

The value chain for seed and ware potatoes in Kenya

Opportunities for development



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Opportunities for development

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Foreword

Potato in Kenya is an important food crop, second to maize. In 2011 the Dutch and Kenyan government agreed to support a public-private partnership initiative to support seed potato development in Kenya in order to increase yields and enhance food security.

The Ministry of Economic Affairs, through the Netherlands Embassy in Kenya and the office of the Agricultural Counsellor at the Netherlands Embassy in Kenya, commissioned a mission to study the opportunities for development of the seed and ware potato value chains in Kenya with private sector support.

LEI and Centre for Development Innovation (CDI), both part of Wageningen University and Research Centre, were tasked with compiling the report, and given their knowledge of the Dutch potato sector, the report will identify challenges and opportunities in Kenya that match the expertise and technology available in the Netherlands. Written by Bas Janssens and Siert Wiersema, the report gives an overview of opportunities and challenges of the Kenyan potato value chain, in particular seed potato supply, mechanisation, storage and linking producers and markets. I trust this report will contribute to a better understanding of the challenges the potato sector in Kenya is facing.

May 2013

Hans Wolff - Agricultural Counsellor
Embassy of the Kingdom of the Netherlands - Nairobi, Kenya

Summary

S.1 Key findings

In Kenya potato is an important food crop, second after maize. Potatoes are grown on 128,000 ha per year with average yields of about 8 tonnes per ha. The yield is far below its potential and should be improved to enhance food security.

Of all potato growers in Kenya, 98% are characterised as small-scale farmers, producing less than 0.4 ha of potatoes per year per farm (total of two planting seasons). They produce 83% of the national production. Lack of good quality seed is a main reason for low yields. The fast-track seed project aims to improve availability of certified seed. Imported seed needs to be multiplied locally once or twice to reduce the cost price and make it affordable for small-scale growers. It is estimated that there is potential for at most 1,000 ha of professional seed production in Kenya to meet the market demand for certified seed. In Kenya about 98% of ware potatoes are sold for 'fresh' consumption. For industrial processing the most favourable opportunities are the production of crisps and fresh - not frozen - French fries.

To change the low-input low-output strategy of many small-scale farmers linkages between producers and markets need to be improved.

S.2 Complementary findings

In the short term, improvement of potato growing and crop management should receive higher priority than storage and mechanisation. Storage and mechanisation should be adapted to local conditions and needs. Two cases have been indicated in which investments in professional cooled storage facilities are necessary;

- storage of seed potatoes of varieties with a long dormancy period;
- storage of ware potatoes for processing industry and some high-end retailers.

Long-term seed storage in modern stores required for varieties with long dormancy increases the cost price of seed by 50% compared with short-term storage in diffused light stores. This makes short dormancy an important trait for potato varieties in Kenya, where potatoes are planted during two growing seasons.

Machinery supplied for potato growing in Kenya should be geared to local needs. Higher yields and more multiplications of imported seed reduce the cost price of seed potatoes produced in Kenya. The cost price of imported seed after two multiplications is competitive with locally produced seed from minitubers after three multiplications.

S.3 Methodology

This report describes the current situation of the potato sector in Kenya and opportunities for further development. The study focuses on possibilities of the Dutch agribusiness to facilitate these developments. Existing information has been collected, although information on potato production was not easily available. In addition, during a mission to Kenya stakeholders were visited and interviewed. This resulted in cost-price calculations for seed potato production (short and long-term storage, imported seed and minitubers) and market information.

Samenvatting

De waardeketen van poot- en consumptieaardappelen in Kenia Kansen voor ontwikkeling

S.1 Belangrijkste uitkomsten

In Kenia zijn aardappelen na mais het belangrijkste voedselgewas. Het areaal aardappelen ligt op ongeveer 128.000 ha per jaar met een gemiddelde opbrengst van circa 8 ton per ha. De opbrengsten zijn aanzienlijk lager dan de potentieel haalbare opbrengsten en moeten worden verhoogd om de voedselzekerheid te vergroten.

Van alle aardappelproducenten in Kenia is 98% te karakteriseren als kleine producenten die minder dan 0,4 ha per jaar per bedrijf telen (totaal van twee groeiseizoenen). Gezamenlijk produceren ze 83% van de nationale aardappelproductie.

Het 'fast-track seed project' heeft als doel de beschikbaarheid en kwaliteit van pootaardappelen te verhogen. Geïmporteerde pootaardappelen zouden in Kenia één of twee keer vermeerderd moeten worden om de kostprijs te reduceren tot een voor kleine boeren aanvaardbaar niveau. Geschat wordt dat in Kenya mogelijkheden liggen voor de professionele teelt van hoogstens 1.000 ha pootaardappelen om aan de potentiële vraag naar gecertificeerd pootgoed te voldoen.

In Kenia wordt 98% van de consumptieaardappelen verkocht voor verse consumptie. Voor de verwerking zijn de kansen het beste voor chips en koelverse frites.

S.2 Overige uitkomsten

Op korte termijn verdient de verbetering van de aardappelteelt en gewasmanagement hogere prioriteit dan opslag en mechanisatie. Opslag en mechanisatie moeten afgestemd worden op lokale omstandigheden en behoeften. Er zijn twee gevallen in kaart gebracht waar investeringen in professionele luchtgekoelde aardappelbewaarplaatsen nodig zijn:

- opslag van aardappelrassen met een lange kiemrustperiode;
- opslag van consumptieaardappelen voor de verwerkende industrie en een enkele luxe supermarkt;

Langdurige opslag van pootaardappelen met een trage kiemrustdoorbreking in moderne bewaarplaatsen verhoogt de kostprijs van pootaardappelen met 50% ten opzichte van kortdurende opslag in eenvoudige zogenaamde 'diffused light'-bewaarplaatsen. Dit maakt korte kiemrust een belangrijke gewenste eigenschap van aardappelrassen voor Kenia, waar aardappelen twee seizoenen achtereen geteeld kunnen worden.

Mechanisatie-import moet afgestemd worden op lokale behoeften. Hogere opbrengsten en meerdere vermeerderingen van geïmporteerd pootgoed verlagen de kostprijs van in Kenia geproduceerde pootaardappelen. Na twee vermeerderingen is de kostprijs van lokaal geproduceerd pootgoed concurrerend met het pootgoed verkregen uit drie vermeerderingen op basis van miniknollen.

S.3 Methode

Dit rapport beschrijft de huidige situatie van de aardappelsector in Kenia en de kansen voor de verdere ontwikkeling van deze sector. De studie is gericht op mogelijkheden voor de Nederlandse agribusiness om deze ontwikkelingen te faciliteren. Bestaande informatie is verzameld, hoewel de informatie over de aard-

appelsector in Kenia niet eenvoudig beschikbaar. Tijdens een missie is meer gedetailleerde informatie verzameld en zijn verscheidene stakeholders in Kenia bezocht. Dit leidde tot een kostprijs voor de pootgaard-appelproductie (korte en lange bewaring, en miniknollen) en marktinformatie.

1 Introduction

1.1 Background

In 2011 the Kenyan Ministry of Agriculture, the Netherlands Ministry of Foreign Affairs and Economic Affairs and the Dutch embassy in Nairobi joined hands and started the seed potato development project. This project is a public-private initiative that supports the development of the Kenyan seed potato value chain.

The potato sector in Kenya has huge potentials and can contribute to food security. Because there is currently limited knowledge of the potato sector, there is a need for an inventory and a description of the actual situation, and an assessment of possible developments. On behalf of the seed potato project, specific needs related to technology and knowhow of local potato growers on storage and mechanisation have been identified. Dutch suppliers can fulfil those needs and can contribute to the future development of the potato sector in Kenya.

1.2 Objective

The objective of this study is to:

- Give an overview on the potato sector in Kenya, related to areas of production and production volumes;
- Identify the main bottlenecks and prospects in the seed and ware potato value chain;
- Identify business opportunities for the Dutch potato industry and technology providers.

1.3 Method

Although information on agriculture and especially the potato sector in Kenya is not easily available, by means of a literature review some information has been collected. It was hardly possible to find statistical data and useful recent figures of the Kenyan potato sector. In addition, various publicly available data sources (e.g. FAO, CIP, Kenyan ministry of Agriculture) have been consulted in order to get a broad overview of Kenyan potato crop-production statistics. Also, a mission to Kenya was organised to interview stakeholders from the potato sector. During these in-depth interviews primary information was gathered and secondary data were validated. Appendix 1 gives an overview of the visited stakeholders.

2 Potato production in Kenya

2.1 Introduction

In Kenya, potato is the second most important staple crop after maize and plays a major role in national food and nutritional security. Its ability to grow in high altitude areas where maize¹ does not do well and its high nutritional value makes it an important food crop. Potato is grown by some 500,000 farmers on about 128,000 ha with average yields of 7.7 tonnes per ha. Most potato growers are small-scale farmers; it is estimated that 90% of them have land holdings of less than 1 ha. Fewer than 0.05% of potato growers have more than 25 ha of land.

In 2007, Kenya was the eighth biggest potato producer in Sub-Saharan Africa, after Egypt, Malawi, South Africa, Algeria, Morocco, Rwanda and Nigeria, with an output of 790,000 tonnes in 2006 (FAO statt). Furthermore, potatoes are an important food and cash crop in the medium and high rainfall areas.

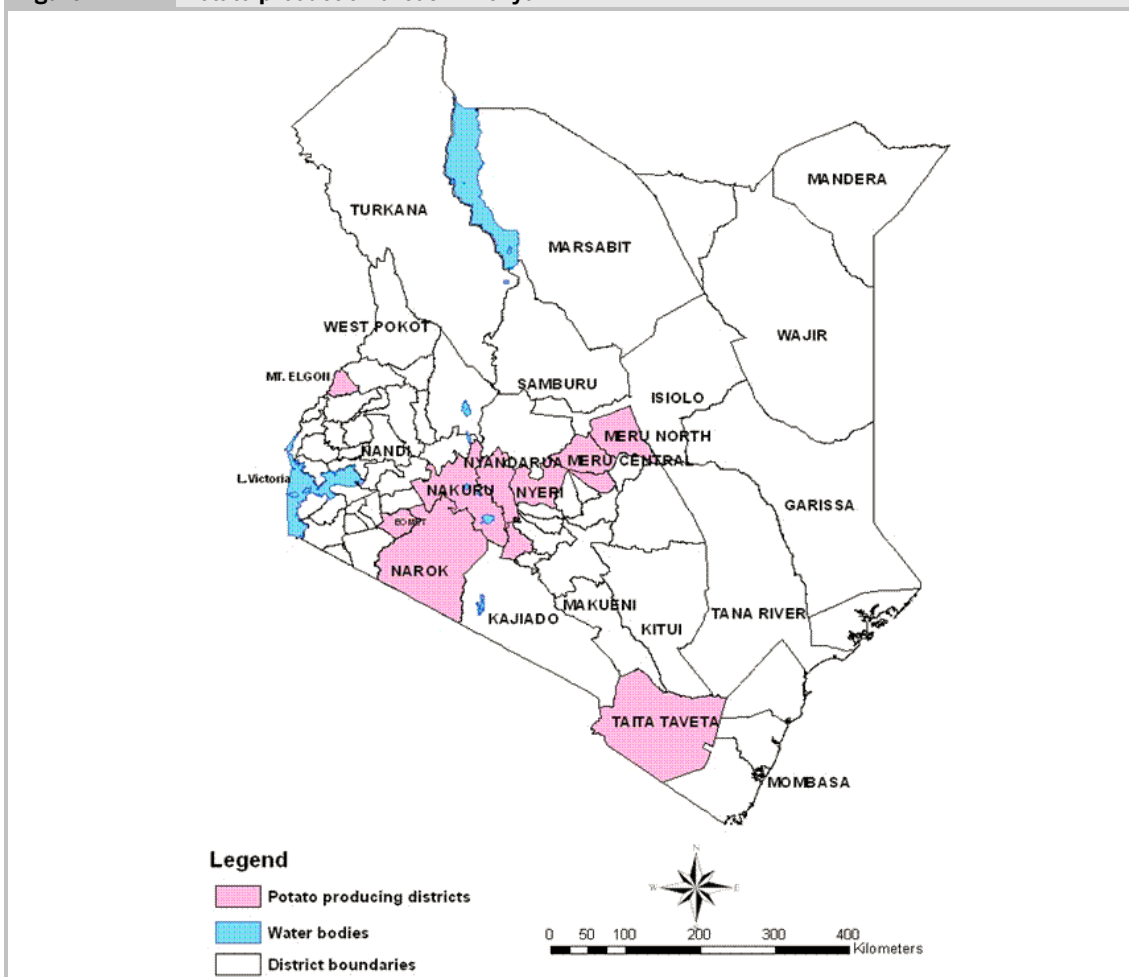
Appendix 2 gives a brief overview of the Kenyan economic situation. When the main bottlenecks - infrastructure and the investment climate - are solved, Kenya could become an industrial hub and a strong exporter. This would enable the country to reach 6% growth in the medium term, which would propel it to the Middle Income Country status of USD1,000 per capita income by the end of this decade.

2.1.1 Production regions

In Kenya, potatoes are mainly cultivated in the high-altitude areas (1,500-3,000 m above sea level), where Kenya's main staple food maize has no comparative advantage. These areas include the slopes of Mt. Kenya, such as Meru, Embu and Kiringa; parts of Laikipia and both sides of the Nyandarua (Aberdare) range that covers parts of Nyeri, Muranga, Kiamba and Nyandarua Districts. Potatoes are also grown in the highlands on Mau Escarpment (Mau Narok and Molo) Tinderet, Nandi Escarpment and Cherangani hills. Small acreages are also cultivated in the Kericho and Kisii areas and isolated patches near the Coast in the Taita hills. Cultivation is concentrated in highland areas from 1,200 to 3,000 m above sea level; over 70% of potato production is grown above 2,100 m above sea level. At this altitude potatoes grow faster than maize and produce more energy and protein per ha per day.

¹ Recent years yields of maize, the most important crop, have decreased, due to virus diseases.

Figure 2.1 Potato production areas in Kenya



2.2 Farm size

Specific to the Kenyan potato sector is the great number of small-scale farmers. Table 2.1 presents an estimation of the number of different types of potato growers: small-scale, small/medium-scale, medium/large-scale and large-scale farmers. This estimation is based on statistics (FAOSTATT): 135,000 ha (2008), 121,500 ha potatoes (2010) and 500,000¹ farmers (KENAPOFA, 2010).

