international organizations, such as German Red Cross, the Food and Agriculture Organization (FAO)[12] and the WFP, that provide different kinds of incentives to farmers who adopt it.

According to the information provided by CFNG members, in 2006 about 500 households were practising likoti in the southern districts of Qacha's Nek, Quthing and Mohale's Hoek, whereas the number of CA farmers in Botha-Bothe and Berea districts, in the northern lowlands, was about 350. Since then, the number of *likoti* farmers has steadily increased. Even though precise figures are not available, WFP alone estimates that so far about 5,000 households – or 1.5% of the rural households – have adopted *likoti* with its support in different districts. Considering that the farmers supported by WFP cultivate on average 1.63 ha of land, currently there are about 8,163 ha of land under conservation agriculture (2.5% of the total arable land). However, these figures do not include the farmers who have adopted the *likoti* practice with the support of other organizations such as Growing Nations and FAO as well as those farmers who have adopted the practice on their own accord.

4.2 SOURCE OF THE DATA, FIELD SURVEY AND METHODOLOGY

The present case study analyses and discusses the information collected in 2006 under an FAO initiative entitled "Monitoring and evaluating the impacts of Conservation Agriculture (CA) in Lesotho: implementation of a comprehensive baseline study comparing conservation and conventional practices at small-scale farming level". The baseline survey was implemented under the FAO project OSRO/LES/503/UK – *Support to vulnerable rural households in Lesotho* – through a working arrangement between FAO Representation in Lesotho, the Department of Economics of the University of Roma Tre (Rome, Italy), the Department of Soil Science & Resource Conservation of the National University of Lesotho (NUL, Roma, Lesotho), and the Faculty of Lifescience of Copenhagen University (Denmark)[13]. The

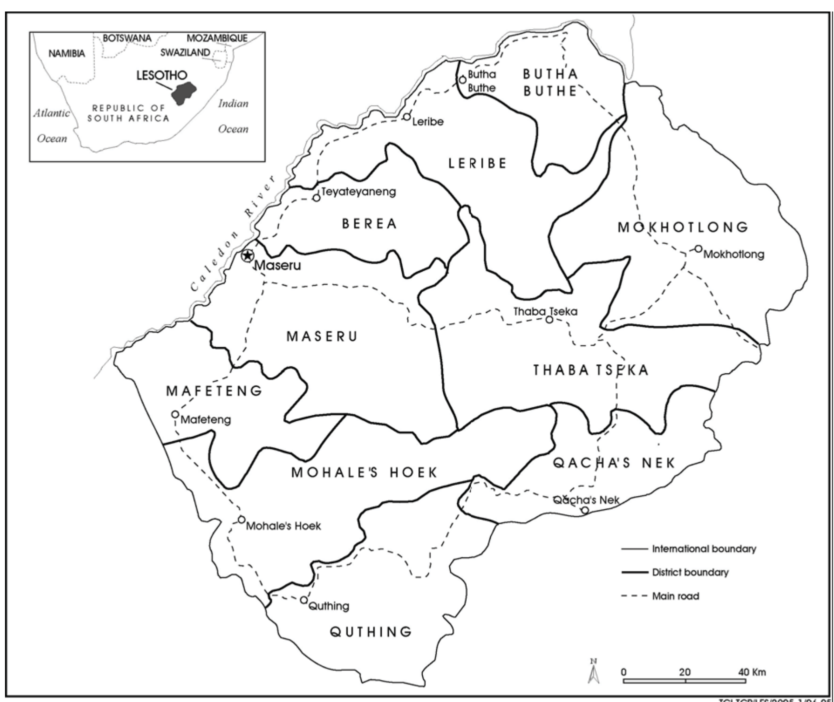
[12] FAO started to promote CA in Africa in 1998 and one of the first contacts was indeed Brian Oldrieve.

[13] The Emergency Programme of FAO Lesotho – headed by Ms. Farayi Zimudzi – was responsible for managing and disbursing the funds and for the overall supervision of the activities implemented under the baseline study. The NUL - Department of Soil Science & Resource Conservation, in the persons of Dr. M.V. Marake and Ms. Botle Mapeshoane, supervised and conducted the soil analysis. The Copenhagen University organized and participated in the field missions by assigning a Master's student in Agricultural Development, Ms. Stine H. Pedersen. Assoc. Prof. Andreas de Neergaard and Dr. Adrian Bolliger supervised the research on the impacts of CA on agricultural production and soil fertility. The Department of Economics of the University of Roma Tre, under the supervision of Prof. Pasquale De Muro, focused on food security issues and the assessment of socio-economic sustainability.

specific objective of the survey was to assess the socio-economic impacts of *likoti* on small-scale farmers, with a special focus on agricultural outputs, food security status, and economic and environmental sustainability.

The baseline study was implemented from January to October 2006. Two sub-sample populations of CA[14] and conventional farmers were monitored through a household survey. The areas included in the survey were: Makhoakhoeng and Ha Mamathe in the western lowlands of Botha-Bothe and Berea districts, respectively, and Tebellong and Tsoelike in Qacha's Nek, in the mountains (Figure 7). The sites were selected from those where CA had been practised for a longer time (at least two agricultural seasons). In total, a sample of 229 farmers (117 CA and 112 conventional) was interviewed in two phases – before and after the harvest. The sub-samples represent a cross section of households in the selected sites. CA farmers were selected randomly amongst those who participated in training or other CA related initiatives (the complete lists were provided by local organizations promoting CA). Conventional farmers were selected partly randomly and partly purposively, in order to compare soil structure and crop yields in 'conservation' and 'conventional' fields.

FIGURE 7
Lesotho Administrative Map



[14] CA farmers were defined as farmers who were practising likoti on at least one of their fields or in a garden.

TABLE 1

Farmers interviewed (by gender of the head of the household) and soil samples tested (by location)

Location	Respondents - *Likoti*			Respondents - Conventional			Soil samples tested	
	FHH	MHH	Total	FHH	MHH	Total	Likoti	Control
Lowlands: Makhoakhoeng (Botha-Bothe) and Ha Mamathe (Berea)	26	33	59	27	32	59	34	27
Mountains: Tebellong and Tsoelike (Qacha's Nek)	18	40	58	13	40	53	38	24
Total	44	73	117	40	72	112	72	51

FHH: Female Headed Household; MHH: Male Headed Household

The questionnaire submitted during the first phase (January to April 2006) was made of five sections: background household information (household composition and wealth status); food availability and food security; farmers' participation in associations and community organization; agricultural production activities; knowledge and perception of CA practices. During this phase, 165 composite soil samples[15] were collected and a random selection of 123 was sent to the Department of Agriculture in Cedara, KwaZulu-Natal, and analysed for soil fertility[16] and soil texture (Table 1). The questionnaire submitted during the second phase included information on: agricultural yields and profitability; food security status; household vulnerability and community cohesion. During this phase, the yields obtained by a smaller sub-sample of farmers were recorded.

The information collected through the questionnaires allowed two datasets to be organised, comprising of about 300 variables on demographic and social features, household composition, wealth, assets, food security, community organization, social capital, agricultural production activities, knowledge and perception of CA and agricultural yields. Part of these data were analysed and the results were discussed in a document prepared for FAO Representation Lesotho and funded by DFID.[17] Subsequently, the author undertook additional analysis under her Ph.D. research with the aim to evaluate whether and how social capital affected the adoption of CA as an innovative agricultural practice in Lesotho.[18] The present case study synthesizes the results achieved in the

[15] Stratified random soil samples were taken on each field to make one composite sample for each field. The soil samples were taken randomly from the field with an auger to a depth of 30 cm, and mixed.

[16] Soil samples were tested for P, K, Ca, Mg, Zn, Cu, Mn, pH, acid saturation, organic carbon and clay.

[17] Silici, L., Pedersen, S.H. and Mapeshoane, B., 2007. *The impact of CA on small-scale and subsistence farmers. The case of likoti in Lesotho.* Report prepared for FAO Representation Lesotho

[18] Silici, L., 2009. The Role of Social Capital in the Adoption and the Performance of Conservation Agriculture. The Practice of Likoti in Lesotho. Ph.D. Dissertation, Department of Economics, Università degli Studi Roma Tre, Rome, Italy

former investigations and further analyses the data in order to illustrate the impact of CA on crop production intensification. Special emphasis is given to aspects of sustainability such as social, economic and environmental.

4.3 CHARACTERISTICS OF THE SURVEYED SITES: LAND AREA AND TOPOGRAPHY

Lesotho is divided into four agro-ecological zones - Lowlands, Foothills, Mountains, and the Senqu River Valley. The Lowlands cover the western part of the country and occupy about 5,200 km^2, or 17% of the total surface area. In spite of its narrow extension, this region supports more than half of the national population, constitutes 70% of the limited arable land, and provides most of the available non-agricultural employment. The Northern lowlands are the most agriculturally productive and receive more reliable rainfall. The Southern Lowlands are generally warmer and dryer. By contrast, the mountainous eastern side of the country is sparsely settled, arable land is scarce and communities are much more isolated from urban services and markets (LVAC, 2006).

Qacha's Nek district is located in the south-eastern highlands (Figure 7). Its land area is 2,349 km^2 of which only 2,000 ha (less than 1% of total land area) are used for crop production (MAFS, 2005). It has approximately 3.7% of the national population with a density of 34 people per km^2 (FAO, 2001c). The chieftainship of Tebellong lies at an elevation of 1,700 to 1,900 m a.s.l. while Tsoelike lies between 1,800 and 2,000 m a.s.l. Both areas are situated on top of the Senqu River Valley escarpment. The average annual rainfall is 800 mm. Summer temperatures range from 18°C to 25°C while the winters are cool (0° to 15°C) with frequent snowfall in July and early September. Crops planted include maize, beans and sorghum. Wheat is mainly grown in the highlands of the district.

Most of the surveyed sites in Botha-Bothe and Berea districts are located in the Northern Lowlands (Figure 7). The land area of Botha-Bothe is 1,767 km^2 of which 7,763 ha (less than 5% of the total land area) is used for crop production (MAFS, 2005). The population accounts for 5.9% of the total Lesotho population (FAO, 2001c) with a population density of approximately 72 people per km^2. Qholaqhoe is the principal village in the Makhoakhoeng area. It lies on the borderline between the lowlands and the foothills of the northern part of the district at elevations between 1,500 and 2,000 m a.s.l. and occupies the upper slope positions of the sandstone escarpment above the Caledon river flood plains. The average annual rainfall is 800 mm with 60% falling during the summer months of December and January. Summer temperatures range from 25°C to 34°C while the winters are cold (-2 to 14°C) with occasional snowfall around June and July. The major crops include cereals – maize and sorghum – beans and potatoes. However, winter precipitation in good years allows for a winter cropping season with wheat and peas as the main crops.

The land area of Berea district is 2,222 km^2 of which 27,158 ha (about 8% of the total land area) is used for crop production (MAFS, 2005). The population accounts for 13.9% of the total Lesotho population and the population density is of 135 people per km^2 (FAO, 2001c). The village of Ha Mamathe is located in the northern lowlands of the district at an elevation ranging from 1,500 to 1,800 m a.s.l. The area is characterized by the same agro-ecological features and climatic conditions present in Botha-Bothe. Maize is by far the most grown crop. Other crops include beans and sorghum.

The consequences of soil erosion and land degradation are clearly visible both in the mountains and the lowlands: overgrazing of range lands, uncontrolled burning and cultivation of steep slopes without the implementation of proper conservation measures have progressively denuded the landscape. In all the surveyed sites, farmers reported to observe a steady decline in their fields' fertility and attributed it to the fragility of the local environment. Indeed, as was mentioned earlier, in Lesotho land degradation (due mainly to the overexploitation of the natural resource base) and chemical soil depletion (loss of organic matter, nutrients and acidification) exacerbate each other in a vicious circle which increasingly exposes the landscape to water and wind erosion.

4.4 CA AT THE SURVEYED SITES

The practice of *likoti* was first introduced in Tebellong in 2000 by Pastor August Basson and his locally based association, Growing Nations. In 2003 FAO started to support Growing Nations in providing seeds and fertilizer to farmers who adopted the practice. In 2005, WFP also started to support the diffusion of conservation farming, by providing Food for Work (FFW) to farmers who attended training and worked in the fields of the 11 local trainers who in the meanwhile had taken over Rev. Basson's duties. A Masotho Pastor, Rev. Rantimo, has been the pioneer of *likoti* in Tsoelike. Just as Rev. Basson has done, Pastor Rantimo started to train farmers elsewhere in the country (in collaboration with Dorcas Aid, a Dutch NGO), while a local trainer, Mr. Isaac Sehahle, took over his duties. Pastor John Mokoena and Rev. Pete West, from Rehoboth Christian Church, started *likoti* in Makhoakhoeng in the cropping season 2001/02. They immediately decided to supply the farmers who joined their training programme with seeds and fertilizers, because most of them lacked production assets and money to buy inputs. In 2006, there were 14 "CA leaders" in Makhoakoheng and Ha Mamathe, each being responsible for a village or an area.