Table 2.1 Estimation of composition of potato growers groups					
Potato growers group	% farmers	No. farmers	Average potato area per farm (ha)	Total potato area (ha)	% area
Small scale	90.0	450,000	0.2	90,000	70
Small/medium scale	8.0	40,000	0.4	16,000	13
Medium/large scale	1.95	9,750	2	19,500	15
Large scale	0.05	250	10	2,500	2
Total	100.0	500,000		128,000	100

Source: own estimation.

¹ The exact number of potato growers is unclear. Other sources suggest 790,000 growers.

Potatoes in Kenya are grown mainly by small-scale farmers, many of them women, although some larger-scale growers specialise in commercial production. The table shows that small and small/medium-scale farmers have more than 80% of the potato acreage under production. There are no figures indicating the production volumes by the different groups.

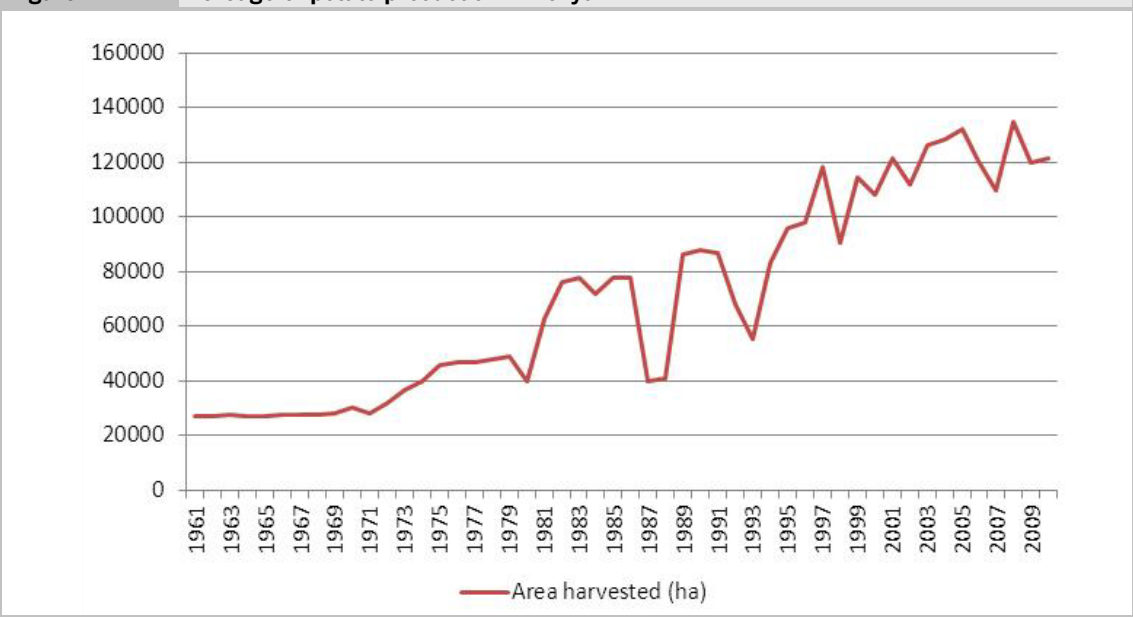


Small-scale ware potato field

2.3 Low yields

While average potato yields in North America and Western Europe often reach 40 tonnes per ha, yields in developing countries are usually below 20 tonnes per hectare. The national average potato yields for Kenya have been reported at 7.7 tonnes per hectare, but this figure has fluctuated considerably over recent years, from 9.5 to less than 3 tonnes per ha (FAO). In more recent years yields per ha were very low (Appendix 3).

Figure 2.2 Acreage of potato production in Kenya



Source: FAO Stat.

The low potato yields have been attributed to poor agronomic practices, low use of inputs - especially fertilisers and fungicides - low soil fertility, limited access to good quality seeds, poor seed stock, diseases (particularly late blight, brown rot, and viruses), and insect pests such as the potato tuber moth.

As a result of low potato yields the profitability of potato crop is minimal as well. Appendix 5 shows a gross margin calculation of ware potato growing. Figures show the costs of seed are very high: more than 50% of all input costs (seed, fertilisers and chemicals).

2.4 Production constraints

2.4.1 Seasonality

Most farmers produce potatoes twice a year due to bimodal rainfall patterns in most potato growing areas. The long rainy season lasts from March/April to June/July, while the short rainy season lasts from October to December.

Figure 2.1 Two seasons potato cropping scheme: long and short rain

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Short rains		H	H							P	P	
Long rains			P	P			H	H				
Irrigated	P	P			H	H		P	P		H	H

P= planting, H = harvesting

Source: Kenyan ministry of Agriculture (1998).

Off-season potato production is limited to a few areas where irrigation is available. However, most farmers use their irrigation water for other high value crops such as vegetables and flowers. This seasonality of production limits profitability in potato farming as the majority of farmers depend on rainfall leading to gluts and lean times consecutively. June to August is usually the glut season while December, April and May are the scarce periods. Farm gate prices during the scarce periods are often 2-4 times higher than the price during the glut season.

Since farmers usually do not store their ware potatoes, they are faced with low prices during the glut season. On-farm research has shown that farmers can store potatoes in low-cost, on-farm stores for periods up to 2 months, until the potatoes start to sprout. The main reasons farmers do not store their potatoes are: a) the immediate cash needs at harvest time, b) the dependency on traders who may only come to buy potatoes during harvest periods, and c) consumers who are used to buying freshly harvested potatoes and often pay a lower price for 'stored' potatoes.

2.4.2 Low soil fertility

A constraint on potato production in the highlands of Kenya is the rapid decline of soil fertility due to continuous cultivation without adequate replenishment of mined nutrients. Due to the small size of farm holdings, farmers continually plant crops on the same land practicing intensive cropping systems, without a fallow period. Fertiliser is mostly applied below the recommended rate. The often applied Diammonium phosphate has been in use for a long time while it has been shown that this leads to increased soil acidity. The acidity problem is compounded by the fact that the soils in the highlands are derived from acidic volcanic rocks and have been highly leached by high rainfall. As a result, most of the potato growing areas in Kenya have a soil pH of less than 5.5. This severely limits availability of potassium, nitrogen, phosphorus, sulphur, calcium and magnesium while availing excessive levels of aluminium, manganese, boron, iron and zinc. It is quite possible that the problem of low soil pH has led to nutrient imbalances that lead to even further decline of potato yields. Soil analysis as a basis for fertiliser application is therefore critical in most potato producing areas.

2.4.3 Lack of certified seed

There is insufficient supply of certified seed to the extent that farmers almost entirely depend on informal seed sources. Informal seed sources include positively selected and farm-saved seed, seed from local markets and seed purchased from neighbours and relatives. The main source of seed for most farmers is small seed tubers saved from the previous harvest. Only about 1% of the potato area is planted with certified seed.

Kenya Agricultural Research Institute (KARI), Tigoni, has the mandate to produce basic seed for multiplication in high altitude farms. Until recently, KARI Tigoni was the sole source of clean basic seed in Kenya. Due to its double mandate of research and commercial production of basic seed, and further handicapped by institutional arrangements hampering productivity and efficiency, KARI Tigoni has not been able to produce more than 25-50 tonnes of basic seed per year.

Recently, the International Potato Center (CIP) has promoted the use of hydroponic systems (including aeroponics) in which minitubers are produced from in-vitro plants in protected greenhouses. Minitubers are harvested at regular intervals while plants are kept in good condition via a continuous supply of water and nutrients. The system is applied worldwide and is known to be very sensitive to management practices. In addition, minitubers tend to be small and therefore sensitive to growing conditions when the first-generation tubers are planted in the field. Yields and health of crops planted from first generation minitubers is therefore often disappointing. In Kenya, KARI Tigoni as well as several large seed farms have installed aeroponic units to produce mini tubers. Based on results from other countries it is expected that in the short term these aeroponic units will not supply sufficient amounts of clean seed in order to solve the inadequate supply of certified seed in Kenya. This has been the main reason that the Dutch Government has been asked by the Kenyan Ministry of Agriculture to work together with the Kenyan seed sector and the quarantine organisation Kephis to design and implement a fast track system for rapid supply of adequate quantities of healthy seed to Kenyan farmers (see section 3.2.1).



Potato planting

2.4.4 Brown rot

In most potato growing areas, brown rot (caused by *Ralstonia solanacearum*) is considered as an important disease contributing to poor yields, high post-harvest losses, and poor quality of farm-saved seed. In Kenya, brown rot is generally referred to as 'bacterial wilt' due to its symptoms in the field. Lack of crop rotation, use of infected seed, and absence of chemical control methods are main causes of the spread of this disease to most of the potato growing areas. The situation is further aggravated by the absence of a certified seed programme that would normally control the trade of planting material and ensure its quality. At present farmers can buy seed anywhere in Kenya without knowing the quality of the seed. In seed with latent infection, the presence of the disease is not visible for seed buyers and this is a potential source of inoculum of brown rot leading to disease outbreaks and pathogen spread from place to place and season to season. It can be concluded that brown rot is a major threat to the potato sector in Kenya. It is hoped that through supply of healthy seed from the fast track seed potato project combined with a national strategy to control brown rot this disease can be gradually controlled.

2.4.5 Late blight

Late blight caused by *Phytophthora infestans* is a major fungus disease in Kenya causing huge yield losses. The climate is favourable for the development of late blight, particularly during the two rainy seasons. High costs of chemicals to control the disease limit the use of fungicides, particularly by small-scale farmers. Instead of applying preventive applications of fungicides they often start spraying when the disease is already present in the field making control very difficult. Infested fields are then the source of inoculum (spores) for other fields and in this way late blight can spread rapidly throughout the production areas. The situation is further aggravated by poor spraying techniques and the use of cheaper and less effective chemicals. Varieties with some degree of resistance are available but they still need fungicide applications to control the disease. It has been observed that late maturing varieties tend to have more resistance to late blight than early varieties but farmers in Kenya prefer early maturing varieties. It can be concluded that methods to control late blight are available but they are not adequately applied by small holders with

limited resources for inputs. Only market-oriented farmers with good crop management experience can adopt effective control practices.

2.4.6 Crop rotation

Crop rotation is essential to minimise build-up of soil-borne diseases and pests and to maintain adequate soil structure and fertility. For seed potato production crop rotation is essential to ensure good health standards of the seed produced. Crop rotation is particularly important to avoid problems with bacterial diseases such as brown rot and various species of nematodes.

In countries such as the Netherlands a minimum crop rotation of 1:3 is mandatory for potato meaning that potatoes are grown in the same field once in three cropping seasons. Increasingly, seed potato producers adopt a crop rotation of 1:4 in order to increase the health standard of seed potatoes.



Ware potato production field near Mount Kenya

In Kenya, farm size is small and potato growing is very popular both as a cash crop and as a food crop for home consumption.¹ As a result, there is a high frequency of potato production within the rotation. Often potatoes are produced every other season on the same field; in some cases crop rotation is not applied at all, especially in areas with intercropping. In the long run, the current practices in Kenya are not sustainable from the point of view of soil-borne disease and pest management, as well as soil structure and fertility management. The situation is further aggravated by the fact that some (small) tubers remain in the soil after harvest and produce volunteer plants in the next crop. The next crop is supposed to be a rotation crop but these volunteer plants will allow diseases to multiply from one season to the next season so the effect of crop rotation is severely reduced.

¹ Small-scale farmers use a part of their seasonal ware potato production for own home consumption which means they don't receive any cash for this part to invest afterwards.

2.4.7 Storage

Since there are usually no long intervals between harvests (typically two to three months), storage of ware potatoes for sale and consumption is not a usual practice in Kenya. In some areas such as Meru District, farmers have developed their own structures, constructed of cement floors, wooden walls and corrugated iron roofs. At higher altitude locations where the climate is colder, such as the Timau region, farmers store potatoes outside the house covered with dry grass, which can be effective for up to three months. Storage structures promoted by the National Potato Research Centre in Tigonu have not been widely adopted.

Farmers in Kenya store potatoes for three major reasons which include:

- Provision of seed for the subsequent crop
- Preservation of ware potatoes for home consumption
- Surplus in hope getting higher market prices

Seed tubers are often stored in pits lined with dry leaves and covered with straw, where they are likely to sprout prior to being replanted. Seed is stored for about two months between harvest and next planting. Generally seed potatoes are stored in houses or in piles on the ground in sheds. A few farmers store seed in so-called Diffused Light Stores (DLS). In these stores seed tubers are stored on trays or racks arranged in layers in 'shaded, well aerated rustic stores'. Even though this type of store provides excellent conditions for seed tubers, it is not widely used.

In Meru there are only three weeks between harvest and planting. For breaking dormancy Meru farmers store seed potatoes in closed pits.

Ware potatoes are stored up to three months which is generally insufficient to maintain a supply of potatoes until the next harvest. Many farmers buy potatoes for home use after consuming their own. Farmers typically store about a half a tonne of potatoes in their house or farm building for their own use for up to nine weeks. Losses during storage can average up to 20% for the two-month storage period.

2.4.8 Mechanisation

Most small-scale farmers cannot afford motorised mechanisation (no cash to invest, farm acreage and parcels are too small) and do most work manually (planting, fertilising, harvesting). Only for spraying, most small-scale farmers use a manual or motorised knapsack sprayer with varying degrees of success. Applying manure, fertiliser and pesticides manually gives misdistribution which finally restricts crop production (yield). During the December mission we visited a number of farms growing potatoes on larger scale. Generally speaking the level of mechanisation is medium to low. The age of machines is often high.

Soil

Although the soil was not examined a first impression is that in different areas the soil was medium heavy with a small percentage of stones. When the rainy season is still active during the harvest period attention has to be paid to haulm killing, especially for seed potatoes. Another important subject is the sieving capacity of the windrowers and harvesters in order to get rid of the soil and to be able to harvest in the first place. Larger farms should consider a store loading line where the hopper-bunker could or even should be equipped with a roller cleaning unit to sieve out the remaining soil before storage.

On the other hand with medium heavy soil in dry conditions during the planting season a decent soil preparation creating a fine planting bed is advised. Rotary harrows and or power harrows for soil bed preparation and rotary ridgers to increase to ridge volume after planting can improve the potato growth substantially.

2.4.9 Finance seed and equipment

Major financial issues facing farmers are insufficient capital for growth, expensive inputs, poor returns and diversion in funds and cash flow difficulties between planting and harvesting. Seed costs amount 40%-50%

of the total input costs (seed, fertiliser, spray) and even more in case of certified seed. Such high expenses force potato growers to economise on seed investments and seed quality by preferring informal seed sources (see Section 2.4.3). Most small-scale farmers never buy any certified seeds but collect seed potatoes they need from their own or neighbour's ware potato production. Moreover most small-scale farmers consume a great part of their potato production themselves. The negative side of home consumption is that no cash is generated to invest in the next crop.

Finance of small investments in seed potatoes is difficult for most farmers because they lack cash. These farmers prefer to invest in crops with the highest profitability first, such as vegetables. Sources to finance are personal savings, bank loans and supplier credit. Most farmers (75-80%) only use personal savings as a source of finance. Regarding banking at least 20% of the Kenyan farmers do not operate a bank account. Bank rates for commercial bank loans and advances were 20% (2012, Kenyan National Bank of Statistics), which makes costs of finance extremely high. With such interest rates it is only logical that farmers (and processors) are interested in investments that give high returns in the short term.

2.5 Main findings

In Kenya potato is an important food crop, second after maize. Potatoes planted during two growing seasons per year, are grown on 128,000 ha per year with average yields of about 7.7 tonnes per ha. Potato yields are far below their potential and should be improved to enhance food security.

Of all potato growers, 98% are characterised as small-scale farmers. It is estimated they produce 83% of the national production. Main problems potato producers have to deal with:

- Brown rot or 'bacterial wilt' is a widespread and important disease contributing to poor yields, high harvest losses and poor quality of farm-saved seeds. Besides brown rot other diseases such as late blight causes huge yield losses;
- Lack of certified seed. There is insufficient supply of certified seed to the extent that farmers almost entirely depend on informal sources. The main source of seed for most farmers are small seed tubers saved from the previous harvest. Only about 1% of the potato area is planted with certified seed.
- Seed costs amount to between 40 and 50% of the total input cost and even more in case of certified seed. Lack of cash, credits and high interest rates force small-scale farmers to a low input - low output strategy: consequently product quality and yields are low.
- Seed and ware potatoes are stored for a short period of at most 2 to 3 months. Most storage facilities are very simple such as pits, in piles or even in house or; losses during storage can average up to 20%.
- Most small-scale farmers do most work manually; they cannot afford mechanisation. On larger farms the level of mechanisation is low and the age of machines is often high.

3 The potato value chain

3.1 Introduction

This chapter focuses on the potato value chain in Kenya: institutions, the seed potato value chain and the ware potato value chain.

3.2 Institutions involved in Kenyan potato sector

Besides farmers, processors and suppliers, various players are involved in the Kenyan seed and ware potato production system. Most important actors are:

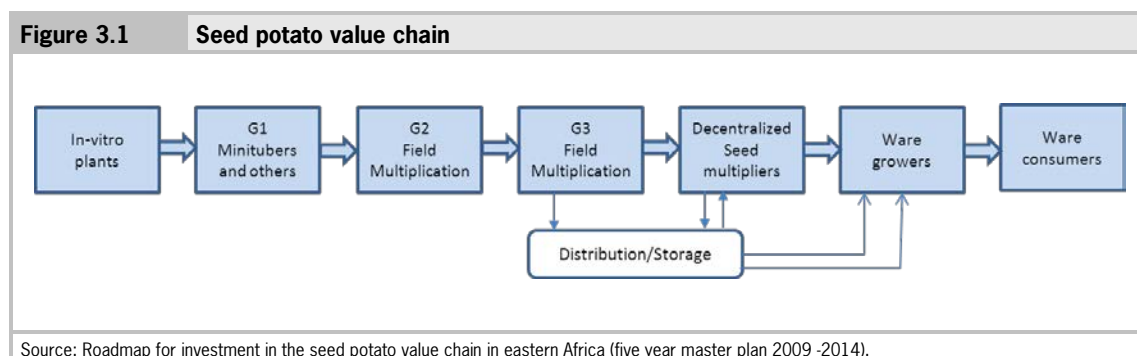
- The Ministry of Agriculture (MoA) is working on revitalising the Kenyan potato sector. The initiatives have included formulation of a National Potato Policy, review of the national framework and formation of a potato task force to look into factors affecting the industry and compile a report of its findings. MoA has requested the Dutch Government to support the development of the Kenyan seed potato sector and increase the availability of certified seed through import of seed potatoes from the Netherlands. This has resulted in the Fast Track Seed Potato Project. There is particular interest in the supply of seed potatoes of modern processing varieties;
- Kenyan Agricultural Research Institute (KARI) is a prominent national institution bringing together research programmes in food crops, horticultural and industrial crops, livestock and range management, land and water management, and socio-economics. Seed potato research is dominated by KARI-Tigoni (National Potato Research Centre) and supported by CIP. They are the main bodies involved in the potato research in the country and remain the major sources of breeding materials and pre-basic seed potatoes;
- Kenya Plant Health Inspectorate Service (KEPHIS) is a regulatory agency for quality assurance on agricultural inputs and produce in Kenya. KEPHIS undertakes: plant variety protection; seed certification; phytosanitary inspection of imports and exports and analysis of soil, water, agricultural produce, fertilisers and pesticides. Kephis is a government institution with the mandate for both quarantine issues as well as seed certification. The body is mandated to supervise and carry out Distinctiveness, Uniformity and Stability (DUS) test and National Performance Trials (NPTs) before officially releasing and allowing commercialisation of any varieties. KEPHIS is also responsible for providing import permits for seed potatoes and performing import inspections. KEPHIS is a main Kenyan partner organisation in the Fast Track Seed Potato Project.
- Agricultural Development Corporation (ADC) is a governmental parastatal with the mandate for multiplication and bulking of seed potato with KARI-Tigoni as its specific seed source for breeder seed. ADC uses the out-grower model to facilitate multiplication. ADC-Molo has a cold storage capacity of 2,000 tonnes constructed in 1985 with support of the Dutch Government. With the recent purchase of 700 acres ADC now owns over 2,000 acres of land. ADC also funded the rehabilitation of the potato cold store and built a tissue culture laboratory and minituber production facility to enable the corporation to fulfill her potato mandate.
- Kenyan National Federation of Agricultural Producers (KENFAP) has been known as the Kenya National Farmers Union (KNFU) in the past. Commodity Associations agreed to join the Union in order to strengthen the valuable voice of farmers in Kenya. The change from individual to corporate membership came in with the change of name from National Farmers' Union to a Federation of Agricultural Producers.
- Kenya National Potato Farmers Association (KENAPOFA) operates under the umbrella of KENFAP. Through its membership of 10,400 farmers growing 3,350 hectares of potato, KENAPOFA is an influential player in the sector.

- Midlands is a farmer-owned company that is registered to produce clean and certified seed. Midlands is also thought to be carrying out trials of imported varieties into the country for commercialisation.
- Suera farm is a registered seed multiplication farm planning to organise the distribution of seed potato to 200-300 farmers in the region.
- Kisima farm is also a farmer-owned company specialised in horticulture (flowers), arable farming (1,300 ha) and registered to produce seed potato.
- Financial institutions availing credits to farmers.
- The International Potato Center (CIP) with headquarters in Lima, Peru has a regional office in Nairobi. CIP works with partners to achieve food security, well-being, and gender equity for poor people in root and tuber farming and food systems in the developing world. CIP does this through research and innovation in science, technology, and capacity strengthening. CIP promotes the use of tissue culture facilities and hydroponic/aeroponic units for the production of minitubers in an attempt to make countries self-sufficient in seed supply.
- The German agency for Technical cooperation (GTZ) is a government agency providing technical assistance with limited capital funding throughout the major regions of the world. GTZ has been involved in the development of the Kenyan potato sector for decades.
- The US Agency for International Development (USAID) is the United States federal government agency primarily responsible for administering civilian foreign aid. USAID has shown interest to support the potato sector.

3.3 Seed potato

3.3.1 General information

The seed potato sector in Kenya is very small. In the value chain for quality seed potato (Figure 3.1) different actors produce seed potatoes of different generations, starting with pathogen-free seed from laboratories or imported high quality certified seed (pre -basic) and ending with ware producers.



The scheme described shows two field multiplications (G2 and G3) by specialised seed multipliers followed by distribution to decentralised seed producers for further multiplication. It is advice to multiply seed potatoes at maximum 2 or 3 times. Due to lack of seed potatoes Kenyan seed growers multiply seed potatoes 6 or 7 times or even more which leads to extreme degeneration of seed health. Because seed potato is bulky, transport costs are a significant component of final costs and multiplication should take place as close as possible to point-of-use by ware potato growers. Hence distribution and storage are very important functions in providing seed to decentralised multipliers and on to ware growers.

Available figures suggest that between 1 and 2m tonnes of ware potatoes are produced annually. To be realistic: a production of 1,000,000 tonnes per year requires 165,000 tonnes of seed potatoes. In 2011 only about 1% or 1,650 tonnes of total demand for certified seed was available.

The seed potato sub-sector

Potato yields per ha have been declining mainly due to adverse weather conditions, poor soil fertility, use of low yielding varieties and poor quality seeds. Use of low yielding varieties and poor quality seed is highly attributed to an existing inefficient seed system, regulatory and policy framework.

Although the formal system of seed potato production started in 1958, many elements of the system have systematically collapsed and only about 1% of seeds used by farmers are certified while about 3% consists of other good quality seed. Currently, the farmer seed system, is characterised by poor seed quality with 96% sourced from farm saved seed or neighbouring farms, due to unavailability of good quality seed and lack of guidelines and knowledge.

Currently the potato seeds sub-sector lacks capacity to produce and multiply (pre-) basic seed and is short of an elaborate distribution system causing farmers to have to travel long distances to source certified seed from ADC or the other few existing multipliers (see 3.3.1). The existing seed production and distribution system is characterised by a number of constraints and inefficiencies which include:

- inadequate funding and personnel at both institutional and farm level;
- inadequate distribution of roles between public and private sector;
- limited land at research and multiplication levels making it difficult to allow for the mandatory requirement of three year fallow/crop rotation. As a result inadequate quantities of breeder and basic seed are produced.

The prerequisite National Performance Trials (NPTs) and Distinctiveness, Uniformity and Stability (DUS) test for variety release are poorly funded and also perceived to be costly and time consuming. Moreover, high costs of inputs such as fertiliser; inadequate technical know-how among farmers and extension service providers; high transportation costs during distribution and the perishable nature and business of seed tubers in addition to lack of on-farm storage facilities and poor access roads have continued to slow down the efficiency of the seed potato sub-sector. Low accessibility and knowledge gaps by farmers and lack of recognition by law have continued to stifle use of other quality seeds. On the other hand, seed certification process is perceived to be costly, inefficient, bureaucratic and too involving and this is coupled with lack of knowledge and information on importance of certification by both extension service providers and farmers have compounded the above mentioned problems. Lack of stakeholders' and actors' forum or institutional structure for advocacy, lobbying and pursuance of relevant sub-sector issues has slowed down formulation, revision and implementation of relevant sub-sector policies and regulation (Seed potato sub-sector in Kenya; five year master plan 2009-2014).



Seed production field

3.3.2 Fast Track Seed Potato Project supported by the Netherlands

The lack of good quality seed is generally believed to be the main reason for the low potato yields in Kenya. Only 1% of the potato area is planted with certified seed. Local seed multiplication systems have not been able to produce sufficient quantities of (pre-) basic seed for further multiplication. As a result the Kenyan seed sector has not been able to develop into an effective seed supply system to serve a wide range of potato farmers. This situation is not likely to change in the near future. For that reason the Kenyan Ministry of Agriculture has requested the Netherlands to cooperate in the development of the seed potato sector in order to increase the output of certified seed. This has resulted in the design and implementation of the 'fast track seed potato project'.

The approach in this project is to import Dutch seed potatoes on an annual basis, multiply this seed in Kenya with large-scale professional seed growers, and then make the seed available to the many small and medium-scale farmers. The local multiplication of the imported seed is necessary to reduce the cost price of the imported seed and make it affordable to a wide range of potato producers. The project includes close cooperation between the Kenyan and the Dutch Phytosanitary organisations. This cooperation includes three main components: 1) A Pest Risk Analysis (PRA) and specification of the import requirements for Dutch seed potatoes; 2) National variety performance trials (NPTs) required for registration of Dutch varieties in Kenya; and 3) Supporting the local multiplication, certification and commercialisation of imported seed.

Only seed potatoes of registered varieties can be imported into Kenya. Four large-scale farms in Kenya are currently producing certified seed (Table 3.1). These farms are prepared to invest in commercial multiplication, storage and marketing of the imported Dutch seed potatoes. Considering the good climatic conditions for seed production it is anticipated that these professional seed growers will multiply imported seed one or two times. The projected output of certified seed as planned by these farms, once the registration of new Dutch varieties has been completed, is shown in Table 3.1. The projected output of certified seed is sufficient to plant annually some 8,000 ha of potatoes or about 7% of the total planted area. In the near future the impact of the project on the supply of good quality seed will be much greater than this 7%. Some of the certified seed sold by the four seed farms will be multiplied more times by other farms, thus increasing the total amount of good quality seed. In addition, more (large-scale) farms will be attracted to import and multiply seed potatoes, due to the huge demand for good quality seed in Kenya, thus increasing the overall supply of certified seed.

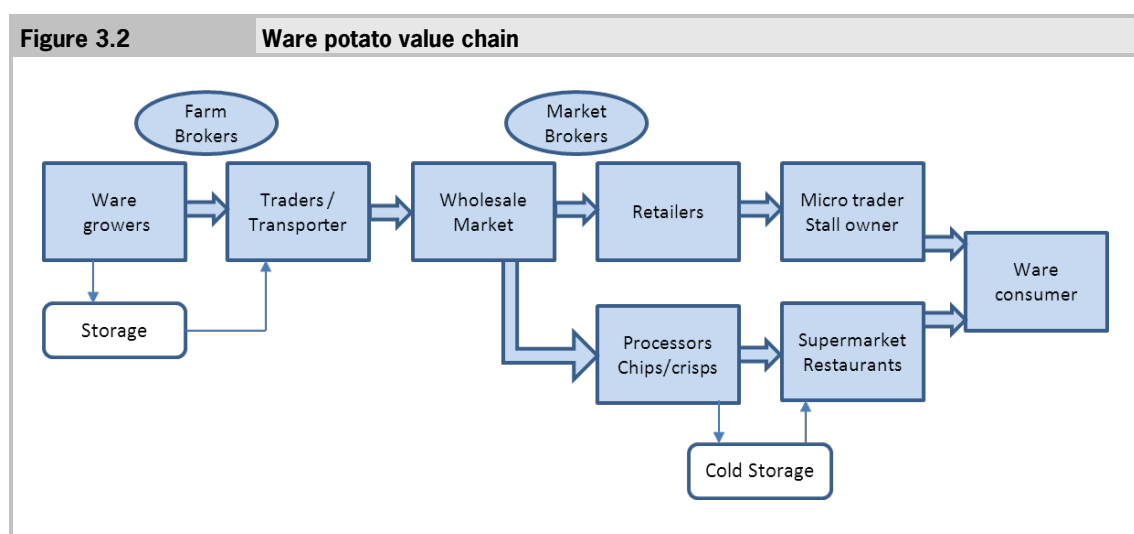
The fast track seed potato project started in 2011 and is progressing well. The PRA has been completed and import requirements for seed potatoes have been formulated. As a result, the Kenyan border is now open for Dutch seed potatoes and commercial import of seed has already taken place. In addition, some 40 new varieties are currently being tested in national performance trials for registration in Kenya.