During the survey, two workshops were organized with the local trainers – one in Tebellong and one in Thaba Kholo (Makhoakhoeng) – with the aim of discussing the opportunities and the challenges associated with the diffusion of *likoti*, as well as to better understand their training methodology. In Tebellong and Tsoelike CA trainers use to follow up the training sessions by visiting the farmers on average three times per month and organizing open gatherings if they feel that there is any issue or problem to be discussed. By visiting farmers while they are at work in their fields, and organizing the meetings there, they often capture the interest of the other farmers who are nearby. Apart from teaching the principles of *likoti*, trainers encourage household members to work together, as well as to organize work parties with other farmers. CA leaders in Makhoakoheng and Ha Mamathe go to visit the trainees on average once a month and do not organize regular meetings, although they describe individual interaction as quite constant. Even though they encourage CA farmers to work collectively, work parties are very rare. According to their view, farmers are not cooperative and they do not trust others' commitment.

4.5 CHARACTERISTICS OF THE SAMPLE: SOCIO-ECONOMIC FEATURES

In order to assess the distribution of welfare among the respondents, two indexes were formulated based on the existing literature on livelihood strategies and well-being in Lesotho[19]: an Asset Index and a Capabilities Index. The former measures the endowment with productive assets, which includes livestock, land and other productive means. The index can be considered a proxy of the wealth of the households, even though it does not include other economic resources and monetary earnings. The Capabilities Index is built by synthesizing variables such as the availability of a salary and other formal income sources, the ownership of a tractor, the capability to hire workers through *matsema* (collective wok), the presence of disabled members in the household and the household dependency ratio (calculated as the ratio of household members more than 60 years old and less than 18 to the 19-59 year old members). It measures the household capability to generate welfare. Both indices range between zero and 100, and the respective distributions have been divided into quintiles in order to rank the households as *very poor*, *poor*, *moderate*, *better off* and *rich* (see Annex III for further details).

On the basis of the Assets Index, most of the farmers can be classified as poor. However, the percentage of CA farmers classified as *very poor* (the lowest quintile) and *poor* (the fourth quintile) is higher compared to the conventional farmers (Figure 8). Consistently with these observations, the difference between the average Assets Index of the 'conventional' group (40) and the average Assets Index of the CA group (34.6) is statistically significant at 5% level (t=2.4; $t^{238}_{0.95}$=1.65). It is worthy to note that, within each sub-sample (or farmer category), female headed households (FHH) are less endowed with productive assets (i.e. a higher share is classified as *poor*) compared to male headed households (MHH). The wide majority of farmers can be classified as *poor* also on the basis of the Capabilities Index. About 10% of the FHH and 5% of the MHH in each sub-sample belong to the lowest quintile,

[19] Previous analysis carried out by IFAD, CARE and Sechaba Consultants were taken especially into account.

meaning that they can not generate enough income to achieve minimum living standards (Figure 9). Taking into account the average Capabilities Index for the two farmer groups (41.5 and 39, for the conventional and the CA farmers, respectively), the differences between conventional and CA farmers are still present, although less significant (t=1.35; $t_{0.9}^{238}$=1.28).

These results are consistent with the figures available at national level, according to which the wide majority of Basotho families in rural areas are poor.[20] In relative terms, some households can be considered better off because they rely on some kind of formal income or because they are more endowed with land and livestock. Others, and especially most vulnerable categories (elderly or sick people, orphans, widowed women), rely instead on a reduced or unstable livelihood basis, experiencing a declining welfare and food security status.

FIGURE 8
Endowment with productive assets (asset index), frequency distribution by farmer category and gender

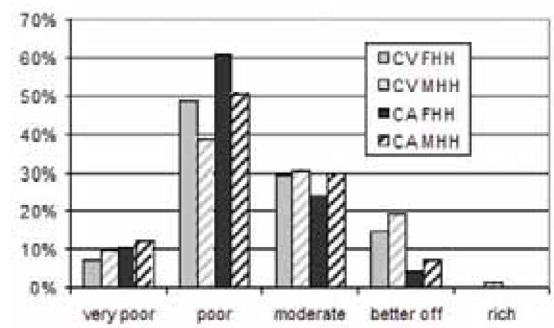
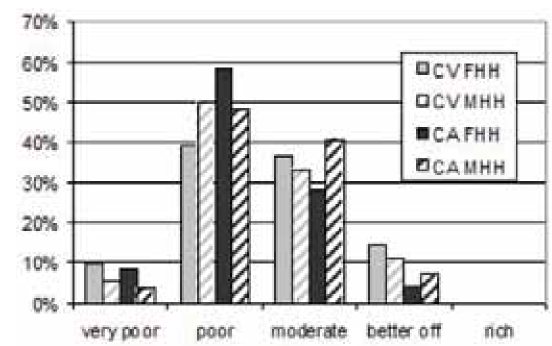


FIGURE 9
Capabilities factors (capability index), frequency distribution by farmer category and gender



In the surveyed sample, most households can be classified as poor, but those practising *likoti*, and especially the female headed households, are even poorer. The presence of vulnerable categories amongst CA farmers is not surprising, since most of the projects promoting CA in Lesotho targeted disadvantaged households.[21] The baseline survey was conducted over a period of six months

[20] Lesotho Bureau of Statistics (BOS), 2002. The Core Welfare Indicator Questionnaire (CWIQ) Survey.

[21] For instance, in the CA sample, 42% of the female respondents aged 36-59 are widows heading a households. Whereas in the conventional sub-sample the share of relatively young widowed women who are left in charge of a family is much smaller (about 20%). Furthermore, female headed households, and especially those from the CA sample, are larger and have a higher average dependency ratio.

during the same agricultural season, so it was not possible to include a dynamic assessment of the impact of CA on farmers' well-being status. However, the fact that most farmers continued to practise *likoti* also after the incentives had ended means that the technology proved to be suitable to their socio-economic conditions.

While physical assets seem not to be a determinant factor for the adoption of CA, literacy and education play an important role. The frequency analysis shows that the share of literate heads of the household plus those who completed the primary school is larger among the CA farmers. It is interesting to notice also that, while the women in the conventional sub-sample have the lowest degrees of education at all levels, the women in the CA sub-sample reported the highest percentage of literacy and accomplishment of primary school among all respondents (Table 2).

TABLE 2
Education of the head of the household, by gender and farmer category, relative frequencies

Education HH	CA FHH	CV FHH	CA MHH	CV MHH	CA Total	CV Total
None	2%	17%	8%	11%	6%	13%
None, read and write	40%	49%	49%	41%	46%	44%
Primary School	44%	20%	22%	27%	30%	24%
Secondary School	13%	15%	17%	18%	16%	17%
High School	0%	0%	3%	1%	2%	1%
University Education	0%	0%	1%	1%	1%	1%
Total	100%	100%	100%	100%	100%	100%

These results confirm a recurrent finding in the literature, i.e. the critical relevance of education to innovation adoption and diffusion. Furthermore, the fact that the women of the CA sample are significantly more educated than the women of the conventional sample[22] suggests that human capital represents a determinant asset, particularly when access to other assets is limited by socio-economic factors or gender bias, as still occurs in Lesotho.

[22] The proportion of literate CA FHH plus those who completed primary education is significantly higher than the proportion of literate CV FHH ($z=1.66$; $z_{0.95}=1.64$) and literate CV MHH ($z=1.98$; $z_{0.95}=1.64$); while there is no statistically significant difference between the proportion of literate CA FHH and the literate CA MHH ($z=1.51$; $z_{0.95}=1.64$), nor between the latter and the CV FHH nor the CV MHH. The test performed aims to assess the significance of the difference between the share of CA FHH having basic education and the respective shares of CA MHH, CV FHH and CV MHH having basic education. The test gives a z variable distributed as a normal standard variable. The relationship between the educational levels of women and the choice to adopt CA is confirmed by the chi square test, performed on the distribution of CA FHH in comparison with the other farmer categories. The chi square test was performed in relation to the attributes: no education, literacy and primary education, on the distribution of CA FHH in comparison with the CV FHH ($\chi2=7.48$; $\chi2;0.975=7.4$), the CV MHH ($\chi2=4.6$; $\chi2;0.9=4.6$) and the CA MHH ($\chi2=5.18$; $\chi2;0.9=4.6$).

CHAPTER 5

The impact of Conservation Agriculture on Sustainable Crop Intensification

5.1 IMPACT ON CROP PRODUCTION

As expected, the interviewees planted mainly maize, sorghum and beans. Most farmers in both sub-samples cultivate one or two fields (including both owned and sharecropped fields), the total land cultivated by CA farmers (0.77 ha) being on average smaller than the land cultivated by the conventional farmers (0.95 ha). So the size of the fields is usually very small and female headed households – both CA and conventional – plant even smaller fields.

Data on the outputs for each crop were collected through the second questionnaire and the yields were calculated in tons of maize/ha using appropriate conversion factors for beans and sorghum.[23] Unfortunately, the quality of the information collected through the questionnaire was extremely low. A part from mistakes and missing answers that could occur due to the different methods farmers used to measure the output, respondents tended to declare smaller yields compared to those they actually got. In order to get a better estimation of the yields, the output was directly measured for a sub-sample of farmers. As a whole, data were recorded from 29 fields in Makhoakhoeng (14 *likoti* and 15 ploughed), 26 being comparable fields (fields located next to each other with similar soil characteristics). In Tebellong and Tsoelike (Qacha's Nek), yield records were collected from 24 CA farmers, whereas it had not been possible to directly measure the yields of the conventional farmers due to logistical and time problems. The visits to the farmers confirmed that, when asked, they often reported a lower output compared to what was then recorded in the store room. This is not surprising taken into account that in the Basotho culture people do not like to talk about their economic resources.

[23] The conversion factors were built by Stine H. Pedersen considering an average of the yields obtained from the growing seasons 94/95 to 03/04, according to the "Lesotho Agricultural Situation Report 2000/01-2003/04" (MAFS, 2005).

TABLE 3

Average maize yields (tons of maize/ha), by location and tillage method

Location	Number of observations		Average yield (t/ha)	
	Likoti	Ploughed	Likoti	Ploughed
Makhoakhoeng	14	15	1.36	0.87
Qacha's Nek	21	-	0.73	0.2*

*WFP and FAO, 2006. Assessment of 2005/2006 Agricultural Production in Lesotho. The WFP/FAO assessment relied on primary data (records collected from 101 farmers throughout the country) as well as secondary data (meetings and data collection from the MAFS and local extension services)

According to the records collected for this sub-sample of farmers, in Makhoakhoeng the maize yields obtained by using *likoti* (1.36 t/ha) were higher than those obtained in the ploughed fields (0.87 t/ha), the difference being statistically significant at the 0.1 level. In Qacha's Nek, CA farmers got about 0.73 t/ha of maize, which is more than three times the district average yield for that growing season – 0.2 t/ha, according to WFP and FAO (Table 3, Figure 10 and Figure 11).

FIGURE 10

Likoti farmer in her sunflower field

The most important difference between the conventional and the conservation farming practices is the tillage method. All the households included in the CA sub-sample planted at least one field using *likoti*. Among the conventional farmers, the wide majority ploughed with animals. Indeed, hiring a tractor to plough may be relatively expensive: according to the prices recorded under the survey, on average a tractor owner charges M494 per hectare. Ploughing with animals does not imply any monetary expense but the

FIGURE 11
Two likoti farmers in a maize field

household needs either to have its own cattle or needs to rely on some assets (land, money to buy inputs, mechanical equipment, and so on) in order to sharecrop with somebody who owns cattle.

Digging planting basins with a hoe is thus cheaper than ploughing, since virtually every household with one or more members capable to farm some land can afford it. On the other hand, the workload required by this planting system is much heavier. CA farmers reported that digging the holes and planting with *likoti* took on average 320 man hours per hectare, compared to 145 man hours/ha usually needed for ploughing and planting with animals. These figures are consistent with the information provided by the CA trainers, according to whom *likoti* farmers need on average 375 man hours/ha the first season and 275 man hours/ha or less from the second season onwards.

Furthermore, *likoti* farmers are taught to weed their fields three times per season. In fact, 63% of the CA respondents said to weed at least twice compared to 34% of the conventional farmers. Considering that the large majority of the farmers (90%) in both categories weeded by hand (which takes on average 150 man hours/ha), the amount of labour required to weed the *likoti* fields is considerably higher. However, as will be discussed later, labour requirements – including for weeding – diminish progressively over time.

These findings suggest that, in order to fully understand the costs and the benefits associated with the CA practices, and compare them with those associated to conventional practices, it is necessary to consider not only the yields, but also other aspects, such as the economic profitability, the returns to labour and the social sustainability of the technique.

5.2 ECONOMIC ANALYSIS AND LABOUR PRODUCTIVITY

Table 4 compares the costs that farmers face to prepare the fields and buy inputs (according to the information collected under the survey) with the value of the produce obtained. Both conventional and CA farmers used on average 17 kg/ha of seeds of maize, in accordance with the quantities recommended by the MAFS (15-20 kg/ha). Regarding the use of inorganic fertilizers, CA trainers recommend farmers to use eight grams per hole, which gives 140 kg/ha, but farmers who reported to employ inorganic fertilizer used on average only 87 kg/ha. Conventional farmers used on average 105 kg/ha of inorganic fertilizer, which is also very low compared to the quantities recommended by the MAFS (300 kg/ha of 3:2:1 (25) for maize, sorghum and wheat).[24] The cost of pesticides and herbicides has not been considered in the analysis because only a negligible share of farmers in both categories reported to be able to afford them. The fee to hire the tractor is included among the costs of the farmers who ploughed with the tractor and sowed using draught power[25] (first column in Table 4).