Seed farm	Current seed potato area planted per year a) (ha)	Projected seed potato area planted per year (ha) b)	Projected annual output of certified seed (tonnes) c)
ADC farms	150	200	5,400
Africalla	20	100	2,700
Kisima farm	100	200	5,400
Suera farm	5	80	2,160
Total	275	580	15,660

a) Planted area is the sum of two crops per year; b) Planted area is the sum of multiplications 1 and 2; c) Output refers to the second multiplication of imported seed.
Source: farm visits.

3.4 Ware potato

In the value chain for ware potato (Figure 3.1) actors produce and process ware potatoes.



A great part (>90%) of 500,000 ware potato growers in Kenya have to be characterised as small-scale farmer (see chapter 2.2). The scheme shows traders and brokers have a dominate position between farmers and consumers (see also Section 3.4.3 on marketing). For most traders potatoes are the only source of income. Major markets include large urban centres.

3.4.1 Potato consumption

Nearly all Kenya's potatoes are consumed locally. The potatoes are (almost) entirely sold to the domestic consumption market. Since nearly all potato production is locally consumed (imports and exports are negligible), consumption can be estimated by total production. However, unlike some other regions where rural people consume far more potatoes than their urban counterparts, Kenyan potatoes are greatly in demand by urban residents. Demand continues to rise in urban areas where preference for potato French fries and chips increases due to changing life styles. Consumption is mainly in unprocessed form at home and restaurants.

The average annual potato consumption per capita was estimated at 28,5 kg in 2003 (FAOSTAT), which is high according to world standards, but much less than comparable figures in some regions, such as Andes or Netherlands.¹ In major production areas in Kenya, where potatoes are eaten daily, the per capita consumption is estimated to be 116 kg annually. Another source (www.potato2008.org) reports an average consumption rate of almost 25 kg annually per capita. Experts of KARI indicate consumption of potatoes is slowly rising: over the past 15 years, consumption of potatoes has increased from 25 kg to about 30 kg annually per capita.

Because no grading or branding is done, it is hard for consumers to choose the best potatoes. Quality issues are also a major concern for consumers. Potato trade needs to be professionalised to cater for the needs of increasingly quality conscious consumers. Apart from households restaurants, hotels and canteens are major potato consumers. To conclude, potato production is highly pro-poor and contributes to food security through substantial employment, income and nutritious food; and it has growth potential if constraints are removed.

¹ More actual figures indicate productions of 450,000 tonnes in 2010 (FAOSTATT) and 1,400,000 tonnes in two growing seasons (KENAPOA), which means an average consumption of 11-35 kg per capita, depending on supply.

Most popular local variety

Kenyan consumers prefer local potato varieties. The variety Shangi is the most popular variety to consume (42% of varieties traded is Shangi, 27% is the variety Tigoni). It is important to understand why Kenyan consumers prefer Shangi. Shangi needs a very short cooking time which saves energy and costs, preferred by low-income households. At this moment quick preparation seems to be much more important than taste to consumers.

Because Shangi germinates rapidly after harvest, seed tubers are planted shortly afterwards within a few weeks. This short dormancy allows the seed from one season to be planted in the next growing season, so expensive storage is not necessary for this popular local variety. Rapid germination, short storage and limited cooking time makes Shangi attractive to subsistence farmers as well.

Although most varieties in Kenya have white skin there seems to be some preference for red skin varieties.

3.4.2 Import and export

Kenya used to be an exporter of Irish potatoes to India, the Middle East and Europe three decades ago when production was at a peak. Nowadays potato consumption in Kenya is expanding rapidly owing to population growth and changing dietary habits occasioned by urbanisation. This is evidenced by a high intake of potato crisps and French fries among the burgeoning youthful population in urban areas. Nowadays, consumer demand for potatoes exceeds supply, which is also a result of declining yields. Fresh potatoes are not imported; a small amount of prepared products such as French fries is imported.

Seed potatoes

Until recently Kenya kept its borders closed for seed imports. Due to the very strict quarantine regulations, the import of high quality (seed) potatoes was difficult. During the past 30 years no certified seed potatoes have been imported, nor exported. Only recently, after reaching phytosanitary agreement between the Kenyan and Dutch phytosanitary authorities, some 90 tonnes of Dutch seed potatoes were imported. The seed concerned the variety Desiree, which was already a registered variety in Kenya.



Potato supply for processing in bags

3.4.3 Marketing

Most farmers do not store potatoes but sell directly from the field, leading to glut periods and low prices. Experts indicate that 80% of the total potato production in Kenya is sold via local markets or traders while farmers use 20% of the production to consume at home. Seasonality in production makes farmers prone to exploitation by traders and brokers. This results in widely fluctuating farm gate prices and market prices during the year. Over 90% of farmers sell their potatoes through middlemen. The potatoes are marketed through a vertical chain involving many different handlers resulting in high transaction costs. There is domination of brokers and traders along the marketing channel. Brokers and traders do not store ware potatoes but deliver the produce directly to the market. Nevertheless, losses due to rotting and greening are reported which means even simple storage facilities are lacking.

The potatoes are sold via informal channels such as open markets and stalls with little observance of prescribed standards (bags). The volumes handled by individual farmers do not command economical volumes for competitive marketing. Considering the market power of traders traded volumes and prices are not transparent.

The price differences between producers and consumers are very high and up to 300% in cities such as Nairobi (Table 3.2) but up to 1,000% in distant cities such as Mombassa. Also, the margins between wholesale and retail prices in urban areas are high due to inefficient distribution systems.

	Farmer	Broker	Roadblocks	Council	Market (whole sale)	Retail
Amount of ware potato (kg * 10 ⁶)	1,400	1,400	1,400	1,400	1,400	1,400
Price (Ksh per kg) a)	7.43	8.18	8.53	8.81	12.47	22.00
Value (in mln Ksh)	10,405	11,446	11,937	12,331	17,455	30,800

a) December 2009 prices.
Source: Muo Kasina and John Huria Ndeturi, 2010.

A clear example of how farmers are exploited by traders is the system of selling per bag. On the request of traders, farmers pack ware potatoes in extended bags instead of using standard bags of 110 kg. Extended bags may contain between 120 and 200 kg of potatoes, depending on the trader. Since farmers are paid by bag and not by weight, they are paid very little per kg of potatoes. At the same time they do not know the actual weight they are selling. Although the potato packaging was standardised into 110-kg bags, the practice of selling in extended bags continues due to the power of the traders. Directives¹ to prevent these practices did not succeed. Some processors who buy potatoes from contract growers, introduced to pay potatoes based on weight, such as producers in Western Europe. In Western Europe, payment per kilogram is standard.

The main part of the potato production in Kenya is sold unprocessed. In the case of potatoes, successfully emerging supermarket chains have not played any role so far. On markets and in supermarkets potatoes are sold loose. In Kenya only 2% of fresh fruit, vegetables and potatoes end up in the supermarkets as final marketing outlets. Correspondingly, only 6% of urban households buy fresh fruit and vegetables in supermarkets whereby potatoes are not likely to be the product of immediate choice for these limited fresh purchases, since prices for potatoes are comparatively high at supermarkets. Supermarkets are becoming an increasingly important outlet for processed goods in general and for processed food items in particular, but for fresh products, open air markets, small shops, kiosks and hawkers will remain important outlets (Hofller and Mangi, 2006). Fresh food and market shares indicate where consumers buy fresh products such as potatoes: supermarket (4.7%), open air market (56.1%), kiosk (35.9%), hawker (2.2%) and others (1.2%) (van der Lans et al., 2012).

¹ Legal Notices No. 44 of 2005 and No. 113 of September 2008.

3.4.4 Processing

A small part - estimated 1-2% at most - of the Kenyan potato production is processed into French fries (chips) or potato chips (crisps) by processors. In urban regions many small-scale processors who are un-registered operate informally at the back of their business areas and houses. These small-scale home-processors produce and hawk cooled (not frozen) French fries to restaurants and hotels directly. Most potatoes are sold fresh (raw) to consumers or restaurants and are consumed in boiled form: home preparation or prepared by hotels and restaurants. Many restaurants with French fries on the menu produce them directly from fresh potatoes within their own kitchen facilities, rather than keeping stock of frozen French fries as is the case in many other countries. The potato processing industry has a limited scale, is still at an infant stage and is unable to meet even the domestic demand.

As the potato crisps/chips processing industry in Kenya is growing rapidly, the demand for better quality processing potatoes will increase as well. Demand trends on chips are:

1. Increasing urbanisation and urban population;
2. Increasing tourism industry;
3. Affordable prices of chips;
4. Increasing incomes of urban households.

After a small test in a supermarket as well as at a processing plant it was found that the requirements for chips (crisp) quality are still on a medium level. For processing it is necessary that the potato quality improves and remains constant throughout the year. A processor is interested in a constant quality potato throughout the year, as this will also lead to a constant quality of the end product. In case the processor starts to set standards on minimum accepted quality of potatoes (size, % of damage, underwater weight etc.) and enforces this by a bonus-malus system of the payments, larger farmers will be stimulated to mechanise in order to optimise growing conditions and improve quality (and yield).



Road-side selling of table potatoes

Kentucky Fried Chicken (KFC) entered the Kenyan market in 2011 and opened its first restaurants in Nairobi. The largest hurdle in getting American fast food restaurants into Kenya had been the supply chain:

how to ensure ingredients were kept to standards set by KFC's parent company. KFC imports processed, pre-blanching, blast-frozen potato French fries from Egypt and South Africa because it has total traceability back to source. They work together with Kenyan companies to ensure that in the future KFC will have local French fries suppliers. Kenya has other fast food restaurants, including South Africa's Steers, Pizza Inn and Chicken Inn. It will be a matter of time before McDonald's or Burger King will open their first restaurant as well. The major reason these fast food companies are not found in Kenya yet is the concern over the supply chain of all products they need (not only potato products, particularly meat products) and to bring it up to the quality control standards they demand.

Crisps (Chips)

The top three of Kenyan crisp producers process about 10,000 tonnes of potatoes per year into 2,500 tonnes of crisps. Deepa Industries Ltd has a market share of 80%. Half of crisps production is bought at supermarkets by consumers who can afford to do so, especially citizens in cities such as Nairobi, and 20% through other distribution channels. Crisps are partly exported (30%) to Tanzania, Zimbabwe and Uganda. Deepa contracts farmers to produce and supply potatoes. Farmers who commit a breach of contract, will not get offered a new contract. Worldwide most crisps are produced and traded regionally. Transport distances of voluminous, lightweight products such as crisps are limited and expensive. Consequently international trade (im- and export) of crisps is rather exceptional which indicates opportunities for local productions of crisps are more favourable than processing of French fries. In the short term crisps production is the best opportunity for value adding. Available figures indicate that a small part of the total Kenyan potato production (at most 1%) is processed by industrial processors.

French fries (chips)

In Kenya, the major part (75%) of all restaurants and hotels process their own French fries and about 25% get fresh fries supplied (non-frozen) by processors on a daily basis. Compared with crisps the Kenyan French fries industry is small (1,000-2,000 tonnes of potatoes). Kenya has only one frozen fast food processor (Njoro Canning; head office and factories located in Njoro near Nakuru) and four fresh/chilled fast food processors (Tesfaya et al., 2010.). All the processors are not registered and operate informally. It is suspected that the number of processors is higher than five, as they are unregistered and operate informally at the back of their business areas and houses. Small producers process at least 600 tonnes of potatoes annually.

Njoro Canning contracts farmers to produce and supply potatoes. It processes and stores frozen fast food in its storage depots located at Njoro, Nairobi and Mombassa. Having cold storage depots especially in Nairobi and Mombassa helps Njoro Canning to immediately supply frozen chips to retail outlets such as hotels and supermarkets on demand (Tesfaya et al., 2010). No export of frozen French fries is reported in Kenya. Other potato products such as flour, starch, wine etc. are not commercially processed yet. The French fries market is a global market dominated by a few authoritative players (e.g. McCain, Aviko, Simplot/Farm frites, Lamb Weston).



Low-cost processing of fresh French fries for daily delivery to restaurants

At this moment European and North American potato processing industry has to handle overcapacity which results in low prices of frozen French fries. As a result these high-quality frozen fries are exported all over the world and export to Mombassa is easily possible and cheap as well. Consequently, frozen French fries produced in Kenya have to be able to compete on price as well as quality with imported fries from Egypt, Europe or North America. This opportunity will not be easy and it will be hard to compete as long as frozen French fries prices are low on global level. The most likely opportunity for processing in Kenya at this moment and near future will be locally produced fresh cooled (non-frozen) French fries.

3.4.5 Logistics: bad roads

Only 11% of Kenya's roads are paved, which means 89% are unimproved. A great part of the roads is damaged as result of overloaded trucks and heavy rainfall. Bad roads lead to high depreciation and maintenance costs of trucks, are time consuming (low speed) which makes transport expensive. Fuel costs account for about 20% of the transport cost. Damaged and unimproved roads also influence the quality of transported potatoes negatively. A good road network is crucial for an effective distribution system. More so for potatoes which are very bulky. In potato producing districts most of the access roads are dry weather roads which are impassable during wet seasons resulting in high transportation costs of both ware and seed potato and lowering of product prices by traders as soon as the rains begin. This is also followed by an increase of input prices and a decrease in ware potato prices.

3.5 Main findings

Many players are involved in the Kenyan seed and ware potato sector. Most important actors are: the Ministry of Agriculture (MoA), Kenyan Agricultural Research Institute (KARI), Kenya Plant Health Inspectorate Service (Kephis), and Agricultural Development Corporation (ADC).

The seed potato sector in Kenya is very small. Currently the potato seed sector lacks capacity to produce and multiply (pre) basic seed and is short of an elaborate distribution system. Most important typifying factors are:

- Due to lack of seed potatoes farmers use seed potatoes 6 to 7 times or more before they buy new seed;
- Low yields and poor quality seed is highly attributed to an existing inefficient seed system. The Kenyan Ministry of Agriculture has requested the Netherlands to cooperate in development of the seed potato sector in order to increase the output of certified seed. The fast track seed project aims to improve seed quality including optimising the seed system. Important factors to improve yield and seed quality: registered, professional seed potato farms and focus on at most 2 to 3 multiplications of imported seed. As part of it four large-scale farms in Kenya are currently producing certified seed.

Until recently Kenya kept borders closed for seed import. No seed potatoes were imported past 30 years. Recently, after reaching phytosanitary agreement between the Kenyan and Dutch phytosanitary authorities 90 tonnes of seed potatoes were imported.

To save energy and costs, Kenyan consumers prefer local varieties such as Shangi, which needs short cooking time. At this moment quick preparation seems to be more important than taste.

Kenya does not export or import fresh ware potatoes. Retailers and fast food chains in Kenya import frozen French fries from neighbouring countries (Egypt, South Africa).

Seasonality in production makes farmers prone to exploitation by traders and brokers who don't respond to officially standardised size of packaging (110 kg per bag). Traders and brokers have a dominate position in the ware potato value chain. Consequently the potato market in Kenya is not very transparent. In Kenya most ware potatoes are consumed fresh; the average consumption per capita increased from 28.5 to 30 kg annually. Especially in urban regions demand will rise as result of changing life styles.

The processing industry is rather small and processes only 1-2% of the total production. For processing most favourable short-term opportunities are production of crisps and fresh (not frozen) French fries. Especially in urban regions many small-scale home-processors operate informally. These small-scale home-processors produce and hawk cooled (not frozen) French fries to restaurants and hotels directly.

4 Bottlenecks and opportunities

The Kenyan government and international community aims to improve food security in Kenya. Focused on potatoes all stakeholders want to increase the potato yield and subsequently the national production. This chapter focuses on the most important bottlenecks and the consequences of possible opportunities.

4.1 Low input - low output

Low inputs result in low yields and profitability of potato growing. As result of the Dutch seed potato project it is expected that the supply of certified seed potatoes will increase. In spite of an attractive price of certified seed potatoes most small-scale growers still prefer cheap seed potatoes (out of/no cash). Constraints faced by potato farmers on accessing quality seeds are: seed unavailable, quality seeds are expensive, lack of knowledge, distance to source quality seed and poor roads. Most farmers are unaware of the need of various types of quality seed and benefits accrue from use of these seeds. Furthermore planting, fertilising, spraying and pest management and storage should be optimised. To improve potato production farmers have to be supported in variety selection and potato growing.

Besides improving seed distribution and consequently availability of certified seed, small-scale farmers need proper potato production information, which should be disseminated to farmers so that potatoes are produced optimally. Training and demonstration on potato growing and quality seed are essential, preferably at local or village level.

An opportunity is to develop a programme which encourages small-scale farmers to use certified seed. Opportunities:

- Develop a temporary governmental programme for small-scale farmers. The programme partly subsidises (at most price difference between certified and clean seed) the purchase of high quality certified seeds which is linked to an obligatory training participation;
- Processors who pre-finance seed or intermediate in financing seed by attractive harvest credits combined with attractive interest rates; Processors buy high quality seeds and distribute this to their out-growers as part of a supply contract.

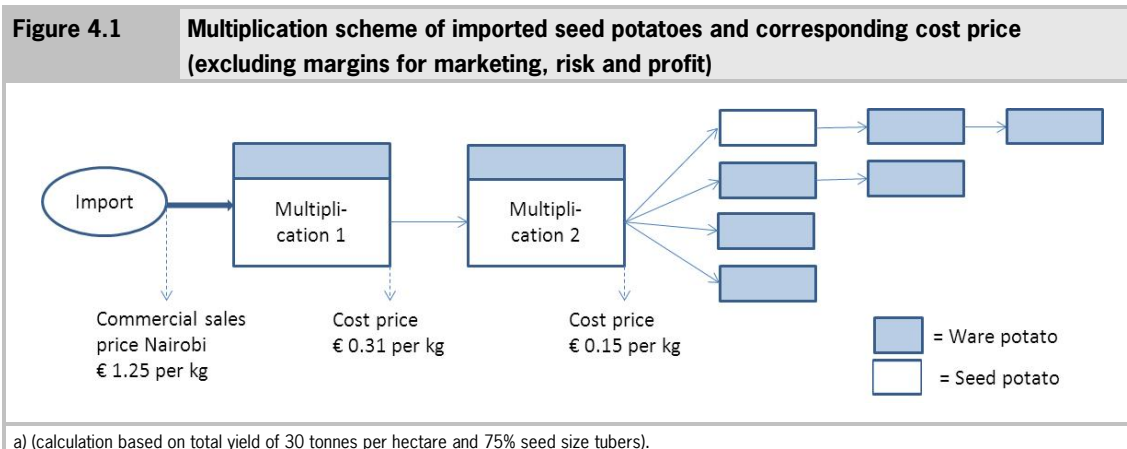
4.2 Lack of certified seed

Lack of certified seed is considered as a main bottleneck in the potato sector in Kenya. This is the main reason that the fast track seed potato project was established. Since the purchasing power of the many small-scale farmers is limited the price of certified seed is a critical issue. Too high a price will be prohibitive for large-scale adoption of use of certified seed while too low a price will not attract sufficient seed growers to specialise in seed production and produce adequate quantities of certified seed. In this paragraph the cost price of locally produced certified seed through multiplication of imported seed is calculated using different yield levels and different numbers of multiplication. Also, seed produced from imported seed from the Netherlands is compared with seed produced from locally produced mini tubers.

4.2.1 Seed multiplication and production

Imported seed potatoes may be multiplied several times, provided soils are free of brown rot and professional seed production methods are applied. However, with each multiplication the health status of seed is gradually decreasing due to increasing incidence of seed borne diseases (seed degeneration). For that reason the number of multiplications should be limited. Experts consider two multiplications on professional seed potato farms feasible. After two multiplications the seed is sold to growers of ware potatoes

who may use the seed for one or more generations. Figure 4.1 shows the multiplication scheme of imported seed potatoes.



Based on the multiplication scheme in Figure 4.1 seed potato production from one container of imported seed (22 tonnes) is calculated and summarised in Table 4.1.

Table 4.1 Production out of one container of imported seed (22 tonnes)

	Multiplication 1	Multiplication 2	Multiplication 3
Hectare planted	5.5	27.8	141.0
Total yield (tonnes)	165	835	4,229
- Ware (tonnes)	41.3	208.8	1,057
- Seed (tonnes)	123.8	626.5	3,171
- Seed (tonnes) after - long storage - period (tonnes)	111.4	563.8	2,854

Assumptions: 4 tonnes of seed per ha, yield 30 tonnes per ha, 10% storage weight loss.

It is assumed that all seed potatoes produced during multiplication are used as seed for the next multiplication (fully internal delivery: no seed sold after multiplication one or two); only ware-sized potatoes of each multiplication are sold to consume. The total yield per ha is 30 tonnes, consisting of 22.5 tonnes of seed potatoes (20.25 tonnes after storage) and 7.5 tonnes of ware potatoes, which are sold for consumption. Seed potatoes are stored for a period of approximately 8-9 months with 10% storage losses.¹

Cost price calculations are based on local production circumstances in Kenya: Kisima farm flyer (2012) presented actual representative economic figures of local potato cropping in Kenya. These figures (presented in Appendix 4) were starting point for all cost price calculations in this chapter. Supplementary assumptions are summarised in Appendix 5.

¹ Weight loss consists of tuber decay, starch loss and moisture loss through the evaporation of moisture in potatoes. In Kenya average weight loss in a well-designed cold store is estimated at 9-10% (storage period 8 - 9 months). Weight loss depends on:

- quality of the stored product at harvest time
- knowledge of farmers
- store design and management
- duration of storage

In particularly weight loss is important in case of long store periods of ware potatoes. In the case of seed potatoes, weight loss is not as important as tuber quality (health) and sprouting behaviour. Nevertheless, in the calculations the full tuber weight losses in seed potatoes during storage have been considered since seed potatoes are sold by weight.

4.2.2 Yield effect

The yield of seed potatoes has a significant effect on the cost price. Table 4.2 shows the cost price of seed potatoes at different yield levels and following a different number of multiplications of imported seed.

Table 4.2			
Cost price of seed potato by varying yields and following a different number of multiplications (€/kg)			
Yield per ha	Multiplication 1	Multiplication 2	Multiplication 3
10 tonnes	0.84	0.64	0.54
20 tonnes	0.44	0.24	0.19
30 tonnes	0.31	0.15	0.12

Imported seed potatoes: sales price at Nairobi = €1.25/kg.
Long storage period.

Table 4.2 shows that improving yield level in seed production is an important issue to realise low cost prices for certified seed. Also, more multiplications of imported seed reduce the cost price. The effect of the second and third multiplication on cost prices is rather small compared with the first multiplication. This means a third multiplication should be weighed against the lower health status (seed degeneration). After 2 multiplications at a total yield level of 20 tonnes per ha the calculated cost price for certified seed is €0.24 per kg (excluding storage costs, profit margins, trade and transport costs, etc.). Allowing for marketing costs, interest, risk and profit margins this may lead to a commercial seed price of €0.35 - 0.40 per kg for certified seed potatoes (after two multiplications).

Conclusion:

- Two multiplications is sufficient to make imported seed affordable to small-scale growers
- The focus should be on high yield levels without compromising on seed quality.

4.2.3 Import of seed potatoes versus locally produced mini tubers

Some large-scale seed potato farms in Kenya are experienced in production of minitubers in hydroponics/aeroponics which is an alternative to import of seed tubers. These farms have knowledge and experience from hydroponics used in flower production. In this chapter we compare both seed production systems.

Per hectare 80,000 minitubers (sales prices of €0.10 or €0.20 per minituber) or 4,000 kg imported seed are planted. Based on presented assumptions (Appendix 5 and Appendix 6) cost prices have been calculated for three multiplications in both systems.

Table 4.3			
Cost price of seed potatoes (€ per kg of seed potatoes) produced out of imported seed or minitubers			
	Minitubers (€0.10)	Minitubers (€0.20)	Imported seed
First multiplication	0.63	1.12	0.31
Second multiplication	0.20	0.29	0.15
Third multiplication	0.14	0.15	0.12

Assumptions:
 - Yield from imported seed: 30 tonnes per hectare.
 - Yield from first field multiplication of minitubers: 20 tonnes per hectare due to small size of minitubers; Yield from second and third multiplication of minitubers: 30 tonnes per ha.
 - In all cases total yield consists of 75% seed size tubers.

Table 4.3 shows that the cost price of certified seed produced from minitubers is always higher than that produced from imported seed, even after three field multiplications. After two multiplications the cost price of certified seed produced from minitubers is 33% (at minituber price of 10 cents) higher or two

times (at minituber price of 20 cents) the price of imported seed. Cost prices of minitubers after three multiplications are almost competitive to these of imported seed after two multiplications. More multiplications of minitubers may reduce the cost price of certified seed further but this will have a negative effect on seed quality, particularly on the health status (seed degeneration).

Conclusion:

- After two multiplications, imported seed is competitive to three multiplications of minitubers

4.2.4 Market potential for certified seed

Table 2.1 (see Chapter 2) shows that most potato growers are small-scale farmers and that only some 250 farmers can be considered as large-scale potato growers. They grow on average 10 ha of potatoes per year each, or 5 ha per season. It is estimated that there are less than 20 farms growing over 20 ha of potatoes per year. The group of large-scale farmers followed by the group of medium/large-scale farmers are more market oriented than the other farmer groups and are likely to be the first ones to buy certified seed potatoes, and invest in mechanisation and storage facilities. This means that at most 10,000 farmers growing 22,000 ha of potatoes per year will be buying certified seed. On average these both farmers groups grow 2.2 ha potatoes per year. These groups have a farm size and presumably adequate financial body that suggests they will invest in modern potato growing. Besides these groups some large-scale grain farmers may grow also potatoes in the future and demand certified seed. Growing 22,000 ha of ware potatoes means a need of 44,000 tonnes of seed potatoes per year. To reduce seed cost most ware potato growers are used to multiply the seed they have bought for at least one more time on the farm through farm-saved seeds. We estimate these ware potato growers will buy certified seed only once a year and not every season, so the potential market of certified seed potatoes will be 22,000 tonnes per year, half of total seed potato requirement of large-scale ware potato growers. Assuming all seeds are multiplied from imported containers only, tables 4.4 and 4.5 present the maximum number of containers and acreage needed to produce 22,000 tonnes of certified seed.

Yield per ha	1 Multiplication		2 multiplications		3 multiplications	
	A	B	A	B	A	B
20 tonnes	296	263	88	69	26	18
30 tonnes	198	175	39	31	8	6
35 tonnes	169	150	29	23	5	3.5

Scenario A: seed rate 4 tonnes, 75% seed size, storage loss 10%.
 Scenario B: seed rate 4 tonnes, 80% seed size, storage loss 5%.

To show effects of increasing yields we introduce two scenarios. Scenario A represents a scenario based on assumptions introduced earlier in this chapter while scenario B assumes higher productivity as result of a higher seed% and less storage loss. Assuming two multiplications of imported seed, yields of 30 tonnes per ha and all seed needed is multiplied out of imported tubers, about 39 containers of 22 tonnes each would need to be imported annually to cover the market for 22,000 tonnes of seed. When results of seed production improve (scenario B: 80% seed and 5% storage loss) and/or yield increases to 35 tonnes per ha, the number of containers required is reduced from 39 to 23 per year.

Yield per ha	1		2		3	
	Multiplication		multiplications		multiplications	
Scenario	A	B	A	B	A	B
20 ton	1,628	1,447	2,118	1,822	2,255	1,904
30 ton	1,089	963	1,301	1,142	1,395	1,293
35 ton	930	825	1,102	968	1,150	999

Scenario A: seed rate 4 tonnes, 75% seed size, storage loss 10%.
Scenario B: seed rate 4 tonnes, 80% seed size, storage loss 5%.