Since in Lesotho agricultural labour is usually provided by household members, it was not possible to consider wages as a direct cost. The opportunity cost of labour has been approximated to zero for two reasons: (i) almost all farmers are practising subsistence agriculture; (ii) there is a high rate of unemployment and lack of alternative off-farm jobs, especially in rural areas. As a result, no costs were assigned to labour intensive activities such as ploughing and sowing with animals, digging the basins and weeding by hand. On the other hand, given the high importance that labour requirements play in the adoption of CA practices, labour productivity has been analysed separately.

TABLE 4

Total expenses (Maloti/ha) and output (Maloti/ha), by farming practice

	Tractor + Animal Draught	Animal Draught	Likoti
Fertilizer – 3:2:1 (50 Kg)	270[a]	270[a]	230[b]
Maize seeds – hybrid (10 Kg)	240	240	240
Ploughing/Digging holes	494	0	0
TOTAL COSTS	**1,004**	**510**	**470**
Output Qacha's Nek[c]	420	420	1,535
Profit Qacha's Nek	**-584**	**-90**	**1,065**
Output Botha Bothe[c]	1,210	1,210	1,890
Profit Botha Bothe	**206**	**700**	**1,420**

a) 2x50 Kg bags, according to the survey results
b)1.7x50 Kg bags, according to the survey results
c) Since the vast majority of farmers produce for home consumption, the price of maize meal has been used, instead of that of maize grain. The price of 2.5 Kg of maize meal is M4.49 in Botha Bothe and M6.25 in Qacha's Nek (FAO/WFP 2006). The cost of milling the maize has been substracted to the price of maize meal.

[24] Many conventional farmers reported to own livestock so they are likely to use also larger amounts of organic fertilizer compared to CA farmers.

[25] Very few farmers ploughed and sowed with the tractor, so they are not included in the analysis

In all the surveyed sites, the yield obtained using *likoti* would give the farmers a significantly higher profit: in Quacha's Nek using *likoti* gives a profit of M1,065 per hectare (compared to a deficit from ploughing), while in Botha-Bothe it gives a profit at M1,420 per hectare, compared to M206 when farmers ploughed with the tractor and M700 when they ploughed and planted with animals. The analysis shows that in Qacha's Nek, farmers who ploughed incurred a loss. Indeed, the average yield of 200 kg/ha obtained in the 2005/06 season is very low, even lower than usual (Qacha's Nek is often the district with the lowest average maize yields in Lesotho).

It could be asked why these households continue to farm using conventional tillage methods, even if they make a loss. First it should be recalled that in this analysis the estimation of the profit serves exclusively as a comparable measure of the benefits associated to the employment of different farming practices. To this aim, a monetary value has been attached to each item, even if in reality farmers neither disbursed nor received any money. For instance, some farmers (especially those who adopted *likoti*) received donations of seeds and fertilizers. On the other hand, many conventional farmers used their own seeds and manure thus had lower costs. Finally, concerning the value of the production, only the price of the maize grain was considered. But maize stubble also has a value as fuel and fodder, which is difficult to quantify. The existence of costs and benefits which can not be easily monetized – including traditional and cultural factors – may explain why farmers continue to cultivate even if they get such low yields.

So far the opportunity cost of labour has been assumed to be nil and wages have not been included as direct costs. However, especially considering that the workload required by the CA practices in the first seasons was reported to be one of the most important deterrent to their adoption, a thorough economic analysis has to consider also the productivity of labour. Table 5 shows the labour requirements for different farming activities, according to the information provided in section 5.1. Table 6 shows the output to labour ratio and the profit to labour ratio in Maloti per man hour. The Profit/Labour ratio gives an approximation of the returns to labour and can also be interpreted as the profitability associated with the farming practice.

In Qacha's Nek, where average yields are usually very low, conventional farmers made a loss, and therefore it is not possible to compare the labour productivity on the basis of the accounting profit. Comparing the different farming practices in relation to the output/labour ratio (Table 6, a), *likoti* get the highest remuneration (2.36 M/man hour). In Botha-Bothe, the profitability of *likoti* calculated through the profit/labour ratio (2.2 M/man hour, Table 6, b) is almost the same as the profitability obtained by ploughing with animals and the double the profitability obtained by using the tractor. Therefore, the amount of labour required by likoti, although much higher compared to the conventional farming practices, is adequately compensated by the yield and return.

TABLE 5

Time spent to perform different farming activities (person hours/ha), by farming practice

Activity	Time (person hour/ha)
Ploughing with tractor, sowing with animals, weeding once by hand	200
Ploughing and sowing with animals, weeding once by hand	295
Digging holes, placing fertilizer and seeds in the holes by hand, weeding 2.5 times	650

TABLE 6

Labour productivity (Maloti/hour) in Qacha's Nek (a) and Botha-Bothe (b)

	Qacha's Nek (a)			Botha-Bothe (b)		
	Tractor+ Animal draught	Animal draught	Likoti	Tractor+ Animal draught	Animal draught	Likoti
Output (M/ha)	420	420	1,535	1,210	1,210	1,890
Profit (M/ha)	-584	-91	1,065	206	700	1,420
Labour (hours/ha)	200	295	650	200	295	650
Output/Labour (M/hour)	2.10	1.42	2.36	6.05	4.1	2.9
Profit/Labour (M/hour)	--	--	1.64	1.03	2.4	2.2

Considering that the figures used for the calculations refer to the workload necessary in the early adoption phases, which is expected to decrease over time, the profitability of CA is likely to augment in the subsequent seasons. On the other hand, if the labour available is not enough to accomplish all the farming activities on time, the output can be badly affected. It is therefore important that the household assesses carefully the labour force available in relation to the number and the size of the fields, in order to get an adequate labour remuneration. At the same time, improved farm management – to be achieved through an incremental shift to CA – helps the household to overcome the resource constraints. For instance, spreading the workload all over the dry season allows farmers to better manage the labour force available. Also frequent and timely weeding significantly reduces weed infestations over time (see section 5.4).

5.3 IMPACT ON FOOD SECURITY

The social sustainability of *likoti* has been assessed also by monitoring the food security status of the surveyed households before and after the harvest. In both phases of the survey, the food security status was evaluated in relation to access and availability of food, frequency of meals and diversity of the diet. A food consumption score (FCS) was calculated to measure the diversity of consumption[26]. Based on the FCS, the quality of the diet can be classified as

[26] The food consumption score measures the diversity of household diet over three days, whereby to each food is allocated a score based on its nutrient density and its contribution to the diet. As an example, animal proteins and milk receive the highest score of 4, cereals receive 2, fruit 1 and so on (source: WFP Lesotho).

low (FCS<10), *adequate* (10=<FCS<22) or *good* (22=<FCS<48). In both sub-samples, the majority of the households consume an *adequate* or a *good* diet; however, the average FCS obtained by those who fall in the *adequate* category is relatively small (average FCS=16) in relation to the top value of the range (FCS=22). In the case of Lesotho, a FCS equal to 16 means a basic diet of *papa* (maize meal) and *moroho* (leafy vegetables) and a few alternatives.

TABLE 7

Average FCS obtained in February and August, calculated with fruit (FCS) and without fruit (FCS*), and percentage variation

	CV FHH	CV MHH	CV Total	CA FHH	CA MHH	CA Total	Total
Average FCS, February	22.5	23.0	22.8	21.0	20.2	20.5	21.6
Average FCS, August	21.6	22.1	21.9	22.3	21.6	21.9	21.9
% Variation (with fruit)	-4%	-4%	-4%	6%	7%	7%	1%
Average FCS*, February	19.74	20.42	20.17	18.25	17.86	18.00	19.07
Average FCS*, August	20.94	21.64	21.39	21.81	21.26	21.47	21.43
% Variation* (without fruit)	6%	6%	6%	19%	19%	19%	12%

In the second phase of the household survey (just after the harvest), CA farmers reported a more diversified diet (i.e., they obtained a higher average FCS), while the conventional farmers' average FCS has slightly diminished. The differences are larger if the FCS is calculated excluding the consumption of fruit, which is widely available in rural areas in the summer, but is not in the winter after harvest. As shown in Table 7, without considering the consumption of fruit, both farmer categories improve the diversity of the diet, but the increase is much more significant for the CA farmers (19%) than the conventional ones (6%)[27]. This result would suggest that the availability of own production is more important for the CA sample and also that:

- CA farmers rely more on their own production, even though on average they cultivate smaller fields and employ fewer resources (the CA sample also give a higher importance to *Own Production* as main source of food).
- Considering that initially most of the CA farmers were involved in a CA project just because they had been targeted as vulnerable and food insecure (which was confirmed by the socio-economic analysis), the improvement in the FCS after the harvest would indicate that currently they manage to achieve an adequate food security status through their own production. (Nevertheless, the amount of produce is still inadequate

[27] The T-test performed on the distribution of the differences between the FCS* (without considering fruit consumption) recorded in February and the FCS* recorded in August, showed that the increase of the average FCS* was significantly higher for the CA sample than the CV sample (t=1.59; t, 227; 0.95=1.44).

to cover the needs of the family all year round, and during the shortage period, poorer households may not have access to food due to income constraints).

5.4 IMPACT ON SOIL AND WATER CONSERVATION

The agro-environmental benefits associated with the use of CA practices are widely documented in the literature (FAO, 2001a, 2001b; IFAD and FAO, 2004; IIRR, 2005; Ashburner *et al.*, 2002; Haggablade and Tembo, 2003). The most important ones can be summarized as follow:

- Reduced tillage improves soil structure and stability and leads to the progressive suppression of weed growth as the seed bank of weeds in the soil decays.
- Crop residues left on the soil surface protect the soil from wind erosion and break the impact of raindrop splash, slowing down the velocity of surface runoff and impeding water erosion. Reduced runoff results in a reduced loss of water, soil, fertilizer and pesticides, so avoiding wastes and contamination of soil and downstream waters. Crop residues also suppress weed growth.
- The soil cover also makes the soil organic matter content to augment over time, increasing soil fertility and improving the structure. Soil organic matter binds the soil particles together into structural units called aggregates and thus helps to maintain a loose, open, granular soil structure. Such a friable soil structure improves water infiltration, retention and availability, impedes water runoff and thereby soil erosion. In turn, improved water infiltration and the reduction of moisture loss by evaporation improve the capacity of the soil to retain nutrients and moisture.
- Crop residues are also a habitat and a source of food for the organisms in the soil, which in turn help the formation of stable aggregates. Stimulation of the biological activity in the soil (micro-organisms and insects) and in the field (predators) creates conditions for effective biological pest and disease control and, in general, has a positive impact on agrobiodiversity.
- Better soil structure and increased fertility improve the rooting conditions for plant development and growth, and reduce the probability that the crops will suffer from drought and other natural disasters.
- Crop rotation and intercropping maintain and enhance soil fertility, while crop rotation helps to break insect pest, disease and weed cycles. The inclusion of leguminous green-manure or cover crops in small-farm systems not only provides dense cover and large quantities of organic matter to the soil, but also significant quantities of microbially fixed nitrogen (FAO, 2001a).

Conservation agriculture also contributes to wider environmental benefits such as:

- Less erosion impedes land degradation and desertification.
- Reduced runoff limits the loss of water and soil, but also of fertilizer and pesticides, and so avoids the contamination of soil as well as pollution and siltation of downstream waters.
- No-tillage and mulching reduce the release of carbon into the atmosphere. And sequesters more carbon which mitigates climate changes and the impact of greenhouse gases.
- Biodiversity above and below the ground is enhanced through diversification, improved field conditions and stimulation of biological activity (soil micro-organisms but also pest predators). Living cover crops and crop residues provide the habitats for a variety of animals (insects, birds, small mammals, reptiles, and so on), plants and micro-organisms, which are necessary to sustain key functions of the agro-ecosystem (FAO, 2001a; Benites *et al.*, 2002).

The environmental impacts of CA depend critically on whether and to what extent the basic conservation principles are applied as well as the length of time they have been practised. In order to assess the fertility status of the fields, and thereby compare the extent of soil degradation, under the survey 71 soil samples from CA fields and 51 from adjacent non-CA fields were tested for nutrient analysis.[28] According to the soil analysis, the nutrients and the organic matter contents are higher in the *likoti* fields than in the ploughed ones, but the difference is not statistically significant. This small difference may depend on the fact that, at the time sample were tested, the households had being practising *likoti* for two to four seasons, and it was thus too early to expect any significant change in the fields' soil health status. Nonetheless, according to a soil fertility index (SFI) built to compare CA with conventional fields, the overall soil fertility was higher in the former.[29] This finding suggests that in the CA fields soil fertility was building up or at least was not degrading as fast as in the ploughed fields.

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[28] Stratified random soil samples were taken on each field to make one composite sample for each field. The soil samples were taken randomly from the field with an auger to a depth of 30 cm, and mixed. Soil samples were analysed at Department of Agriculture in Cedara, KwaZulu-Natal. The tests included analysis of phosphorus (P), potassium (K), Calcium (Ca), Magnesium (Mg), Exchangeable acidity, Total cations, acid saturation, pH, Zn Mn, Copper (Cu), NIRS organic carbon and NIRS clay. This section is drawn on the work made by Stine H. Pedersen and Botle Mapeshoane, who analysed and discussed the results of the soil tests for FAO Lesotho.

[29] The formula to calculate the SFI is drawn on Oelofse (2005):

SFI = Average[PCA/PCV + KCA/KCV + CaCA/CaCV + MgCA/MgCV]x100

The SFI gives the average fertility of the CA fields relative to that of the ploughed (CV) fields. A value higher than 100 indicates that fertility under CA is relatively better than under CV. The SFI was calculated using data on soil nutrients for 50 pairs of CA and conventional fields, giving a value of 114. The T-test then confirmed the hypothesis that a SFI=114 was significantly different from 100 (t=2.62, p=0.0117).

This analysis, although partial, largely confirms the results achieved by most of the experiential literature on conservation agriculture. However, in order to fully assess the impacts of *likoti* on soil and water conservation further research should be conducted on a long-term basis.

5.5 THE ROLE OF SOCIAL CAPITAL

The positive impact of social capital[30] on the effective use of SWC measures has been demonstrated by several empirical studies in Uganda (Sanginga, 2006), Kenya (Barbier, 2000; Mwakubo *et al*., 2006; Nyangena, 2007), Philippines (Cramb, 2004) and Peru (Swinton, 2000). Indeed, several social capital dimensions affect the relevance of the factors determining the adoption of CA. For instance, higher levels of trust and reciprocity help farmers to access labour and credit (through labour exchanges, social networks and associations), thus reducing the need for external incentives. By fostering cooperation and collective action, social capital also facilitates extension and field activities, and encourages adaptive research by enabling the formation of farmer groups and networks among researchers, extensionists and farmers at different levels. As a means to support institutional agreements, avoid conflicts and foster community participation, social capital may also help to solve the problems related to the use of common pool resources, such as land tenure and grazing rights, which seriously affect the adoption of CA in SSA (Calegari and Ashburner, 2005). The presence of social capital also supports a receptive attitude towards the cultural and institutional changes that accompany technical transformations in any process of innovation adoption and diffusion.

According to the information collected from key stakeholders, the socio-economic suitability of *likoti* is in fact counterbalanced by a number of cultural and relational issues. For example, since the ox-plough is identified with a particular social status, some Basotho stigmatize the practice due to the

[30] Social capital may be defined as the social relations within a group and among this and other groups, and the features and the norms that characterise these relations, which enable the individuals and/or the groups (through collective action) to reach desirable outcomes. “Structural” social capital refers to all types of social interactions that can be established within a group or a community (networks, formal and informal associations, kinship and friendship ties, etc.) – or bonding social capital – and among different groups or communities (such as associations among members of different ethnic or religious groups and networks of associations) – or bridging social capital. “Cognitive” aspects include the attributes (such as behavioural norms, shared moral values, personalized and generalized trust) as well as the informal and formal agreements through which these relationships work.

fact that labour is provided by people instead of animals.[31] Also, the customary rules which allow villagers to collect the crop residues and herd their livestock in the fields after the harvest may represent an obstacle to the adoption of CA. Farmers who do not allow the neighbours into their fields in order to keep the mulch cover and avoid soil compaction, could incur relational social problems with the rest of the community. In order to assess how these aspects affect the socio-economic sustainability of CA in Lesotho, the following paragraphs analyse the role of social capital and other culture related issues in the process of adoption and diffusion of *likoti*.

On the basis of the data collected in both phases of the field survey, ten social capital variables were established. Four sought to evaluate the rate of participation in formal and informal networks or the "structural" dimensions of social capital.[32] Six variables were related to the cognitive aspects of social capital, such as trust and reciprocity.[33] The different forms of social capital which characterize the sample were then analysed along with the socio-economic and farming related variables, in order to assess possible relationships and dependencies. The empirical analysis was conducted with the support of Bayesian networks, whose structure – learnt inferentially from the data – reflect the (conditional) dependencies among the variables[34] (annex IV presents a methodological note with some examples of Bayesian networks).

From the analysis it emerged that the households who adopted *likoti* are more endowed with social assets than those who did not. In particular, a "network dimension" characterizes CA farmers in the lowland sites, while a "trust dimension" is stronger among respondents in the mountains. These differences somehow reflect the different impacts that the socio-economic trends discussed earlier are having on the local communities. In the lowlands,

[31] After the ox-plough was introduced by the first European missionaries, it spread very fast among Basotho, and soon people started to identify the plough with a particular social status. According to Ferguson (1990), "some women would refuse to marry a man who did not own a plough". Even if agricultural outputs are in decline, farming – and conventional methods introduced under the British Protectorate – continue to have a significant social role. Therefore, people – including the poorest – can be very reticent about farming without ploughing or without livestock, which also has a great, intrinsic value in Basotho culture.

[32] Membership in associations and groups; Attendance at church meetings and related activities; Attendance at the *pitso* (public village assembly); Occurrence of sharecropping agreements.

[33] Quality of the relationships among community members; Generalized trust; Rate of mutual assistance among households; Respect of rules on grazing and Reasons to break such rules; Perception of traditional collective work parties (*matsema*).

[34] Bayesian networks are graphical models built as directed acyclic graphs (DAG) made of nodes and arcs (edges): the nodes represent random variables, each variable assuming certain values or states; the arcs express the likelihood that two variables are (conditionally) dependent. In this work, the structure of the Bayesian networks was built directly from the data collected during the household survey through an inferential process. This method is called structural learning and works by testing the conditional (in)dependence among one variable and all the other variables through an iterative process: for each couple of variables, the (in)dependence is tested conditionally to the subset of all the other variables.

where temporary migration to South Africa and urban and peri-urban areas is more frequent, community and kinship linkages deteriorate faster than in the mountains and traditional coping strategies are less effective. At the same time, "looser", choice-based networks with balanced reciprocity, are substituting community groups that used to rely on generalized reciprocity. Even though these networks represent an important asset for their members, compared to the past, vulnerable groups are more likely to be marginalized. In the mountain sites, instead, the "trust dimension" seems to be closely related to the persistence of traditional institutions, including community support mechanisms. These findings are supported also by the information provided by key interviewees. For instance, all the chiefs reported that, mostly due to the general impoverishment of the people, the quality of relationships and the degree of cooperation are worse than in the past. However, interviewees in the lowlands especially stressed the decrease in reciprocal trust and the diffusion of a nascent "payback" mentality.

Apart from these location specificities, the Bayesian networks learnt from the social capital variables show that the two dimensions of social capital – network and trust – are interrelated, and that both are linked to the "adoption" variables, suggesting that a higher endowment with social assets, as in the case of CA farmers, has fostered the adoption of the innovative practice. The structural learning of Bayesian networks also found that the degree of knowledge on CA is strongly correlated to the attainment of training, and the effect of training on the degree of knowledge is stronger in the mountains than in the lowlands. That is, *likoti* adopters in the mountains – who revealed to be more cooperative – have a better knowledge of conservation agriculture principles and apply them more correctly than adopters in the lowlands do. Most likely, these differences depend on the different approach used by CA trainers in Qacha's Nek (the mountain district) and in Butha-Buthe and Leribe (in the lowlands). As mentioned earlier, in fact, the former interact frequently with the trainees, organize field visits and gatherings to discuss problems and issues, and also encourage farmers to work collectively. On the contrary, in the lowlands, trainers complain that they cannot rely on farmers' cooperation in spite of their efforts to foster it. Two important conclusions can be drawn from the above discussion:

- Social capital is an important determinant of the adoption of CA practices. However, the higher level of trust among respondents along with the participatory approach used by CA trainers, have been especially relevant to both the performance and the acceptance of the technology. These findings confirm the critical role that a proper combination of social capital and capable agency of committed leaders[35] play in the achievement of local development objectives, as highlighted in the recent literature.[36]

- The conservation farming practice revealed to be very suitable to the local socio-economic conditions, as well as to the environmental constraints. However, the long-term sustainable impacts on crop intensification as a means to sustain livelihoods depend greatly on social, cultural and institutional factors.

[35] According to the definition provided by Sen (1999), agent is "someone who acts and brings about change, and whose achievements can be judged in terms of her own values and objectives, whether or not we assess them in terms of some external criteria as well". Agency is important particularly in situations where institutions are not available that enable citizens to connect with the state and with markets (Krishna, 2001).

[36] See, among the others, Reid and Salmen, 2000, Krishna, 2004, Meinzen-Dick, 2004.

CHAPTER 6

Conclusions: CA and Sustainable Crop Production Intensification in Lesotho

The rationale for applying planting basins in Lesotho is threefold: to stop and reverse land degradation, especially soil erosion, to obtain higher yields and to improve food security. This section briefly summarizes the results of the analysis. It then focuses on the main lessons learnt about the factors that so far have mostly determined the adoption and the performance of CA in Lesotho. It concludes with a discussion about the areas for potential improvement.

6.1 OUTCOMES OF THE ACTIVITIES

The analysis of the survey data has shown that the adoption of *likoti* had brought about significant advantages compared to conventional tillage practices. The most important are:

- Higher agricultural productivity, due to improved efficiency in the use of inputs and other resources.
- Higher social sustainability, due to the accessibility to the technology by all social categories, including the most vulnerable.
- Greater environmental sustainability, due to improved soil structure, enhanced fertility and reduced erosion

Farmers using *likoti* have achieved significantly larger yields by employing relatively fewer means. The economic analysis and the assessment of returns to labour suggest that the new CA practice is profitable notwithstanding the significant workload needed especially in the first two seasons in setting up the *likoti*. Furthermore, if well managed, the workload necessary to prepare the land can be spread over the dry season and over several seasons, thereby relocating the heavy labour out of the peak planting period and also spreading it over time. Preparing the field during the dry season also enables farmers to sow earlier and benefit from timely planting as well as to programme other off-farm activities. In any case, the overall amount of net labour required tends to decrease over time. After the first season, in fact, it is not necessary to design the grid and break the hardpan to dig the basins. In addition, it has been demonstrated that by weeding CA fields frequently in early years and at the right time, the weed infestation reduces progressively over time thus making weeds easier and easier to control. Nonetheless, the availability of labour has to be carefully assessed just because timely and precise farming management is critical to the achievement of positive results.

The spread of conservation agriculture has a great potential to improve the degree of agricultural knowledge, especially with regard to the management of the agro-ecosystem, also among the farmers who continue to use conventional tillage methods. In fact, beyond introducing innovative farming practices, it has increased people awareness about the causes of land degradation and related possible solutions. On the other hand, the *likoti* farmers themselves sometimes fail to apply strictly all the CA principles, as recommended by the promoters of the practice. In some cases, this may depend on the scarcity of the resources available (for instance, this can justify low applications of fertilizer or infrequent weeding); in other cases, cultural related issues hamper the correct adoption (e.g., farmers can not maintain an adequate soil cover because other villagers are allowed to collect the stoves for fuel or fodder). As a result, the potential of CA in Lesotho is still underexploited.

Agriculture in Lesotho is mainly subsistence oriented, but still plays an important role also as complementary source of income. The adverse climate conditions and the fragile environment, along with the progressive impoverishment of the population, have caused agricultural yields to steadily decrease over the last years. At the same time, social and cultural breakdowns have weakened people's ability to farm, which depends heavily on social assets and relational skills. *Likoti* has shown meaningful potential to improve livelihoods and food security employing fewer inputs compared to conventional farming practices. Indeed, the suitability to the local socio-economic conditions – that is, the accessibility to the technique by all social categories – is even more important than the impact on yields (still very significant).

The spread of the practice is also having significant impacts on the environment. Improved fertility and a stronger soil structure are the primary causes of the increase in yields. At the same time, they contribute to stop and reverse the process of soil erosion and land degradation which dramatically affects the Lesotho landscape. The social and the environmental sustainability associated to the CA practice are extremely important. On the one hand, poor resource farmers obtain higher yields, improve household food security and possibly, in the longer run, they will be able to make a living from farming. On the other hand, the positive social and environmental impacts can contribute, on a larger scale, to a sustainable development process based on the revitalization of the agricultural sector and the preservation of the natural resource base.

6.2 LESSONS LEARNT: DETERMINANTS OF THE ADOPTION AND THE PERFORMANCE OF CA

According to the analysis, the factors that so far have mostly determined the adoption of CA in Lesotho are:

Economic incentives: Lack of assets and income, as well as the socio-demographic features of the farmers and their households, do not affect the possibility to adopt the technology. However, in order to start practising CA, vulnerable households may need some support for buying the inputs and be sure to get enough yields so that they can continue to farm with their own resources. Indeed, the majority of the respondents received some forms of subsidy – either inputs or food – to start *likoti* but this support, except in a few cases, stopped after the first season. Furthermore, when asked about the main reason for starting CA, only 5% of the farmers who had already abandoned CA and 8% of those who were still practicing mentioned "the provision of food and other incentives." This means that the wide majority of the farmers would continue to use *likoti* even after subsides have stopped and would confirm the economic sustainability of the practice.

Human capital: CA farmers are more educated than conventional farmers. In particular, female adopters, who are the less endowed with economic assets and other resources, are significantly more educated (even though at low levels of education) than the other categories, and especially compared to female conventional farmers. Thus, human capital has been found to be an important determinant of adoption, especially when access to other resources is limited, as it is the case for many Basotho women.

Social capital: CA farmers are more endowed with social assets than conventional farmers. In particular, a "network dimension" characterizes CA farmers in the lowlands, while a "trust dimension" is stronger among respondents in the mountains. The two dimensions are interrelated, and both seem to affect the decision to adopt CA. These findings are consistent with the most recent literature on agricultural innovation which highlights the importance of social capital in the adoption and the performance of innovative agricultural practices. In the Lesotho case, higher degree of trust and cooperation among community members may help to find institutional agreements and organizational solutions to overcome some of the constraints to the correct application of the conservation principles, for instance issues related to land tenure and the integration of farming and livestock activities.