Yearly multiplication of 39 containers of 22 tonnes of seed means 1,301 ha seed production are required for the two multiplications of imported seed. This corresponds to at most 13 seed producers, growing 100 ha seed potatoes per year each. With the improved seed production scenario the area required for seed production is 968 ha. Meanwhile it should be noticed that other seed suppliers such as other seed importers or local production of minitubers will be active in these markets as well. Consequently the number of seed potato producers multiplying seed out of imported seed potatoes will be lower in practice. Presented figures include ware production as well, so:

- Seed potato producers also produce and sell a substantial volume of ware potatoes;
- In case seed potato growers increase yields per ha, increase the percentage seed size potatoes, and reduce storage losses fewer containers and acreage are sufficient to meet market needs for certified seed.

The presented figures show the future potential of the Kenyan seed potato market. In later years the market for certified seed may expand slowly as large-scale farmers may buy certified more frequently (to replace the use of farm-saved seed) or some small-medium as well as small-scale farmers will also become interested to buy certified seed potatoes.

4.3 Potato storage

Farmers in Kenya store potatoes for three major reasons which include:

- Provision of seed for the subsequent crop
- Preservation of ware potatoes for home consumption
- Surplus in hope of getting higher market prices

Ware potato

Since there are usually no long intervals between harvests, and fresh potatoes are year-round available from different production regions, storage of ware potatoes for sale and consumption is not a usual practice in Kenya. Many small-scale farmers who produce small amounts of potatoes store ware potatoes for home consumption or partly for selling. They prefer to sell immediately after harvest to fulfil short-term cash need. Ware potatoes are stored up to three months after which tubers will start to sprout and not suitable for consumption. This storage period is generally insufficient to maintain a supply of potatoes until next harvest. Many farmers buy potatoes for home use after consuming their own. Farmers typically store about a half a tonne of potatoes in their house for their own use; for up to nine weeks and usually occurs in farm buildings other than the house. Losses during storage can average up to 20% for a two month storage period. In some areas such as Meru District, farmers have developed their own storage structures, constructed of cement floors, wooden walls and corrugated iron roofs. At higher altitudes where the climate is colder, such as Timau Region, farmers store potatoes outside the house covered with dry grass, which can be effective for up to three months.

Seed potato

Seed is stored for about two months (6-8 weeks) between harvest and next planting period. In case of such short periods simple storage facilities are needed. Generally seed tubers are stored in houses, in piles on the ground in sheds or often stored in pits lined with dry leaves and covered with straw, where they are likely to sprout prior to being replanted. A few farmers store seed tubers in diffused light stores (DLS) at ambient temperature. Tubers are placed in trays or on racks and arranged in layers in 'shady, well aerated rustic stores'. Even though this type of store provides excellent conditions for seed tubers, it is not widely used. In Meru there are only three weeks between harvest and planting. For breaking dormancy Meru farmers store seed potatoes in closed pits.

Constraints in storage

In most cases existing storage practices satisfy. Because most Kenyan farmers harvest two times a year it is advised to invest in simple, low cost potato storage. Simple ventilation technology based on outside air is sufficient. During the mission two cases were listed in which investments in cold stores could increase productivity:

- Seed potato varieties with a with long dormancy period which need a more lengthy storage period for dormancy breaking to become more productive. This means one planting period has to be skipped and meanwhile seed potatoes have to be stored for a lengthy period of 8 to 9 months, similar to the storage period in the Netherlands.
- Ware potato: processors of chips and French fries like to secure continuous potato supply and quality. During periods of deficit these processors prefer to keep a stock of potatoes as a buffer.

To fulfill dormancy breaking some (imported) potato varieties may need a longer storage period while other - especially locally used quick sprouting - varieties have to be planted shortly after harvest and for those varieties short storage is sufficient. To store potatoes for a longer period (4 months or longer) a modern professional storage house is necessary.

Costs of cooled storage

To invest in modern cooled storage the minimum capacity should be 100 ton. At this moment only a few enterprises produce such quantities or more: large-scale farms, seed potato growers and processors. Appendix 7 gives an impression on modern potato storage investments and costs.

These storage facilities are also suitable for bulk storage or potato storage in breathable bags (plastic bags are unsuited). Table 4.6 shows scale effects: costs per kg decrease inversely proportional to storage capacity. Small storage facilities are relatively expensive.

Besides cooling system investments, potato storage also includes an insulated building (shed) and if necessary investments such as boxes, band conveyer, fork-lift truck and eventually refrigeration. Required investment for the store building in Kenya is estimated at half of European investments.

Capacity (tonnes)	100	200	400	500	800	1,000
Cooling and ventilation system	15,000	17,000	24,000	26,000	34,400	35,000
Insulated Building (€)	18,250	34,000	60,000	67,500	90,000	105,000
Total investment(€)	33,250	51,000	84,000	93,500	124,400	140,000
Total investment per tonne (€)	332	255	210	187	156	140
Cost per tonne annually (€)	53	41	34	30	25	23
Cost per kg capacity(€)	0.053	0.041	0.034	0.030	0.025	0.023
Energy and others investments (€/kg)	0.280	0.155	0.093	0.080	0.061	0.055
Total cost post-harvest storage (€/kg)	0.333	0.196	0.126	0.110	0.086	0.078
Potato cost price (1 multiplication) (€/kg)	0.31	0.31	0.31	0.31	0.31	0.31
Total cost price (€/kg)	0.643	0.506	0.436	0.420	0.396	0.388

a) Investment = replacement value; b) Annual costs= Interest, depreciation and maintenance: 10%+4%+2%=16.0%; c) Interest: 20% of 50% of replacement value.

Investments per tonne are rather high for storage capacities of 400 tonnes or less. Small capacity storage investments are relatively expensive and will substantially raise cost prices. Consequently professional modern storage is more attractive for farmers, farmers groups or processors who store big quantities.

Add up the calculated field crop cost price (one multiplication: 0.31 euro per kg) and storage costs (based on 500 tonnes) the total cost price of long stored seed potatoes will be 42 cent per kg. Taking into account trade costs, royalties and margins the sales price will be about 50 cent per kg of certified seed. As storage capacity increases the cost price decreases a bit.

Short versus long storage

Climatic conditions in Kenya potato regions are unique: night temperature 7-10°C and day temperature 25-33°C (see Appendix 4). As presented in Chapter 2, potatoes are generally harvested twice a year: in July and February. Normally seed potatoes are planted within a few months, but some varieties need more time to fulfill dormancy breaking and consequently a longer storage period is required as explained above. For lengthy storage periods other storage temperatures and consequently systems are advised (table 4.7)

	Planting (P) and harvest (H) period	Storage period (in months)	Advised storage temperature (°C)	Advised store system
Short storage	H1 → P2 or H2 → P1	1-3	12-15	Diffused light storage
Long storage	H1 → P1 or H2 → P2	8-9	4	Cold storage

P1= March/April, H1= July, P2= October/November, H2= February.

The Diffused Light Storage (DLS) has proven itself at ambient temperature, is used in Kenya already (for example at ADC Molo-farm) and is simple and cheap compared with cold storage. Large-scale seed potato growers, who grow different varieties, may need a DLS as well as a cold storage facility for short and long-term storage periods. However, in case of big quantities of seed potatoes or in case of modern, large-scale mechanisation DLS is less useful (DLS takes up a lot of room to make sure all tubers get enough light).



Diffused Light Storage (DLS) for seed potatoes

Kenyan farmers prefer varieties which need a short storage period of dormancy breaking: some local varieties are planted shortly (within a few weeks) after harvest. Other varieties may need a much longer storage period to fulfil dormancy breaking. This means these varieties should be stored for a longer period and consequently one planting period should be skipped. Short storage needs a simple, cheap storage facility (DLS: diffused light storage) while long storage needs a professional modern storage building.

Table 4.8 shows the cost price of varieties which need short and long storage period. The cost of DLS required for short storage, are estimated at €0.01 per kg.

Table 4.8 Costs price seed potatoes after short and long storage (€/kg)			
Storage period	Multiplication 1	Multiplication 2	Multiplication 3
Long storage (8-9 months) a)	0.31 + 0.11 = 0.42	0.15 + 0.11 = 0.26	0.12 + 0.11 = 0.23
Short storage (max 3 months) b)	0.29 + 0.01 = 0.30	0.14 + 0.01 = 0.15	0.12 + 0.01 = 0.13

a) Modern potato storage facility with capacity of 500 tonnes; b) diffused light storage (DLS).

As result of investments in modern cooled storage, including simple post-harvest mechanisation, cost of long storage are substantially higher compared with short storage (DLS). From economic point of view short storage is much more attractive. Long storage is more expensive as result of higher costs of modern cold store storage facilities, increased risk of loss of crop because of diseases, rotting and weight loss, and higher interest costs. This means storage facilities should fit to volumes and dormancy breaking periods of varieties of seed potato needed. Long storage is only necessary for seed potatoes of varieties with long dormancy.

Most small-scale farmers prefer certified seed at the lowest possible price which means varieties which need a short storage period will be more attractive to them. Storage suppliers as well as seed importers and seed suppliers should take this into account.

Post-harvest mechanisation

Little attention has been paid to the subject of post-harvest handling. However when storage becomes interesting for companies, in store machines could come into sight for additional cleaning of the crop and efficient loading of the storage rooms. Also, a type of grading (by sieves or webs) will add value to the product by making it more attractive for processors, or customers of seed potatoes. When supermarket chains increase their sales of table potatoes and demand modern packaging to increase value to their product (pre) packing equipment can become interesting as well.

Storage facilities needed

Table 4.8 summarises the needs in storage facilities by different stakeholders and indicates the number of farms or processors who possibly will invest in large-scale storage facilities. Most small-scale farmers will not be able to investment in capital intensive, professional potato storage.

Table 4.9 Storage needs of different producers			
	Small-scale farmer	Large-scale farmer	Processors
Seed potatoes	Uses small amount of seed potatoes. 0.25 ha per farm= 500 kg of seed potato for own use	4-5 seed growers at present. Market potential in the long term: about 10 seed growers might invest in storage. >25 ha seed potatoes per farm=production of 500 tonnes of seed	Few processors might invest in seed storage to supply their outgrowers with planting material
Ware potatoes	Focus on simple, low cost potato storage	Around 5-10 farms in the long term that might invest in modern stores	Buffer storage to secure year-round supply, large amounts, quality is important. 1-2 processors might invest about 3,000 tonnes storage/processor

Table 4.9 indicates potential investors in professional potato storage. The table shows that the number of investors in modern storage facilities is small. Small-scale farmers mostly prefer varieties which need a short storage period and consequently do not need modern storage facilities. To invest in ware potato storage, small-scale growers have to cooperate and invest jointly in a common, cooperative store.

SWOT storage in Kenya

Next table shows the strengths and weaknesses, opportunities and threats of potato storage in Kenya.

Strong	Weak
<ul style="list-style-type: none"> - Product quality improves compared with local storage systems - Less weight losses compared with traditional local storage systems - More flexibility in supply of seed and ware potatoes - Supply during deficit periods: higher prices (ware potatoes) - Long-period storage improves sprouting and yield of slow sprouting seed potato varieties - Suitable climate: constantly cool night temperature throughout the year 	<ul style="list-style-type: none"> - Poor product quality of the stored product at harvest time (especially small-scale farmers) - Lack of storage and product knowledge - Short-term cash need restrains (small-scale) farmers to invest - Lack of finance to invest (especially small-scale farmers) and high interest rates - Storage compensation: level of premium price unclear - Varieties with short dormancy do not need sophisticated storage
Opportunities	Threats
<ul style="list-style-type: none"> - Increase knowledge about potato growing including its relation to potato storage (for instance by experts, small-scale farmers study groups and education) - Only farms producing big volumes of potatoes (at least 10 ha): large-scale farmers - Processors: to secure year-round supply (quantity and quality) - Cooperation between farmers or between farmers and processor in investment and storage - Avoiding glut periods, thus higher potato prices and more profitable potato growing 	<ul style="list-style-type: none"> - Two seasons a year: lengthy storage not necessary (for ware potato); simple storage facilities are effectively in most cases; - Irrigation: whole year supply possible (only ware potato), staggering supply - Market effects when number of facilities for lengthy potato storage increases substantially. - Expected growth of supply of certified seed potatoes and ware potatoes.

4.4 Mechanisation

Farm size

There are only a limited number of farms with an acreage large enough to justify mechanisation (see Chapter 2.4.8); this number will increase most probably, however in the near future still a large part will be grown on small and medium-sized farms. Even for these farms mechanisation can be an option in two ways. Contractors specialised in (potato) field mechanisation could be hired by the farmer to execute the mechanisation of the whole crop (planting, ridging harvesting) or do a part of it. When a contractor works in an area limited in size and with a limited number of e.g. 20 farmers with each 1-2 ha potatoes an area of 30 ha has to be covered which could be economic profitable.

A second opportunity is that a number of medium-sized farmers decide to co-operate in a mechanisation pool. If three or four farmers with each 3-4 ha each buy one machine in the chain (planter, ridger, (leaf topper), wind harvester) they might have sufficient size as well to mechanise. This requires however trust in each other and a professional attitude. Table 4.10 shows a list of machines needed for potato growing on medium-large scale and large-scale potato farms including investments needed.

	Investment		Cost per year	
	Medium/large scale	Large scale	Medium/large scale	Large scale
Potato planter	8,800	26,400	2,024	6,072
Rotary ridging cultivator	12,650	15,950	2,492	3,142
Haulm topper	6,600	9,680	1,848	2,710
Harvester	14,410	39,600	3,660	10,058
Total investment	42,460	91,630	10,024	21,983

a) Assumptions: tractors and machinery for soil preparation are available (plough, disc harrow, cultivator). B)Interest. 10% value after depreciation; 20% interest; c) Investments CIF Mombassa, excluding import duties and inland transport.; d) Medium large: 30 hectares potatoes per season (=60 ha per year); large scale 30-100 hectare per season (60-200 per year).

Compared with European standards labour in Kenya is cheap and possibly discourage to invest. In spite of this, labour should be set in efficient and effectively to produce economically. When a group of 30 field workers do haulm cutting and harvesting manually they do for instance 0.5 hectare per day. When these both activities are done partly mechanically these field workers will harvest 3-4 hectares per day. Moreover the loss of tubers will be minimised, while in case of manual harvesting losses will raise easily to 5%.



Potato harvester

Tractors

On medium and large-scale farms the power of the available tractors ranges between 60 and 120 hp (and even higher on the wheat farms) this should be sufficient to start with small or medium-sized mechanisation. As machinery from Western Europe is often requiring a number of hydraulic connections, this is an item of attention.