Training and capable agency: Knowledge on CA is found to be strongly correlated to the attainment of training, and the effect of training on the degree of knowledge imparted is stronger in the mountains than in the lowlands. The finding may be well explained by the participatory approach used by the trainers in the mountains, combined with the farmers' good attitude towards cooperation and trustfulness. The positive impact of the commitment of CA trainers in Qacha's Nek on the performance and the acceptance of the technology, confirms the critical role that a proper combination of social capital and capable agency play in the achievement of local development objectives, as highlighted by the literature.

Drawing on the discussion above, a number of consistent policy implications for the successful diffusion of innovative conservation practices, not only in Lesotho but also in other Sub-Saharan countries can be derived. The most important are:

Incentives to the adoption of CA practices

The critical impact that a proper application of conservation practices can have on the livelihoods of vulnerable household categories justifies the provision of some incentives, such as inputs or small loans, that would enable them to start practising. Food aid and other forms of subsidies, although useful for those households who need to recover their livelihood basis, should be used carefully in order not to create dependency or discourage food production. In all cases, support should be given on a provisional basis and under payback schemes. Moreover, participation in training and demonstration activities should be a necessary condition to receive further assistance.

Initial labour intensiveness is still a major deterrent to the adoption of *likoti*, just as happens in other African countries where similar planting basin systems have been adopted. If the fields are properly managed, the net workload decreases over time, but if there is not enough workforce available, it becomes harder and harder to harness the potential benefits. Thus some kind of temporary support may be necessary also to overcome the possible initial labour constraint. For example, programmes targeting vulnerable households can employ landless workers on others' fields.

Finally, beyond having positive impacts on agricultural yields and food security, CA has also a critical role in the conservation of the environment and the natural resources. The environmental impacts can be considered as positive externalities from which the whole society benefits, but they are not perceived by individuals, especially when adequate policy support is lacking. Furthermore, most of the social benefits (and also some private ones) manifest themselves in the medium to the longer term, whereas the highest costs have to be sustained in the early adoption phases. Therefore, public-funded support to the spread of CA may be justified also by the need to overcome this dichotomy between the social desirability of the technology and its on-farm attractiveness. To this aim, public support should include not just economic subsides and other forms of direct incentives, but also more effective advisory services and information campaigns.

Education, Information and Advocacy

More information about the concept of conservation agriculture and its potential advantages should circulate countrywide, not just among potential adopters. The main objectives of broad information campaigns should be to reduce scepticism and achieve a wider acceptance of CA also amongst the conventional farmers and to raise awareness about the long-term environmental and social benefits. The ‘supply’ of information should be accompanied by an adequate investment in farmers’ receptive capacities. In other words, whenever necessary, a more general effort is needed to enhance education, which indeed was found to be particularly relevant to women’s involvement.

Special training and information sessions have to be conceived for local researchers, officials of the Ministry of Agriculture and extension staff in order to provide farmers with both training and technical assistance. In particular, a deeper involvement of the extension staff in training and field activities would also foster a wider acceptance of the CA practices.

Farmers’ Participation and Training

The importance of participatory processes in the adoption of agricultural innovation has been extensively discussed in the literature. Participation at community level of all members, and especially of the local leadership, allows a better understanding and a wider acceptance of new ideas and practices, especially if they need not just a technical shift but also a radical cultural change, as in the case of conservation practices. The survey has identified a number of issues that community would better address through a more participatory approach. For instance, access by herders and other villagers into CA fields after the harvest is one of the most important deterrents to the correct application of CA principles. In order to overcome it, community members should not just discuss the issue of herding livestock out of the fields. They should also find feasible community-based solutions for the livestock owners and alternative fodder and fuel sources. Similarly, a closer integration of farming and livestock could help overcome other constraints, such as the supply of organic manure, or the production of fodder crops in rotation with other crops. Under such approach, common rules on range lands and promotion of CA would be complementary elements of an integrated strategy that aim to combat land degradation and conserve the natural resource base.

The extent of farmers’ participation is also important with regard to training. The effectiveness of CA practices largely depends on the timely and appropriate management of all the farming activities. Therefore, the enhancement of technical knowledge and precision skills through adequate training is critical. Equally important is the approach used by the trainers. It has been demonstrated, in fact, that the promotion of participatory field activities and a close interaction between farmers and trainers lead to the better assimilation of CA principles and, in turn, to a more appropriate application. However, this formula is more likely to succeed where the degree of trust and cooperation among farmers, i.e. social capital, is higher.

6.3 LESSONS LEARNT: AREAS FOR FURTHER RESEARCH AND IMPROVEMENT

The diffusion of *likoti* has brought about several advantages to its adopters, but its potential is still underexploited. As already stressed, in fact, not all farmers are strictly following the CA principles, and this may depend on technical and/or resource constraints but also on cultural bias and institutional problems. The previous section discussed a number of possible actions to be taken to further enhance the positive impacts of CA. This section focuses on those factors that, albeit commonly identified as important determinant of the adoption of CA, are still lacking or absent in Lesotho.

Among the most important, effective policy support has been virtually absent. In spite of Government's acknowledgement of the benefits associated with minimum tillage techniques, the concrete involvement of the Ministry of Agriculture and Food Security (MOAFS) in the diffusion of CA has been limited. The low commitment of the MOAFS is reflected also in the lack of support from the extension services, as admitted also by the local extension officers interviewed during the field survey. At policy level, neither the creation of the Conservation Farming Network Group (CFNG) nor the support that FAO and WFP gave to the organizations that first promoted *likoti*, translated in a functioning multiple stakeholder partnership. Lack of interaction among farmers and other actors, including extension services, in turn affected the degree of farmer participation in the diffusion and, most importantly, in the adaptation of the technology to the local conditions.

The low interaction of formal research and farmers' indigenous knowledge has been another important missing aspect. In particular, institutional issues related to land tenure, such as the use of stubble as fuel or fodder by the villagers, and the integration of the livestock and the farming systems, have received inadequate attention by the promoters of CA. In order to properly adapt the conservation principles to the local agro-ecological conditions, as well as to the cultural beliefs, it would be very helpful also to assess the innovations developed by the farmers themselves. However, neither the NGOs and the international organizations involved nor the MOAFS have significantly interacted with innovating farmers.

Borrowing the lexicon from the Agricultural Innovation System (AIS) approach, in Lesotho the promotion of innovative CA practices has not been based on "a dynamic process of interacting embedded in specific institutional and policies contexts" (Hall, 2006). Limited stakeholder interaction and inadequate policy support not only limit the potential benefits associated with the use of the technique, but they also hamper the internalization of social costs and benefits, discourage the social acceptance of the innovative practices, and ultimately affect the rate of adoption.

Adaptive research based on constant interaction among formal researchers, technology promoters and local farmers is especially important in the diffusion of CA practices, just because of their flexible nature. In order to fully exploit the benefits of a technology that can be suited to different environment conditions, in fact, farmers need to enhance their innovation capabilities, which are not only of a technical nature. Participatory research activities are critical also in order to include aspects of indigenous knowledge and traditional institutions, and ultimately facilitate the tremendous mind shift that has to take place in the transition from conventional to conservation farming practices and which is one of the biggest challenges to the adoption of CA. However, according to Fowler and Rockstrom (2001), "identification and recognition of local traditions or indigenous knowledge is important, but it is the actual possibility of building on these that has real potential. […] For this approach to succeed, the social environment should be conducive, the intervention must involve communities not individuals, the activities must involve all potential players."

A critical component of a working participatory and adaptive research system should thus be the creation of multiple stakeholder partnerships. As the Swiss Commission for Research Partnerships with Developing Countries (KFPE) has put it, "ideally, a research partnership should strive for a dynamic equilibrium in which all involved parties are open to a multiple transformation in terms of mutual learning, cultural understanding, scientific upgrading, capacity building, and attitudinal behaviour towards all partners. Applying trans-disciplinary or multilevel, multi-stakeholder approaches, where all relevant stakeholders are actively participating, helps generate meaningful results and fosters processes that promote impact. In such partnerships all partners have a voice in decision-making processes and their capacities are used and further developed in a complementary and most fruitful way" (Maselli, Lys and Schmid, 2006).

Very recently, in July 2009, Growing Nations – Rev. Basson led organization – signed an agreement with the International Fund for Agricultural Development (IFAD) for the provision of a grant to establish a training centre and to develop new training curricula[37]. A key step will be to collect the training material that already exists and give it to farmers in a workable format. Further challenge will be the establishment of intensive training modules for agricultural students. For this reason, Rev. August Basson decided to move Growing Nations' activities to Maphutseng, in Mohale's Hoek district, where the centre, and the possibility to learn *likoti*, is more easily accessible for farmers from the whole country. Playing an adequate catalyst role, this initiative could provide the right incentive for more actors to get involved in the diffusion of the practice. At the same time, the centre is in a privileged position to start conduct systematic research on this and other conservation practices, following an adaptive, participatory approach.

[37] For more information about Growing Nations and its current activities visit http://www.barrymannphotography.com/GN-articles.html

Sustainable crop production intensification should contribute to the economic development of farming communities and seek to stimulate local economies through understanding and development of local, national and regional markets. This case study has mostly focused on the factors that can support the diffusion of small-scale conservation agriculture as a means to improve livelihoods and food security of resource poor households. However, as it has been mentioned, in the longer run the diffusion of CA could contribute to a wider development process at national scale. Due to the significant environmental and social benefits associated to its proper adoption, CA could allow farmers to enter a virtuous circle so that eventually they will be able to sell their produce in the local markets or engage in other income generating activities.

It is relevant to mention that for two successive years, in 2007 and 2008, some *likoti* farmers who before adopting CA were unable to produce enough maize for themselves, were able to sell excess grain production to the World Food Programme (WFP).[38] The case confirms the concrete possibility for *likoti* farmers to shift from subsistence to commercial agriculture. However, at the current status, most CA farmers are still far from achieving this goal. Furthermore, to boost production is just one of the leverages needed to develop the commercial agricultural sector. Adequate policies – and related investments – should also address many other factors: the provision of adequate infrastructure, the strengthening of market linkages, product differentiation into niche and high value markets, among the others.

This section has pointed out some issues that would be worthy of more careful assessment, both in research activities and at policy level. In spite of these areas for improvement, however, the results of the analysis have shown that the diffusion of *likoti* has already led to sustainable crop production intensification by enhancing soil fertility and consequently crop yields. These results are especially significant if they are put in the context of growing vulnerability which has been characterizing Lesotho in recent years. Indeed, the suitability of the conservation agriculture practice to different social and economic conditions, even the poorest, is one of the most important benefits associated with its adoption. As a farmer well put it, the main advantage of *likoti* is just that "*Everybody can do it*".

[38] New agriculturist on-line, 08-4, available at http://www.new-ag.info/08/04/focuson/focuson5.php

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ANNEX I
The Adoption of CA in SSA: Constraints and Opportunities

Table 1 and Table 2 summarize the advantages and the disadvantages associated with the use of CA practices, as identified by the empirical literature. Among the advantages, higher and more stable yields represent the most important benefit for African farmers who adopt conservation agriculture. Associated with decreasing variable costs, larger outputs increase net profitability and help to strengthen and diversify rural livelihoods. Further important benefit is the enhancement of food security, due to larger outputs as well as to nutritional improvements. A more diversified diet results from the availability of diverse crops planted in rotation or along with cereals, the extension of cultivated spaces (thanks to additional resources, including time), and – on a longer term – increased income.

Beyond increasing net profitability and food security, CA ensures long-term socio-economic and environmental sustainability, even in densely populated areas, such as occurred in Burkina Faso (Kaborè and Reij, 2003). African soils are increasingly affected by land degradation and desertification, but these phenomena have to be contextualized in order to understand the local-specific causes, features and consequences. CA may benefit African agriculture just because of the possibility to adapt a wide range of practices and techniques to different socio-economic contexts as well as to different agro-ecological conditions. In semi-arid lands, conservation agriculture retains water and moisture in the soil, keeps the soil temperature even, and protects the land from erosion during heavy downpours. In sub-humid and humid areas, crops planted at closer spaces and cover crops help suppress weeds and protect the soil. On slopes, conservation agriculture reduces runoff and soil erosion, and can be effectively used in association with terraces, contour grass strips and other erosion control methods (IIRR, 2005).

Further advantages for African farmers stem from lower labour requirements. In many countries, the rural population is steadily being reduced by rural-urban migration and by the HIV/AIDS pandemic. These phenomena concern particularly the younger male population, meaning that those with the best potential for heavy physical work are no longer working on the land, while a growing number of households are headed by women. At the small scale, once the conservation farming system is well established, the shorter time required for land preparation and weeding, along with the more even distribution of labour throughout the year, allow to reduce the workload during the peak season. Also draught animal power (DAP) systems permit labour saving by shifting from the mouldboard plough to shallow ripping. Time saving and reduced drudgery of field activities benefit all farmers, but a major opportunity arises for women (Fowler and Rockstrom, 2001; Haggblade and Tembo, 2003).

On the other hand, the adoption of CA may in some cases imply higher labour requirements. Especially in the transition phase, many small-scale conservation farming practices require temporary additional work to prepare the land and for weed and pest control. In particular, land preparation by digging planting pits and frequent weeding may impose an extremely hard and time consuming extra burden on women. However, to assess this kind of impacts may be difficult since the division of labour among household members is not always clear-cut and it differs from place to place and from family to family (IIRR, 2005).

Even though labour requirements diminish after the first or the second season (leading to the important advantages already mentioned), such initial effort may prevent resource poor farmers, and especially women and the elderly, from adopting the technology. The shift from conventional to conservation practices may also require additional financial resources to buy inputs and purchase (or hire) and maintain new equipment. The choice of an appropriate combination of CA practices and inputs should limit the expenses. However, if additional costs cannot be avoided (especially those arising from the initial labour demand), poorer, more risk-adverse farmers might need to be supported with some kind of incentives.

An important constraint to the adoption of conservation farming in Africa is represented by the difficulty of keeping a permanent soil cover due to insufficient biomass production. This may be due to agro-ecological and weather conditions, such as high humidity or poor rainfalls. But the most important reason for scarce soil cover is that available crop residues serve many other scopes such as animal feed, fencing, and fuel. For CA to be successfully adopted, substitute sources of fuel and fodder should thus be found. Otherwise, crop rotations and cover crop cultivation should allow the production of enough residues to meet the various needs. Proper crop selection, right choice of crop rotation and improved crop residues management may help achieve these objectives. For instance, many Burkinabe farmers who have started CA have then invested in livestock, since they could increase the production of fodder crops (Kaborè and Reij, 2003). However, especially in drier areas, sufficient biomass production still requires a lot of time and resources, and in most African countries, such as in Zambia – where the benefits of CA have been extensively described – most fields remain uncovered. Apart from technical answers, the even allocation of crop residues among multiple purposes also require the appropriate involvement of institutions, community participation and cooperation.

Another aspect that must be addressed jointly by community members is the integration of crop and livestock production, especially wherever livestock constitutes a major component of the local economy. The integration of livestock into CA may contribute significantly to the overall efficiency of the local agricultural system. Farmers can introduce forage crops into crop rotations, and these can be used for both fodder and soil cover, as well as to reduce pest problems. On the other hand, animal manure can be exploited to recycle nutrients in the fields, thereby reducing the environmental problems caused by intensive livestock production (Friedrich, 2006). However, conflicts between the use of organic matter to feed the animals or to cover the soil may still be difficult to solve. In many societies traditional rules allow animals to graze on stubble. Apart from reducing the biomass available for soil cover, free communal grazing on harvested fields causes soil compaction. Livestock keepers and CA farmers should find alternative solutions such as fencing animals out, planting unpalatable cover crops, enforcing land tenure arrangements, changing traditional grazing rights, or growing special plots of fodder crops (Calegari and Ashburner, 2005). Integration of crop and animal production systems is therefore essential for sustainable rural livelihoods, not just for technical reasons but also – and in some cases especially – because of the intrinsic cultural value that farming and livestock have in African societies.

Indeed, in Africa, cultural and institutional issues affect the adoption of innovative practices, including CA, more than elsewhere. The shift to conservation practices involves a profound mindset change, and this may be especially difficult where practices such as ploughing, clearing the land and free animal grazing are embedded in local institutions. Many African societies are also influenced by the idea that the current situation cannot be changed and that those who are born in poverty will die in poverty. In such cases people – and especially vulnerable categories, like women – are highly risk adverse and purposely avoid transformations which are likely to improve their situation (see for instance, Bolliger *et al.* 2005) on the failure of some CA experiences in South Africa). In most cases, such behaviour is rational. For instance, where women do not have rights to the land, any improvement they achieve in crop production may expose them to the risk of loosing the fields which become more attractive to their male relatives. The role of human and social capital is extremely important in overcoming constraints arising from institutional and cultural factors. Therefore, the adoption and the diffusion of CA in SSA may be held back by a lack of human and social capital, especially among the most marginalized groups and less resource endowed farmers.

This brief discussion highlighted many significant opportunities arising from the adoption of CA in SSA. At the same time, there are also some downsides mostly related to factors that may delay or corrupt the effective adoption of the practices. Some of these constraints may in turn transform into opportunities, but an appropriate set of initial conditions and/or adequate policies and interventions is needed. Based on the recent literature review, the factors that have been found to determine the successful adoption of CA in Africa can be summarized as follows:

- Incentives, usually employed to compensate for initial additional costs of technology adoption. In Zambia (Haggblade and Tembo, 2003), Ghana (Boahen et al., 2005) and Lesotho (Mapeshoane *et al.*, 2005; Silici *et al.*, 2007), for instance, incentive schemes have facilitated a relatively quick rate of adoption, but their long-term sustainability has not be confirmed yet. In other cases, such as in Burkina Faso, conservation practices have been adopted for a long time without external incentives (Kaborè and Reij, 2003).
- Adequate training, effective support from extension services, and organization of field activities (exchange visits, farmer field schools, workshops, etc.). These are critical for farmers to develop appropriate technical knowledge and management skills, as has been demonstrated in Zambia (Kabwe and Donovan, 2005; Haggblade and Tembo, 2003), South Africa (Bolliger *et al.*, 2005) and Ghana (Boahen *et al.*, 2005).
- Enhanced participation and interaction between formal research and indigenous knowledge. Many socio-economic and cultural constraints can be overcome by encouraging farmer participation in the identification of the system components best suited to their specific needs (Nyagumbo, 1999). Participation and knowledge sharing among farmers and researchers also have technical implications, since they usually support and speed up adoption and adaptation of the technology (Fowler and Rockstrom, 2001), thereby ensuring its long-term sustainability (Bolliger *et al.*, 2005).
- Education is important both to overcome institutional constraints and cultural biases, and to improve farmers' management skills (Bolliger *et al.*, 2005). For instance, Haggblade and Tembo (2003) and Chomba (2005) find that in Zambia retired school teachers, draftsmen and accountants have got better results from the employment of conservation practices. Higher educational levels enhance farmers' openness to innovation adoption and adaptation.
- Social Capital. As stressed also in the present case study, several structural and cognitive dimensions of social capital affect the relevance of the factors determining the adoption of conservation practices. Higher levels of trust and reciprocity, as well as easier access to labour and credit (for example through labour exchanges, social networks and associations),

help farmers to internalize social costs and benefits associated with the shift to CA, thus reducing the need for external incentives. By fostering cooperation and collective action, social capital also facilitates extension and field activities, and encourages adaptive research by enabling the formation of farmer groups and networks among researchers, extensionists and farmers at different levels.

As a means to support institutional agreements, avoid conflicts and foster community participation, social capital may also help to solve the problems related to the use of common pool resources, such as land tenure and grazing rights, which seriously affect the adoption of CA in SSA (Calegari and Ashburner, 2006). Last but not least, the presence of social capital may also support a receptive attitude towards the dramatic mental and institutional changes that have to accompany the technical shift from conventional to conservation tillage methods (Coughenour and Chamala, 2000).

- Women's inclusion. Depending on the practice promoted, women may find it more difficult than men to get the support they need to shift from conventional to conservation agriculture. Due to cultural biases or even to the legal system, in many African countries women have restricted access to resources (land, inputs and credit), education, training and extension services. Such limitations may seriously reduce the opportunities arising from the use of conservation practices. This is why, whenever it may be needed, incentive strategies, farmer participation activities, extension and research programmes should have a gender oriented focus.
- Policy support (both national and international). According to Benites *et al.* (2002), it is especially important for a number of specific achievements such as the involvement of the private sector (e.g., for the production of locally adapted equipment and inputs), multiple stakeholder partnerships, and the promotion of adaptive research.

TABLE 1

Potential benefits associated with conservation agriculture

Agro-ecological benefits	Resulting from…	Due to…
Progressive suppression of weed growth	Improved soil structure and stability	Reduced tillage
Long-term yield increase	Reduced water and wind erosion	Reduced tillage and soil cover
	Increase in soil fertility and stability and improved soil structure	Reduced tillage, soil cover, mulching, intercropping and crop rotation
	Improved retention of water, nutrients and soil moisture	Reduced tillage, soil cover, mulching
Reduced runoff	Decreased erosion, improved soil structure and water retention capacity	Reduced tillage and soil cover
Improved rooting conditions	Increase in soil fertility and stability and improved soil structure	Reduced tillage, soil cover, mulching, intercropping and crop rotation
Improved agro-biodiversity	Higher biological activity in the soil and in the field	Soil cover and mulching
	Crop diversification	Crop rotation and intercropping
Output stability	Reduced vulnerability to climatic shocks	Improved rooting conditions
	Enhanced biological pest and disease control	Crop rotation
		Higher biological activity in the soil and in the field
Reduced waste of water and inputs	Reduced runoff	Decreased erosion, improved soil structure and water retention capacity
Environmental benefits	**Resulting from…**	**Due to…**
Decrease of land degradation	Reduced erosion, higher soil fertility, improved soil structure	Reduced tillage, soil cover, mulching, intercropping and crop rotation
	Improved agro-biodiversity	Higher biological activity in the soil and in the field
Reduced downstream sedimentation and siltation	Reduced runoff	Decreased erosion, improved soil structure and water retention capacity
Reduced contamination of soil and surface and ground water	Reduced runoff	Decreased erosion, improved soil structure and water retention capacity
Reduction of CO2 emissions to the atmosphere	Higher carbon sequestration	Reduced tillage, soil cover, mulching
Conservation and enhancement of terrestrial and soil based biodiversity	Crop diversification	Crop rotation and intercropping
	Higher biological activity	Soil cover and mulching
Socio-economic benefits	**Resulting from…**	**Due to…**
Increased food security	Long-term yield increase and output stability	Reduced erosion, higher soil fertility, improved soil structure, improved retention of water, nutrients and soil moisture
		Enhanced biological pest and disease control
	Crop diversification	Reduced vulnerability to climatic shocks
		Crop rotation and intercropping

Environmental benefits	Resulting from…	Due to…
Increased net profitability	Long-term yield increase and output stability	Reduced erosion, higher soil fertility, improved soil structure, improved retention of water, nutrients and soil moisture
		Enhanced biological pest and disease control
		Reduced vulnerability to climatic shocks
	Reduction of on-farm costs	Savings in labour, machinery and (in the medium-term) chemical inputs (herbicides, fertilizer and pesticides, depending on the technology adopted)
Technology sustainability	Suitability to different farming systems and agro-ecological environments	Appropriate combination of tillage techniques, equipment and inputs

TABLE 2

Potential constraints to the adoption of conservation agriculture

Technical/Management Constraints	Resulting from…	To be addressed through…
Short term pest and disease problems	Change in crop management	Development of appropriate technology packages and training
	Increased use of soil cover and mulching	Training on IPM and biological pest and disease control
		Application of additional chemicals
Short term weed infestation	Change in crop management	Development of appropriate technology packages and training
	Change in tillage techniques	Application of additional chemicals
		Additional labour
Insufficient management skills	Need to careful plan crop rotations and intercropping, choice of cover crops, new approaches to weed control and pest management, proper application of all basic CA principles, …	Technical support and extension
		Farmers' time commitment to learning and experimentation
		Development of appropriate technology packages and training
		Creation and operation of farming groups and research and extension networks
High perceived risk (country specific)	Technology shift	Appropriate use of incentives (credit, inputs, labour, …)
		Development of appropriate technology packages and training
	Insufficient management skills	Farmers' time commitment to learning and experimentation
		Creation and operation of farmers groups and research and extension networks
	Lack of knowledge and information (country specific)	Technical and institutional support
		Commitment of extension officers and pioneer innovating farmers
	Cultural barriers and community biases	Community participation in, training, demonstrations and technology adaptation

Economic costs	Resulting from…	To be addressed through…
Additional starting costs	Purchase of specialized planting equipment	Enhanced access to markets
	Farmers' time commitment to learning and experimentation	Appropriate use of incentives (credit, inputs, labour, …)
	(At initial stages) additional labour requirements	Development of appropriate technology packages and training
(At initial stages) lower yields	Initial immobilization of nutrients	Intercropping with nitrogen-fixing crops
		Application of additional fertilizer
	Short term pest and disease problems and weed infestations	Training on IPM and biological pest and disease control
		Application of additional chemicals
		Additional labour
		Development of appropriate technology packages and training
	Insufficient management skills	Technical support and extension
		Farmers' time commitment to learning and experimentation
		Creation and operation of farming groups and research and extension networks

ANNEX II

List of Interviews and Workshops Held with Relevant Stakeholders

Beyond the open and the semi-structured interviews listed below, also a number of informal meetings with farmers and local CA promoters revealed to be particularly relevant to the field research. Among the most helpful, it is worthy to mention those with Koili, Joshua, Sello in Tebellong, with Isaac in Tsoelike and with Refiloehape in Ha Mamathe. Further interesting inputs came from the constant interaction with Rev. August Basson (Growing Nations), Mr. Richard Fowler (ARC South Africa), Rev. Pete West and Rev. John Mokoena (Dihlabeng Church and Rehobothe Church in Botha-Bothe).