Training

Essential for a good performance of every machine is that the operator who works with the machines as well as the (farm) manager should be trained in working with the machines. All possible settings should be trained as every situation (size of potatoes, variety, soil, weather, purpose of the crop etc.) may require a different setting of the machine. Too often machines are operated by tractor drivers proudly driving but refusing to look backward and see what actually is going on with the machine, soil and potatoes.

Standardising

Mechanisation requires standardising. Both ridge distances of 75 cm and 90 cm have been noticed in Kenya. A farmer has to decide which one to select influencing all decisions on the field machines. Additionally, once selecting a two row planter the subsequent machines (rotary ridger, leaf chopper and harvester) should be of the same configuration; even the field sprayer should be a multiply of the number of ridges and the ridge distance.

Spare parts

It is advised when purchasing machinery, at least a set of quick wearing parts should come with the machines so the farmer will be assured of continuous operation during the season. Although there is a direct and frequent air connection between Europe and Kenya, the second phase between airport and farm might take a few days.

SWOT mechanisation

The following table summarises the strengths and weaknesses and opportunities and threats of mechanisation in the Kenya potato sector.

Strong	Weak
<ul style="list-style-type: none">- Areas with few stones- Some areas with advanced mechanised arable farming- Two growing seasons (small-sized machines can work for a longer period on a relative large area)	<ul style="list-style-type: none">- Majority of very small farms (<0,5 ha)- Very low yields- High interest rate- Short-term orientation- Low mechanisation level,- Little knowledge about mechanisation
Opportunities	Threats
<ul style="list-style-type: none">- Import of high quality seeds approved- Relative outsiders (vegetable/flower growers, processors) showing interest in investing in potato growing business- Young dynamic population and developing economy will increase demand of quality food- Grain farms which adopt potato growing	<ul style="list-style-type: none">- Government policies (duties, regulations)- Missing: dealer network, availability of spare parts- Standardisation

4.5 Farmers knowledge

Mission experts remarked crop management for seed potato production should be improved. In this connection it is suggested to improve farmers knowledge on potato growing (e.g. tillage, planting, number of stems, yield, fertilising, pest management, harvest and storage). Kenyan farmers can learn a lot from Dutch potato growers. It is suggested that specialised seed potato farms should hire an experienced son of a Dutch seed potato grower for one or two years to teach Kenyan potato growers the tricks and dos and don'ts of seed potato growing.

Most small-scale farmers who grow ware potatoes are not able to hire an experienced professional. For this large group of farmers other opportunities to enhance farmers knowledge should be organised and practiced. Processors contracting potatoes, seed suppliers and suppliers of other inputs (fertilisers), NGOs and other development organisations all play a part to improve potato yields. Opportunities to support potato growers:

- Supervision by processor representatives such as field managers
- Advisory services
- Group meetings and study groups organised by suppliers, advisory services or other stakeholders (see Chapter 3.2)
- Pilots
- Experimental farms and trials
- Training
- Practical experts from NL: young farmers sons

At the moment, only a few farms have the management capacity and resources to get involved in seed multiplication. To improve supply of high quality certified seed potatoes the acreage of seed potatoes should be enlarged and the number of specialised seed potato farms increased.

4.6 Poor linkage between farmers and markets

As discussed in Chapter 3.4.3, there is a poor linkage between farmers and markets. The origins of bottlenecks are:

- Informal trade and sector; sub optimal potato value chain;
- Internal look; the potato sector only focuses on internal business;
- Power of traders and middle men (see 3.4.3);
- Lack of transparency in prices, production and traded volumes;
- Availability and reliability of statistical data of the potato sector (acreage, production).

Opportunities

Suggestions to improve linkage between farmers and markets:

- Payment per kilogram throughout the chain: potato prices should be based on weight (kilogram) and quality (bonus/malus); some processors who contract potatoes, already do (1% of the market);
- Contracting (some processors already do). Farmers and processors make an agreement including volume, price and terms of delivery (quality);
- Focus on opportunities for large-scale potato growing: set up farmers cooperatives (benefits of large-scale production and storage);
- Cooperation between farmers and farmer groups. A farmers group will be able to operate more powerful than an individual farmer. An important condition to cooperate is trust;
- Scale up and professionalising of the potato processing industry will increase potato demand (to produce 1 kg of crisps (chips), 3 kg of potatoes are needed).

4.7 Prospects to include small farmers in the potato value chain

Small-scale farmers are the weakest link in the potato value chain (see 4.6). In this chapter we suggest opportunities to improve the market position of small farmers:

- Processing industry contracts potato outgrowers to grow and deliver potatoes;
- Create conditions to support long-term relationships. To ensure supply of potatoes for processing the processing industry needs outgrowers. To support long-term relationships the industry not only should buy potatoes but also supply and pre-finance high quality seed potatoes (for instance as part of contract);
- Set up potato growing cooperatives which produce sufficient quantities of ware potatoes for joint storage in modern facilities;
- Opportunities for farmers themselves: value adding through storage, grading, packaging for specific customers;
- linking small holders to specific markets e.g. on a contract basis.

4.8 Opportunities for Dutch entrepreneurs

The import of high quality seed from the Netherlands is expected to develop into a continuous flow of high quality planting material into Kenyan and subsequently this will give a boost to the yield of ware potatoes. Kenya aims at a rapid development of the potato sector and higher domestic production. The government is looking for foreign investors to participate in this process to meet the demands for food and food products of the fast growing population. The rapidly growing middle class ensures adequate purchasing power for quality foods and food products. This provides excellent opportunities for the Dutch technology providers and input suppliers. The opportunities summarised:

- Supply of high quality seed potatoes (basic seed) for further multiplication in Kenya of varieties suitable for different purposes such as fresh markets, processing into crisps, French fries and other uses.
- Supply of other inputs such as crop protection chemicals and fertilisers.
- Supplying machinery, equipment and knowhow for seed and ware potato production and processing at different scales of production.
- Providing handling and storage facilities at different scales and volume levels.

- Provide training support for professional use of sophisticated machinery and facilities.
- Provide equipment and support to potato processing initiatives including systems for year-round supply of ware potatoes for processing.
- Capacity building in all areas of the supply chain including crop management, logistics, transport, processing, marketing, retailing. Also, providing support to government programmes related to phytosanitary services, food safety and environmental issues.
- Providing management and consulting services to any area of the supply chain.

4.9 SWOT analysis of Kenyan potato sector

This chapter summarises the strong and weak points, threats and opportunities in a SWOT-analyses of the potato sector in Kenya.

Strong points:

- good climatic conditions for potato production
- good climatic conditions for production of seed potatoes
- potato is important food crop, second after maize
- two main cropping seasons per year thus limited need for long-term storage
- several processing companies already in place, demanding good quality potato raw materials
- Kenyan seed certification and quarantine organisation (KEPHIS) in place to facilitate import of seed potatoes, to certify local multiplication of imported seed, and to enforce UPOV regulations with respect to breeders' rights
- well-managed (large scale) farms available for seed production
- domestic potato consumption will increase

Weak points:

- Poorly developed seed potato sector
- Many soils contaminated with brown rot
- Few professional seed potato growers
- Many small-scale farmers with limited resources for inputs in potato growing leading to low average yields
- Relatively high production costs due to low yields
- Lack of supply of good quality seed
- Poorly developed ware potato supply chains for processing and fresh markets
- Processing industry: infant stage
- Market chains dominated by few traders leading to exploitation of small-scale farmers
- Use of bags hinder farmers to get a fair price
- Lack of suitable processing varieties
- Lack of storage facilities resulting in low prices during main harvest periods
- Poor infrastructure in some potato production areas leading to high transportation costs and high quality loss.
- High local interest rates holding back the necessary investments such as for certified seed, modern machinery and storage
- Home consumption limits income, cash and consequently investments
- No transparency in market and price information

Opportunities:

- increasing importance of medium to high income consumers leading to high demand for processed products such as crisps and French fries
- large tourist industry leading to high demand for quality potato and potato products

- commitment from the Kenyan Ministry of Agriculture to develop the seed potato sector in Kenya with assistance from the Netherlands
- the boost in (seed) potato production as a result of the fast track seed potato project supported by the Netherlands
- the existing processing industry demanding a rapid development of the potato supply chain (suitable varieties for processing, seed supply systems, professional outgrowers, storage facilities, etc.)
- low cost of labour.

Threats:

- Possible political instability
- Incidents leading to closing the border for seed potatoes
- Import of cheap machinery from India
- Illegal multiplication and trade of seed potatoes leading to (further) spread of brown rot
- Irregular rainfall patterns leading to crop failure in areas without irrigation
- Corruption at different levels affecting the efficiency of the potato supply chain

4.10 Main findings

Lack of certified seed is considered as a main bottleneck in the potato sector in Kenya. This chapter focuses on multiplication and production of seed potatoes. Main findings are:

- Seed production from one container (22 tonnes) imported seed is 626 tonnes (564 tonnes after long storage) after two multiplications;
- Higher yields and more multiplications of imported seed reduce the cost price of seed potatoes produced in Kenya. After two multiplications of imported seed the calculated cost price of seed potatoes is €0.24 per kg (excluding storage costs) at yields of 20 tonnes per ha and €0.15 per kg at 30 tonnes per ha. The number of multiplications should be weighed continuously against the lower health status (seed degeneration);
- Cost prices of imported seed after two multiplications are competitive with locally produced seed from minitubers after three multiplications. More multiplications of minitubers may reduce the cost price of certified seed further but will have a negative effect on seed quality, particularly on the health status (seed degeneration).
- From economic point of view short storage in diffused light stores is much more attractive. Long storage is more expensive as result of higher costs of modern cold store storage facilities, increased risk of loss of crop because of diseases, rotting and weight loss, and higher interest costs. This means storage facilities should fit to volumes and dormancy breaking periods of varieties of seed potato needed. Long storage is only necessary for seed potatoes of varieties with long dormancy.
- Imported seed needs to be multiplied locally to reduce cost price and make it affordable for small-scale growers. A market potential of certified seed of 22,000 tonnes in the long term has been calculated. This market need will partly be supplied with seed tubers multiplied from imported potatoes. Calculations and market expectations indicate that there is potential for at most 1,000 ha of professional seed production where seed potatoes are produced out of imported seed. In the short-term seed production should be started on a few specialised large-scale farms and enlarged little by little, to ensure that increasing supply of certified seed will match with increasing demand for good quality seed.
- A limited number of farms have an acreage large enough to justify investments in simple mechanisation (planter, rotary ridging cultivator, haulm topper and harvester). Compared with European standards labour in Kenya is cheap and possibly discourage to invest. In spite of this, labour should be set in efficient and effectively to produce economically;
- Support opportunities to improve farmers knowledge on crop management and post-harvest handling;

- Opportunities to improve linkage between farmers and markets: payment per kg, contracting, and set up of cooperatives;
- Small-scale farmers are the weakest link in the potato chain. Chapter 4.7 summarises opportunities to improve their market position in the value chain;
- The rapidly growing middle class ensures adequate purchasing power for quality foods and food products. This provides excellent opportunities for the Dutch technology providers and input suppliers.

5 Conclusions and recommendations

As part of the fast seed potato project an inventory has been made of the seed and ware potato value chain in Kenya with special attention to seed supply, storage and mechanisation. This chapter summarises the most important findings:

- Food crop: Potato is an important food crop in Kenya, second after maize, with average consumption per capita of 28 kg per year;
- Potential: Potato yields (currently 7.7 tonnes per ha and national potato production in Kenya are far below productions realised some decades ago and far below its potential considering the suitable climatic conditions in the highland areas. This indicates the potato production has potential and should be improved to enhance food security;
- Farm size: Most potatoes in Kenya are grown by small-scale farmers: 98% of all potato growers are characterised as small-scale farmers who produce 83% of the national potato production. These small-scale farmers partly produce for home consumption (20%) while they sell 80% of their ware potato production via markets and traders. Small-scale farmers have lack of cash and credits (high interest rates) and consequently they turn to a low input - low output strategy because they do not have the capability to invest in seeds, fertilisers, storage, chemicals for next crops and to improve production.
- Fast track seed potato project: Currently, some 40 Dutch varieties are being tested in National Performance Trials for local registration. Seed potatoes of registered varieties can be imported following clearly formulated import requirements. In the short-term, the fast track seed project has to focus on medium/large-scale and large-scale producers (who plant about 17% of the total potato area), who produce seed and ware potatoes commercially, since they have the means to invest and tend to represent the more innovative growers. At the same time all farmers should be encouraged, supported and facilitated to improve potato production (extension service, study groups) and improve linkages between farmers and markets;
- Market potential for certified seed: Imported seed needs to be multiplied locally to reduce cost price and make it affordable for small-scale growers. This requires a number of specialised large-scale seed producers. A market potential of certified seed of 22,000 tonnes in the long term has been calculated (see chapter 4). This market need will partly be supplied with seed tubers multiplied from imported potatoes. Calculations and market expectations indicate that there is potential for at most 1,000 ha of professional seed production where seed potatoes are produced out of imported seed. In the short-term seed production should be started on a few specialised large-scale farms and enlarged little by little, to ensure that increasing supply of certified seed will match with increasing demand for good quality seed.
- Cost price of seed potatoes: Higher yields and more multiplications of imported seed reduce the cost price of seed potatoes produced in Kenya. After two multiplications of imported seed the calculated cost price of seed potatoes is €0.24 per kg (excluding storage costs) at yields of 20 tonnes per ha and €0.15 per kg at 30 tonnes per ha (chapter 4). The number of multiplications should be weighed continuously against the lower health status (seed degeneration). This means seed potato growers in Kenya should engage in professional seed production to combine high seed quality with a relatively low cost price. Technical support from experienced seed growers may help to guide the growing number of new seed growers.
- Imported seed versus locally-produced minitubers: Cost prices of imported seed after two multiplications is competitive with locally produced seed from minitubers after three multiplications. More multiplications of minitubers may reduce the cost price of certified seed further but will have a negative effect on seed quality, particularly on the health status (seed degeneration).
- Storage: The climate in the potato regions in Kenya is ideal to use low cost seed storage facilities such as Diffused Light Storage (DLS) for short storage periods. Simple storage should be promoted. Only

two cases have been indicated in which investments in professional cooled storage facilities are necessary:

- storage of seed potatoes of varieties with a long dormancy period;
- storage of ware potatoes for processing industry and some high- end retailers to ensure continuous supply and maintain potato quality.
- Storage costs: Calculations show that long-term storage is more expensive which leads to higher cost prices of certified seed. Long-term storage in modern stores increases the cost price of seed by about 50% compared with short-term storage in diffused light stores. Investments in modern cooled storage should be based on expected volumes of varieties which need long storage periods;
- Varieties: Considering agro-ecological conditions in Kenya, important traits desired for potato varieties include resistance to late blight, short dormancy (to avoid long periods of seed storage), tolerance to drought (irregular rain fall). Apart from varieties for fresh consumption the market requires specific varieties suitable for processing into crisps and French fries.
- Mechanisation: The level of mechanisation on medium large and large-scale farms is medium to low and the age of machines is often high. Kenya has 10,000 large and medium/large-scale farmers growing 22,000 ha per year: average 2.2 ha per farmer per year (total of two seasons) is very small compared with Dutch potato growers. Farmers who grow such small quantities of potatoes should cooperate to invest jointly in machinery. Size of machineries supplied for potato growing in Kenya should be geared to local needs, taking into account labour should be set in efficient and effectively to produce economically. High interest rates hinder farmers to invest in storage, machinery and certified seed;
- Processing: In Kenya most potatoes are consumed fresh. A very small part (1-2%) of the total Kenyan potato production is processed by food processing industry. Due to the actual situation on the world potato market it is hard to compete against imported high quality frozen French fries. Most favorable opportunities in Kenya are the production of crisps and fresh (not frozen) French fries and bring these in urban cities (supermarkets, restaurants). Processors need big volumes of potatoes of constant quality to secure supply for processing. To secure supply and potato quality they should invest in storage, contracting including quality premium, penalties and compensation for storage;
- Priorities for support: In the short-term, improvement of potato growing and crop management should receive higher priority than storage and mechanisation. Large as well as small-scale farmers should be supported to improve potato cropping in order to increase yield and effectively deal with constraints such as seed quality, fertilising and spraying. Possibilities to support: training, education for small-scale farmers study groups, advisory by extension service, suppliers or processors or via experimental farms and trial fields, education programmes, etc.
- Value chain development: To improve market access and linkage between stakeholders in the potato value chain cooperation on different levels should be stimulated. Important condition for cooperation is trust between the members of the value chain. Cooperation, payment per kilogram and contracting are opportunities to strengthen market linkage of small-scale farmers.

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Websites

FAO

<http://www.potatoplatformkenya.com/project.htm>

Appendix 1

Interviews and activities

Day	Visit	Contact person
Sunday, 9 December	Flight Amsterdam - Nairobi	
Monday, 10 December	Kick off meeting Dutch Embassy Berend Jan Westerdijk, Siebold de Vries, Willem Dölleman, Rob Holtrop	Hans Wolff, Landbou wattache
	Amarin Supplier of seeds/fertilisers/Crop Protection Products Plans to add seed potatoes for smallholders to their activities	Mr.Pinhas Moskovich/ Mr.Yariv Kedar
	Travel to Nakuru	
Tuesday, 11 December	ADC farm office State farm	Mr. Paul Njuguna
	ADC farm	Mr. Paul Njuguna
	Travel to Suera Farm	
	Skipped: visit to Suera Farm Seed Potato Grower	Susan Mureithi/Jackson Wambiga Mwaura
	Travel to Nyeri	
At dinner	Warmolt Tolken	Warmolt Tolken
Wednesday, 12 December	Travel to Kesima farm	
	Kesima farm: Seed Potato Grower/Partnership with HZPC	Mr. Martin Dyer/Mr. Derek Roulston
	Skipped: visit to two smallholder groups who intent to emerge to a cooperative with central facilities for grading/storing/marketing.	Officials 2 groups plus Warmolt Tonckens (Solidaridad fast track project)
	Travel to Nairobi	
At dinner	Sjaak Nannes/Rob Holtrop	
Thursday, 13 December	Kenya Highland Seed (KHS) Supplier of seeds/fertilisers/Crop Protection Products Plans to add seed potatoes for smallholders to their activities	Christian Benard Pieter
	Deepa Industry Ltd; Tropical heat potato crisp producer	Mr.Navin Shah/Mrs.Gillian Kadenyi
	Prepare potato meeting	Hans Wolff
	Berend Jan Westerdijk	
At dinner	United Millers	Mr. Sunil Shah/Shah
Friday, 14 December	Potato meeting at Dutch embassy with 27 stakeholders Feedback on the findings of the potato mechanisation and storage mission. Feedback on the progress with the NPTs with the new varieties of seed potatoes. Feedback on further subjects related to seed potatoes in particular and potato value chain in general.	Hans Wolff, Landbou wattache
	Lunch at Hans Wolff residence	
at lunch	Kenfap Limited Supplier of seeds/fertilisers/Crop Protection Products and have plans to add seed potatoes for smallholders to their activities	Mr.Charles Gitau
	Nairobi - Amsterdam Night flight	

Appendix 2

Key figures on Kenya 2011

Population	41.61m
Capital	Nairobi (3,138,295 inhabitants, 2009)
Land area	569,140 km ² ; 17 times the size of the Netherlands
Agricultural land	273.500 km ²
GPD (current USD)	33.62bn
GPD growth	5% in 2011, 6% in 2010, 3% in 2009, 2% in 2008, and 7% in 2007
Origin value added (% of GDP)	Agriculture (23%), industry (19%) and services (3%)
Labour force	15,456,039
GPD/Capita	USD 808 (current USD), USD 1,507 PPP (constant 2005 USD)
Currency (1 december 2012)	Kenyan Shilling (KES) KES100 = USD1.14 = EURO.88 EUR1 = KES109.57 = USD1.30
Literacy (above age 15)	87% (2009)
Life expectancy at birth	57 years
Inflation	2008: 15.1%, 2009: 10.6%, 2010: 4.1%
Interest rate a)	Lending interest rate is the rate charged by banks on loans to prime customers: 15% (2011), 20% (2012)
Main exports (2010) b)	Tea, coffee, horticulture (flowers), tourism
Exports destinations (2010) b)	Uganda, United Kingdom, United Republic of Tanzania, Netherlands
Main imports (2010) b)	31.8% of machinery and transport equipment, 22.1% of mineral fuels, lubricants and related materials, 14.7% manufactured goods
Main imports from (2010) b)	India, China, UAE, South Africa, Saudi Arabia, United States and Japan.
Sources: World Development Indicators, CIA world fact book. a) http://www.oanda.com/currency/converter/ ; b) INE, 2012, UNComtrade.	

Appendix 3

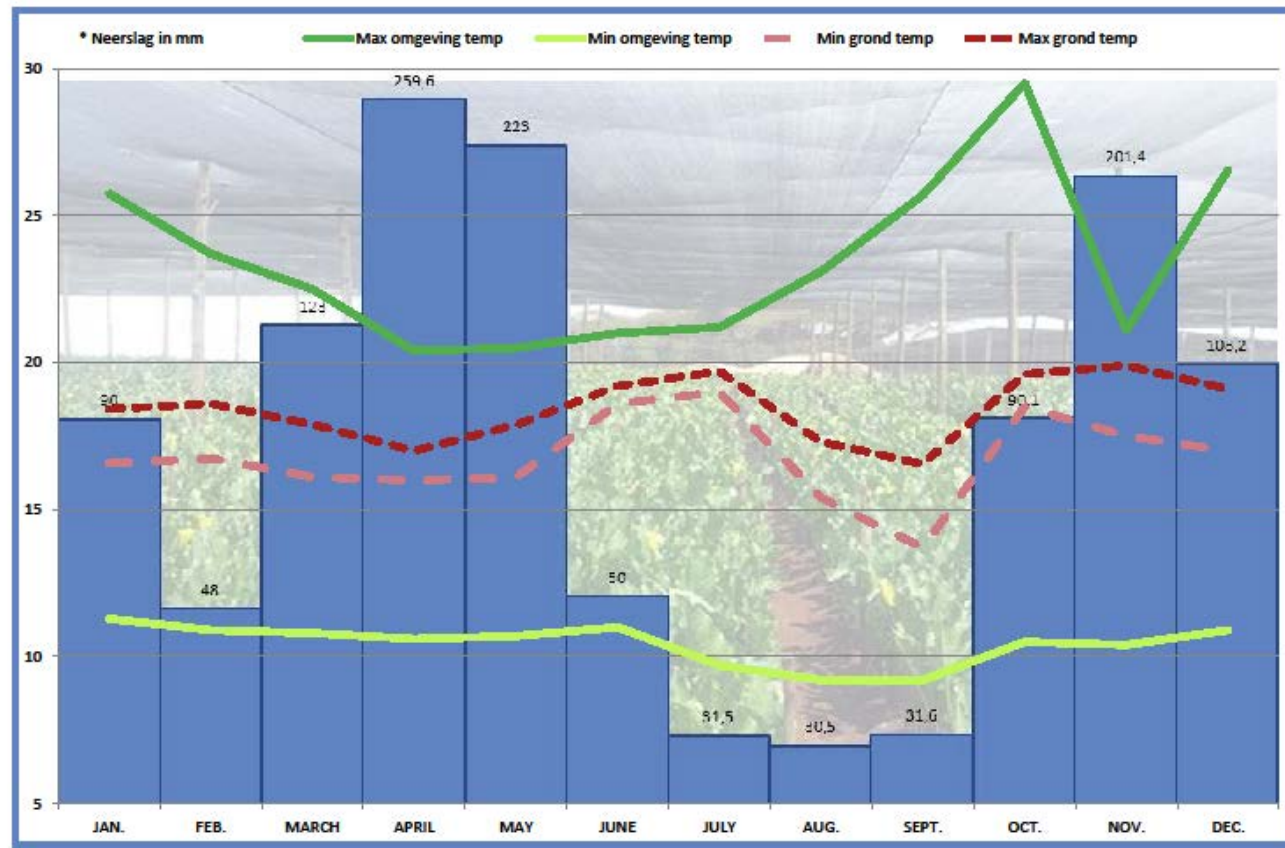
Potato production in Kenya 1990-2010

Year	Are harvested (Ha)	Production (Mt)	Yield (ton/ha)
1990	87,890	779,190	8.87
1991	87,144	987,828	11.34
1992	68,037	632,572	9.30
1993	55,675	654,123	11.75
1994	83,000	806,000	9.71
1995	96,168	928,744	9.66
1996	98,000	744,000	7.59
1997	118,596	835,208	7.04
1998	90,418	679,738	7.52
1999	114,602	1,047,570	9.14
2000	108,516	670,303	6.18
2001	121,496	1,112,850	9.16
2002	111,728	861,566	7.71
2003	126,490	1,223,530	9.67
2004	128,484	1,084,410	8.44
2005	120,842	980,163	8.11
2006	116,348	783,783	6.74
2007	120,000	850,000	7.08
2008	122,717	600,000	4.89
2009	153,114	400,000	2.61
2010	152,994	450,000	2.94

Bron: FAO, <http://faostat.fao.org/>

Appendix 4

Climate Kenyan potato regions



Appendix 5

Gross margin calculation

	Kshs/acre	Kshs/acre	Kshs/ha	Kshs/ha	eur/ha	eur/ha
Seed origin	local	certified	local	certified	local	certified
Land rental (one season)	5000	5000	12355	12355	108	108
Farmers time	6000	6000	14826	14826	130	130
Ploughing	2000	2000	4942	4942	43	43
Clearing	500	500	1236	1236	11	11
Planting	1000	1000	2471	2471	22	22
Food for labours	500	500	1236	1236	11	11
Hilling (*2)	4000	4000	9884	9884	86	86
Spraying (*7)	2100	2100	5189	5189	45	45
Harvesting	8250	19500	20386	48185	178	421
Ridging	300	300	741	741	6	6
Transport	3000	3000	7413	7413	65	65
Sub total [A]	32650	43900	80680	108479	705	948
Seed	24000	42000	59305	103784	518	907
Fertilizer	16000	16000	39537	39537	346	346
Spray	2500	2500	6178	6178	54	54
Bags	1750	13500	4324	33359	38	292
Sub total [B]	44250	74000	109344	182857	956	1598
Total costs [C]	76900	117900	190023	291336	1661	2546
Output [D]	90000	234000	222394	578224	1944	5054
Profit per acre [D-C]	13100	116100	32371	286888	283	2507
Yield (tonnes)	6	15	15	37	15	37
Output bags of 110 kg	50	130	124	321	124	321
Farm gate price per bag	1800	1800	1800	1800	16	16
Farm gate price per 100 kg	1636	1636	1636	1636	14	14
Output	90000	234000	222394	578224	1944	5054
Source: flyer Kisima Farm Field day 2012						
Assumed farm gate price 1800 Kshs per bag						

Appendix 6

Basic assumptions

- Based on figures from Kisima flyer (2012); Kisima is a large-scale seed potato grower
- Planting for seed production: 4 tonnes of seed per ha
- Weight loss: 10% (long storage, one season skipped); 7% (short storage, planting within a few weeks)
- Yield: 30 tonnes per ha (25% ware and 75% seed)
- Internal delivery of seed: After multiplication 1 seed potatoes are stored and planted (Internal supply within a farm: cost price multiplication 1 = seed price for multiplication 2)
- Interest 20% per year on investments:
 - Long-storage seed 9 months, other inputs 6 months
 - Short-storage seed 6 months, other inputs 3 months

Appendix 7

Investments storage facilities

Table B7.1 Investment in mixed air cooling system (excluding building and boxes) and cost per year						
Capacity (tonnes)	100	200	400	500	800	1,000
Investment (€)	15,000	17,000	24,000	26,000	34,400	35,000
Investment per tonne (€)	150	85	60	52	43	36
Cost per tonne annually (€)	24	13.6	9.6	8.32	6.88	5.76
Cost per kg capacity(€)	0.024	0.014	0.010	0.008	0.007	0.006
a) Investment = replacement value; b) Annual costs= Interest, depreciation and maintenance: 10%+4%+2% =16.0%; c) Interest: 20% of 50% of replacement value.						

Table B7.2 Investment in modern storehouse (insulated building; excluding cooling system, boxes, conveyers, etc.)						
Capacity (tonnes)	100	200	400	500	800	1,000
Investment (€)	15,000	28,000	54,000	62,500	90,000	100,000
Investment per tonne (€)	150	140	135	125	113	100
Cost per tonne annually (€)	24	22	22	20	18	16
Cost per kg annually (€)	0.024	0.022	0.022	0.020	0.018	0.016
a) Investment = replacement value; b) Annual costs= Interest, depreciation and maintenance: 10%+4%+2% =16.0%; c) Interest: 20% of 50% of replacement value.						

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