Date	Place	Name	Role/Organization
30/01/2006	Tebellong	Workshop with CA Trainers from Tebellong and Tsoelike	Growing Nations Project
02/02/2006	DAO Qacha's Nek	District Agricultural Officer Field Services Officer	District Agricultural Office (DAO) Qacha's Nek
03/02/2006	DAO Qacha's Nek	Ms Ntseliseng	Crop Officer - DAO Qacha's Nek
06/02/2006	Thaba Kholo	Workshop with CA Trainers from Makhoakhoeng	Dihlabeng Church Project
09/02/2006	Cana	Church Minister of Cana	Church Minister of Cana
10/02/2006	Maseru	Pastor James Qhobela	AFM - Botha-Bothe
02/08/2006	DAO Qacha's Nek	Mr Lesesa Morojele	Nutrition Officer DAO Qacha's Nek
02/08/2006	DAO Qacha's Nek	Ms Ntseliseng	Crop Officer DAO Qacha's Nek
02/08/2006	Tsoelike Auplaas	Pastor Ranthimo	Growing Nations Project
03/08/2006	Liphakoeng	Ms. Mamakhaola Makhaola	Chief of Tebellong area
03/08/2006	Ha Stelling	Mr. Tsiliso Makakane	Chief of Ha Stelling
04/08/2006	Ha Mosue	Mr. Isaac Sehahle	Chief of Ha Mosue
07/08/2006	Thaba Kholo	Workshop with CA Trainers from Makhoakhoeng	Dihlabeng Church Project
17/08/2006	Ha Paramente	Ms. Jeremia Matela	Chief of Ha Paramente
18/08/2006	Thaba Kholo	Pastor John Mokoena	Rehobothe Church
18/08/2006	Makhunoane	Mr. Herbert Matela	Acting Head Chief of Makhoakhoeng area
18/08/2006	Ha Moloi	Mr. Matela Matela	Chief of Ha Moloi

ANNEX III

Methodological Note on the Well-being Indices

Three indexes have been built in order to compare the well-being status of the conventional and the CA farmers as well as to evaluate the distribution of welfare within the sample: an Asset Index, a Capabilities Index and an Outcome. The *assets index* measures the endowment with productive assets, which includes animals, land and agricultural production means and other tools. The index can be considered as a proxy of the wealth of the households, even though it does not include other economic resources and monetary earnings (Table 1). The *capabilities index* is built on variables such as the availability of a salary and other formal income sources, the ownership of a tractor, the capability to hire workers through *matsema* (collective work), the presence of disabled members in the household and the household dependency ratio, and it measures the household capability to generate welfare (Table 2). The *outcome index* measures the household capabilities in terms of consumption, and takes in account the heating method, the dietary diversity (through the food consumption score, FCS) and other consumption assets such as gas stove, radio and television (Table 3).

Each index is built synthesizing a number of variables available from the questionnaires. The variables are weighted by giving different scores to the values, being a higher score associated to a better condition expressed by that variable in terms of asset, capabilities and outcomes.

TABLE 1

Variables used to calculate the Asset Index and relative scores associated to different values

Variable	Value	Score	Value	Score	Value	Score	Value	Score	Max Score
Number of small stock (units)	0 - 5	0	6 - 9	1	10 - 24	2	=>25	3	3
Number of sheep/goats (units)	0	0	1 - 5	1	6 - 15	2	=>16	3	3
Number of cattle (units)	0	0	1 - 2	1	3 - 5	2	=>6	3	3
Number of pigs (units)	0	0	1	1	2	2	=>3	3	3
Number of donkeys (units)	0	0	=>1	0.66					0.66
Number of horses (units)	0	0	=>1	1					1
Number of productive assets (units) *	0 - 1	0	2 - 4	1	5 - 9	2	=>10	3	3
Own ox cart (dummy)	no	0	yes	1					1
Own land/land and cattle (dummy)	no	0	Only land	0.5	land + cattle	1			1

* Productive assets can include: sickle, hoe, garden tools, axe, saw, plough, planter, cultivator

TABLE 2

Variables used to calculate the Capabilities Index and relative scores associated to different values

Variable	Value	Score	Value	Score	Value	Score	Value	Score	Max Score
Pension, salary or remittances as first source of income	None	0	Pens	1	Salar or Remitt	2			2
Own tractor (dummy)	No	0	yes	1					1
Held matsema (dummy) *	No	0	yes	1					1
Disabled member in the household (dummy)	Yes	0	no	0.5					0.5
Dependency ratio (DR)**	=>4	0	1.5=<DR<4	0.5	1=<DR<1.5	1	DR<1	2	2

* Initially a higher importance was given to *matsema* and, compared to the asset index, the capability index appeared more normally distributed within both sub-samples. Lowering the weight associated to *matsema*, the distribution of the capability index becomes more similar to that of the assets index, possibly indicating a higher adherence to the reality.

** DR = the ratio of household members more than 60 years old and less than 18 to the 19 - 59 years old members

TABLE 3

Variables used to calculate the Outcome Index and relative scores associated to different values

Variable	Value	Score	Value	Score	Value	Score	Max Score
Heating method	No	0	with coal or paraffin	0,5	with gas or electricity	1	1
Food Consumption Score (FCS)*	FCS<10	0	10=<FCS<22	1	FCS>=22	2	2
Own gas stove (dummy)	No	0	yes	1			1
Number of radio (units)	0	0	1	0.33	=>2	0.66	0.66
Own television (dummy)	No	0	yes	1			1

* The food consumption score measures the diversity of household diet over three days, whereby each food is allocated a score based on its contribution to the diet. Each food type consumed is allocated a score based on its nutrient density.

The scores have been attributed (i.e. each variable has been weighted) on the basis of the existing literature on livelihoods strategies in Lesotho, in particular taking in account some previous analysis carried out by IFAD, CARE and Sechaba Consultants. The score obtained for each variable is divided by the maximum score obtainable for the same variable and multiplied by 100, in order to normalize the new values associated to each variable. The normalized scores are synthesised in the index through a weighted average as follows:

$$\text{INDEX} = \sqrt[\alpha]{\frac{1}{n}\sum_{i=1}^{n} x_i^{\alpha}}$$

where:

$x_i = i$ - variable
n = number of variables
$\alpha = 2$

The index – ranging from 0 to 100 – is calculated for each respondent farmer/household.

Example: Calculating the Capabilities Index for the household YZ:

Variable	Value	Score	Normalized Score (0-100)
Pension, salary or remittances as first source of income	Pension	1	(1/2)*100 = 50
Own tractor	No	0	(0/1)*100 = 0
Held matsema	Yes	1	(1/1)*100 = 100
Disabled member in the household	No	0,5	(0.5/1)*100 = 50
Dependency ratio (DR)	2	0,5	(0.5/2)*100 = 25

$$\text{CAPABILITIES INDEX of YZ} = \sqrt{\frac{50^2 + 0^2 + 100^2 + 50^2 + 25^2}{5}} = 55{,}9$$

The well-being status can be evaluated through the three indexes for each household and ranked in order to compare different farmers or gender categories. By dividing the distributions into quintiles it is possible to rank the households well-being status and categorize them as very poor, poor, moderate, better off and rich, as it was presented in section 4.5 (Figures 8 and 9). Generally speaking, all farmers categories show a poor welfare status also reflected in the outcome index. The CA farmers show a higher degree of vulnerability especially in relation to the endowment of productive assets, while the differences with the conventional sample diminish in relation to other capability factors, although still present. In both sub-samples, the FHH as a whole show a lower welfare status, even though the differences are accentuated amongst the CA farmers.

The table below reports the average values for the three indexes, reflecting the results obtained with the frequency distribution. The CA sample, and especially the female headed households, report lower average values of all indexes. In particular, the CA female headed households are the worst endowed with productive assets, with an average asset index well below the sample average.

TABLE 4

Average values and standard deviation of the well-being indexes, by farmer category and gender

Indicator		CV FHH	CV MHH	CV	CA FHH	CA MHH	CA	Total
Assets Index	Average	37.3	41.4	39.9	31.6	36.4	34.6	37.1
	St. Dev.	17.3	18.0	17.9	14.5	16.3	15.9	17.1
Capabilities Index	Average	47.0	48.5	47.9	44.0	46.6	45.6	46.7
	St. Dev.	19.4	18.5	18.9	18.1	17.1	17.5	18.2
Outcome Index	Average	41.2	46.0	44.2	39.2	43.1	41.6	42.9
	St. Dev.	17.8	18.7	18.5	18.5	18.5	18.6	18.06.00

ANNEX IV

Methodological Note on the Structural Learning of Bayesian Networks

In order to assess the possible relationships between social capital and the adoption of the conservation farming technology, likely dependences among the variables of interest have been tested through the use of Bayesian networks.

Bayesian networks are graphical models built as directed acyclic graphs (DAG). The DAG is made of nodes and arcs (edges) and is characterized by a descendant path. The nodes represent random variables, each variable assuming certain values or states. The arcs express the likelihood that two variables are (conditionally) dependent. When two variables are (conditionally) independent, they are not connected[39]. Critical elements of a Bayesian network are the prior probabilities associated to all root nodes (nodes with no parents) and the conditional probabilities associated to all non-root nodes, given all possible combinations of their direct predecessors (Charniak, 1991 – in note). Each node having direct parents is assigned the conditional probability table (CPT) of the variable, given its parents. For variables without parents, the node contains an unconditional (also called marginal) distribution.

A Bayesian network can be drawn on the basis of knowledge of the system, as derived by the review of the literature, the analysis of the existing data, as well as the information collected through direct appraisal and/or consultation with experts and knowledgeable stakeholders. In this case, the network structure and parameters are based on a subjective approach to the quantification of probability (as developed by Ramsey, Savage and De Finetti), and the probabilities are 'elicited' (i.e., assigned) considering the likelihood of an event that the network builder can consistently estimate on the basis of the knowledge he/she acquired.

Alternatively (as has been the case in the present work), the structure of the Bayesian network can be learnt inferentially from a set of data. This method is called 'structural learning' and works by testing the conditional

[39] Two sets of variables, A and B, are said to be (conditionally) independent given a third set C of variables if when the values of the variables C are known, knowledge about the values of the variables B provides no further information about the values of the variables A.

(in)dependence among one variable and all the other variables through an iterative process: for each couple of variables, the (in)dependence is tested conditionally to the subset of all the other variables. The statistical software that has been employed in this analysis – Hugin Researcher 7.0 – allows the analyst to learn the structure of the dependencies directly from the data by using either the PC-Algorithm or the NPC-Algorithm. Both algorithms perform dependence tests that calculate a test statistic which is asymptotically chi-squared distributed assuming (conditional) independence.

The use of graphical models thus allows to bypass a number of problems typically stemming from econometric modelling. In particular, the structural learning makes it possible to appraise the structure of dependencies inferentially, with no need for prior specification of the model. Furthermore, Bayesian networks can represent a truthful description of the reality even when a pure deterministic analysis is not possible, due to unavailability of complete or sufficient quantitative data, or due to the need to integrate quantitative with qualitative information (as is often the case when dealing with social capital variables).

However, the main advantage associated with the use of Bayesian networks for investigating inherently context-dependent, micro-level concepts – such as social capital and other socio-economic dimensions – is that the analysis expresses interdependency relationships more complex than mere causality directions. Moreover, software such as Hugin can be used to forecast possible scenarios and also to simulate the impacts of alternative situations/policies/actions by differentially influencing the variables' values and states. Once the network has been built based on the existing situation, it is possible to modify manually the marginal distribution or the CPT associated to a root or a non-root node, respectively, and all the backward and the forward linkages change subsequently. Also, it is possible to propagate the evidence for a certain variable state or value – that is, to simulate that the variable always assumes that state or value throughout the whole sample – and see how this affects the whole dependence structure.

All the Bayesian networks used in the present analysis have been built using Hugin Researcher 7.0, running the NPC-Algorithm at a level of significance set at 0.05. Two kind of graphical representations have been employed. Each Bayesian network is represented as a directed acyclic graph (DAG) in which the ovals stand for the nodes (i.e., the variables) and the arrows stand for the edges. A link such as 'A ---> B' means that B is conditionally dependent on A, given the entire set of variables. A second type of graphical representation shows selected nodes and edges through so-called 'monitor windows' instead of ovals. The monitor windows show the relative frequency associated with each variable's state, according to the related conditional probability table (CPT) (see, for instance, Figure 1). This kind of representation is used when evidence was 'entered' (or 'propagated') in one or more nodes (i.e., when one simulated that a variable assumes only one state) in order to show the effects on the frequency distribution of the variables linked directly and indirectly to the first one/s. For example, in the three images of Figure 1, the red bar in the monitor window of the variable Occupation indicates that evidence was entered in order to simulate what would happen to the frequency distribution of the Capability Index node (represented by the green bars) if the main occupation of the whole sample was, respectively, Salary job, Subsistence agriculture, and Petty trade (the red bar represent the state of the variable that was modified manually).

Figure 1
Conditional dependence among socio-economic variables, whole sample. Evidence in the Occupation node

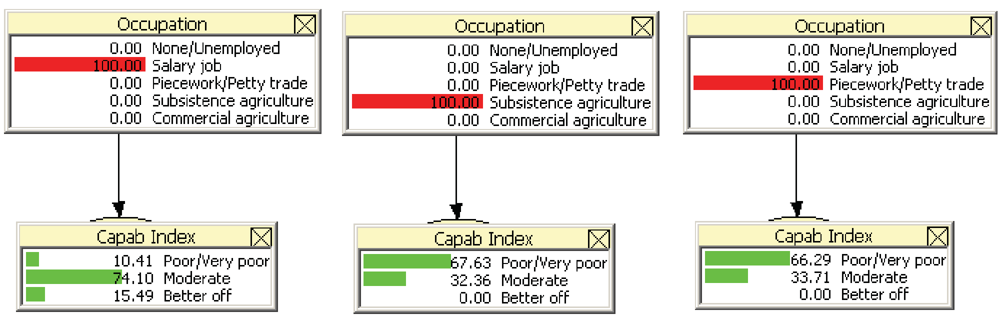


FIGURE 2
Conditional dependence among farming related variables, whole sample

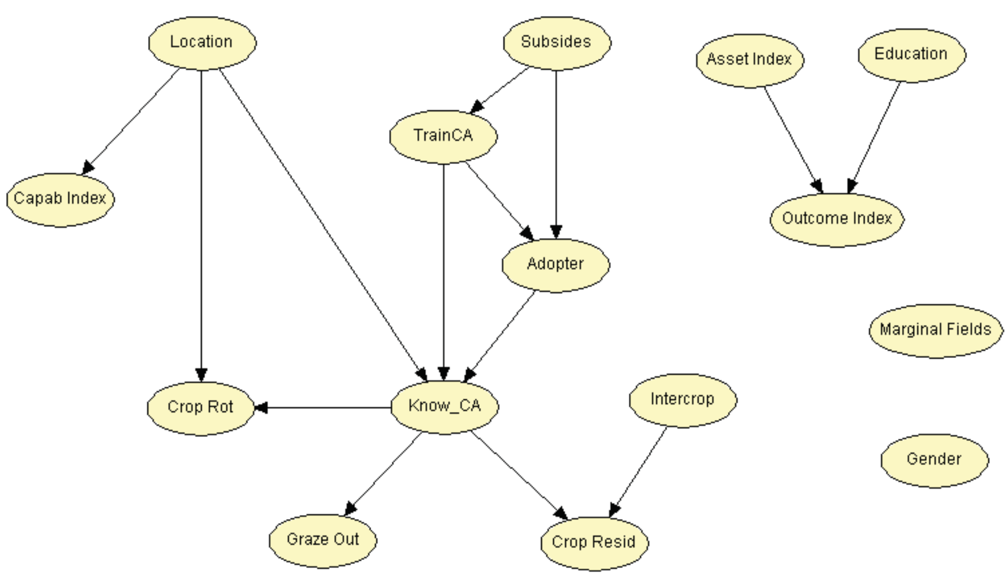
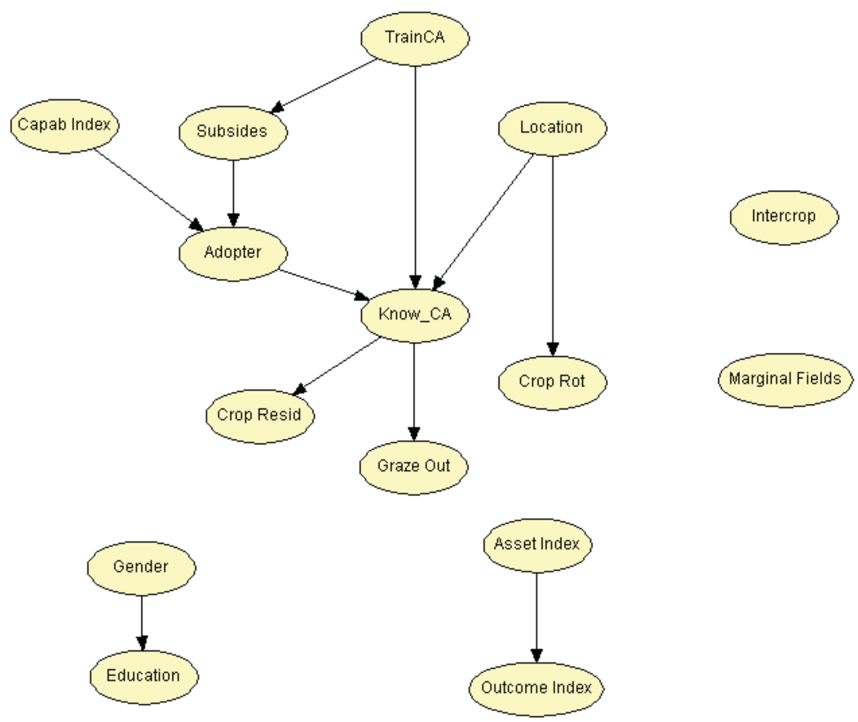


Figure 2 shows the relationships among socio-economic and farming related variables for the whole sample. The effect of Subsides and Training on the Adopter category and on the degree of knowledge of CA (Know CA) is consistent with the expectations, so are the linkages among Know CA and the practices of Crop Rotation, Graze Out of the Fields, Crop Residues as Mulch and Intercropping. None of the socio-economic variables, nor the cultivation of Marginal Fields, are linked to any agriculture related aspect, suggesting that they do not play a critical role in the adoption and the diffusion of the practice.

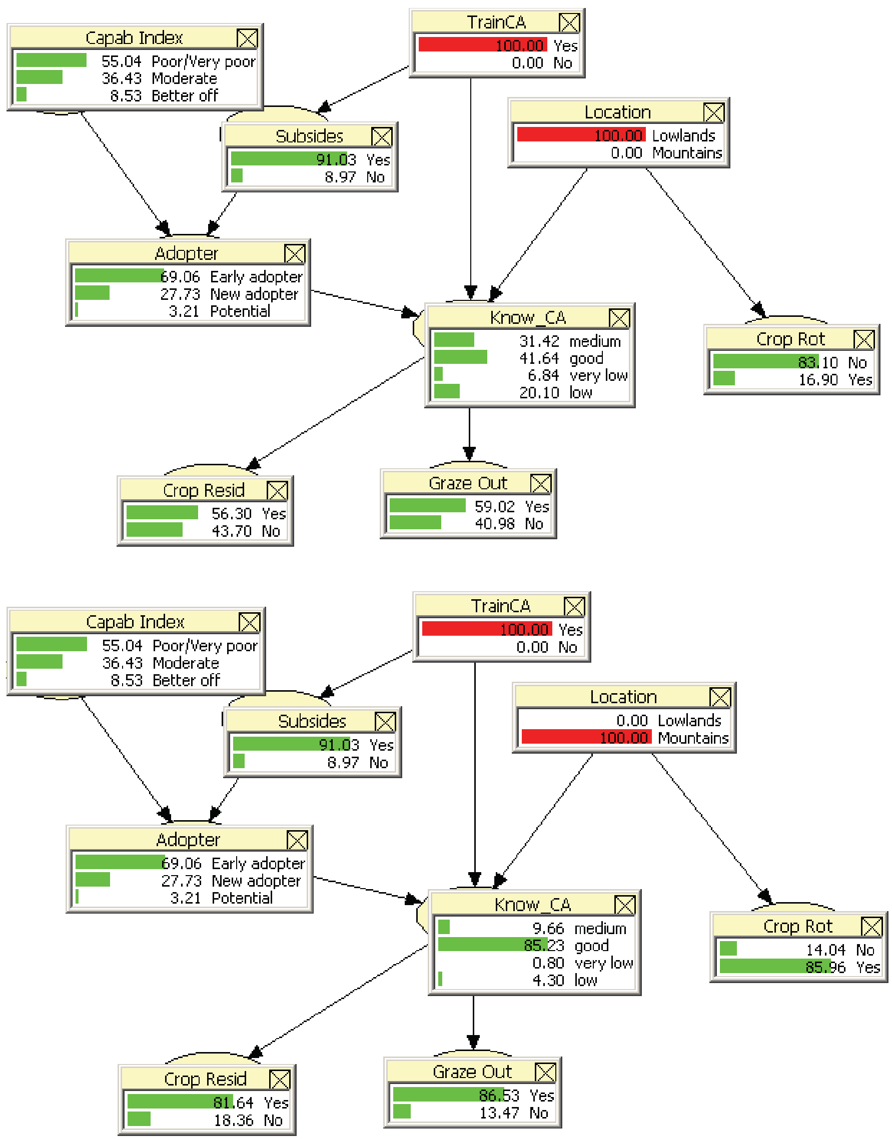
The Bayesian network learnt from the Adopter sub-dataset (Figure 3), confirms most of the results discussed previously.

FIGURE 3
Conditional dependence among farming related variables, Adopter sub-sample



By entering the evidence in the Location node (Figure 4), the effect of training on knowledge and, in turn, the effect of the location and the knowledge on the employment of conservation measures, are weaker in the lowlands than in the mountains. The variable Intercropping is excluded from the network, confirming that this practice plays a marginal role also among the adopters (and suggesting that farmers might deem it not suitable to the local agricultural practice).

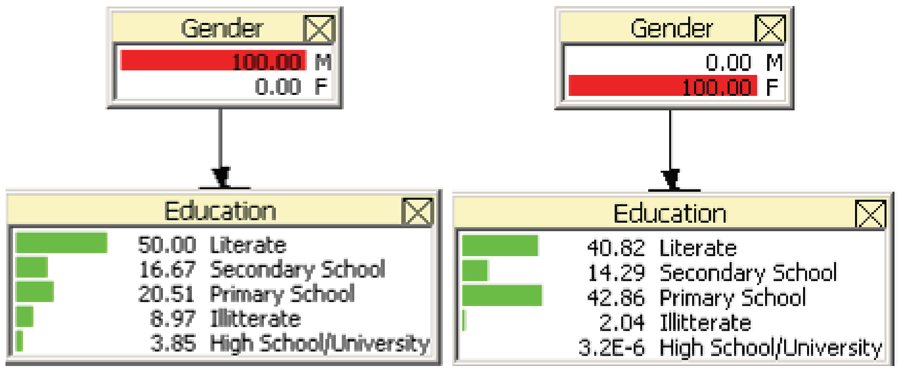
FIGURE 4
Conditional dependence among farming related variables, Adopter sub-sample. Evidence in the Location and Training nodes



Looking at the socio-economic variables, the ownership of marginal fields, endowment with assets and the gender of the head of the household do not affect either the adoption or the performance of CA. However, the educational level and the gender of the CA farmers are interrelated (Figure 5), confirming that better educated women are more likely to adopt the conservation technology, as shown also by the tests performed on the frequencies.

FIGURE 5

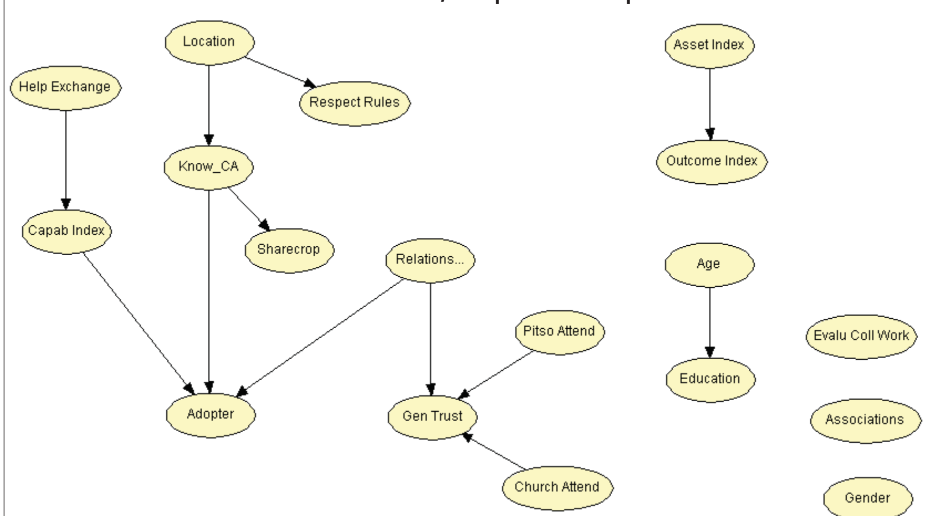
Conditional dependence among farming related variables, Adopter sub-sample. Evidence in the Gender node



Among the adopters (Figure 6), the quality of the relationships in the community, the level of trust, the attendance at church gatherings and at the pitso are all interrelated and, through the node Quality of the Relations in the Community, affect the Adopter variable. Adopter is also influenced indirectly by the rate of help exchange. These findings support the hypothesis that both the dimensions of social capital identified are relevant to the adoption of CA, even though the frequency analysis would suggest that the importance of the "network dimension" is greater for the CA farmers in the lowlands than the importance of the "trust dimension" for the CA farmers in the mountains.

FIGURE 6

Conditional dependence among social capital and adoption related variables, Adopter sub-sample



Conservation Agriculture and Sustainable Crop Intensification in Lesotho

Lesotho is a small mountainous country characterized by extensive land degradation and erratic climatic conditions. In recent years a growing number of development agencies have been promoting conservation agriculture (CA) as a means to enhance rural livelihoods through sustainable production intensification. The present case study prepared under the AGP Framework for Sustainable Crop Production Intensification draws on the data collected by FAO in 2006 and illustrates the impact of CA and more specifically the local version of CA, the likoti-system, on sustainable crop intensification in the south-eastern highlands of Qacha's Nek district and in the western lowlands of Butha-Buthe and Berea. According to these data, the adoption of likoti has brought about significant advantages compared to conventional tillage.

The case study is directed to decision makers influencing national policies from a technical background, the development and environmental communities as well as readers interested in sustainable agriculture. It proves the case that Conservation Agriculture is also successfully being practiced in Africa and that it can be done even without external inputs.

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