

Horticulture in Rwanda

Possibilities for further development



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Summary

Given its climatic conditions, Rwanda is a country with a great potential for agricultural production. At the same time, it is also a net importer of food products. For Rwanda, it is therefore important to focus on increasing the productivity of the agricultural sector. With a sector dominated by small land plots, a focus on horticulture can be evident as the productivity per m² is relatively high.

It is therefore that a consortium of organizations, consisting of Greenport Holland International (GHI) Wageningen University, TNO and BoP Innovation Center, have decided to establish a four year program called Smart Adaptive Sustainable Horticulture (SMASH) to stimulate the development of the horticultural sector in Rwanda (and also in South-Africa and Algeria) by introducing greenhouse horticulture technologies, combined with knowledge transfer, and in close cooperation with the public and private sectors in both countries.

As mentioned, the agricultural sector is the backbone of the Rwandan economy and society. Vegetables in Rwanda are mostly grown from commercially available seeds, which are unfortunately not always of consistent quality. Rwandese vegetable cultivation is characterized by mixed farming systems and small plots. The basis of the farming system is diversification in order to spread risks: various plots along the hill slope and in the valley, and per plot a variety of different crops. Due to the scattered nature of agriculture, the Rwandan government wishes to focus on horticultural production given its higher productivity per m², higher value per kg and a higher share on the export market, in relation to the key staple crops. Greenhouse horticulture could be an important driver for horticultural productivity. To connect the existing reality in Rwanda, a greenhouse has to be small, and has to contribute to the diversification, if it is to fit in the current farming system.

In general, the climatic conditions in Rwanda are suited to horticulture and also to greenhouse production, provided the proper greenhouse design is used. Most critical are temperature at daytime and relative air humidity in the early morning in higher altitude regions. Without mechanical climate control (which would be very costly in terms of fossil energy), natural ventilation is important to manage both temperature and relative air humidity.

Greenhouses do exist in Rwanda. Two types of small-sized greenhouse models have been placed in the recent past, the greenhouse currently marketed by Balton and the greenhouse that was designed in the BTC/RHODA program a few years ago. In our opinion, both greenhouse types are not suitable to the Rwandan climate. The main problem is that the greenhouses

do not have a top ventilation opening, leading to high inside air temperatures. Admittedly, a top opening makes the greenhouse construction slightly more complex and expensive, but it is a necessity.

It is recommended to design a simple and small greenhouse for vegetable production adapted to Rwandese conditions. Use can be made of designs for other African and Asian countries. It is also recommended to interest a Rwandese manufacturer to construct the greenhouses and the greenhouse materials, therewith avoiding import and possible taxation. Furthermore, it is recommended that a wider variety of chemical fertilizers is made available in Rwanda, and that soil samples are analysed periodically to enable a proper fertigation strategy. Also, the quality of available seed is variable, and supply is irregular. Arrangements that realize a steady, and a more diverse availability of varieties, and offer farmer the opportunity to select the variety of their preference, are welcome.

Greenhouse horticulture in Rwanda is just beginning, and the levels of technology and knowledge are low. This does not imply that future technological developments are not possible; depending on the economic situation (especially price and product quality developments) and increase in knowledge level, more advanced greenhouse systems might be feasible.

From a food safety and nutrition perspective, society as a whole demands continuously lower chemical residue levels. In an approach such as Integrated Pest Management (IPM), chemical control agents are used as a last resort. It is therefore recommended that the effectiveness of available chemical control agents is independently assessed, and that biological control agents are made available. It is very important to have sufficient tools available. Each separate greenhouse needs its own set, in order to prevent transmission of diseases among greenhouses. Sanitation rules should be taken very seriously.

Provided future developments in logistics and infrastructure will be implemented in the same speed as has been done so far, and a true Common Market in the East African Community (without barriers of any kind) will be implemented, it is clear that there is and will be a great demand for horticultural products in Rwanda, not only nationally but also internationally. In order to fully capture these markets, as well as utilize the full production potential of the Rwandan sector, more attention should be paid to developing opportunities for vegetable processing. This could have a great impact on minimizing food losses and will add value to products and increase their shelflife. Also, it could have a stabilizing effect on market prices and could provide a stimulus for the development of contract farming.

Of course, this will not be realized overnight, but the potential, also with a growing Rwandan middle class, is there. However, capturing these markets through horticultural development will only be realized if the proper enabling environment is in place.

Greenhouse horticulture is very knowledge-intensive by nature, requiring knowledge and skills at all levels, from the farm manager to the daily worker. There is a wide variety of knowledge sources, such as universities, research centres, extension services, the private sector (especially the supply industry), and other farmers. The knowledge infrastructure should be shaped in such a way that knowledge flows freely, while each stakeholder plays its most functional role. In order to facilitate this, the SMASH project could play an important role in the establishment of the practical training centre combined with a demonstration greenhouse, and in guiding farmers with regards to their cultivation practices. This could be done in close cooperation with the education and research system (for example, ISEA), and the extension service that are already run by the Agricultural Service Centres.

Last but not least, as both a focus on greenhouse horticulture as well as developing the opportunities for food processing will ask for (private) investments, access to finance is essential. The development of access to finance clearly has two faces in Rwanda. On the one hand, the government and commercial banks will have to further step up their existing efforts (such as the Business Development Facility) on overcoming the barriers that naturally come with providing finance to the agricultural sector, and look at ways to stimulate financing schemes that evolve in the market through input suppliers.

On the other hand, the Rwandan farmer needs to become more of an entrepreneur. Most farmers lack the ability to make a sound business plan and judge potential investments on their returns and their timespan. This financial illiteracy can only be overcome by programs that train farmers on basic skills such as accountancy. Only then will banks take these farmers seriously.



Introduction

Given its climatic conditions, Rwanda is a country with a great potential for agricultural production. At the same time, it is also a net importer of food products. For Rwanda, it is therefore important to focus on increasing the productivity of the agricultural sector. However, the country also has a fragmented agricultural scenery, given its mountainous nature, the high population density (the highest in Africa) and the large fraction of the population that is employed in agricultural activities. The average land plots are therefore comparatively small. With these small plots, a focus on horticulture can be evident as the productivity per m² is relatively high.

The Netherlands has a long tradition of horticultural production. In a sense, the same reasons that now influence the increase in focus on horticulture in Rwanda, the relatively small land plots and high population density, have been the same reason for the strong growth in horticultural technology in the Netherlands since the beginning of the 20th century. One of the reasons for this was to increase the productivity per square meter.

With the knowledge and technologies that these developments have created in the Netherlands, and the international

experience that Dutch sector stakeholders have acquired, the Rwandan horticulture sector can be greatly improved. It is therefore that a consortium of organizations, consisting of Greenport Holland International (GHI) Wageningen University, TNO and BoP Innovation Center, have decided to establish a four year program called Smart Adaptive Sustainable Horticulture (SMASH) to stimulate the development of the horticultural sector in Rwanda (and also in South-Africa and Algeria) by introducing greenhouse horticulture technologies, combined with knowledge transfer, and in close cooperation with the public and private sectors in both countries.

This report is a first identification in order to inform all parties on the challenges for horticultural development in Rwanda, and to give direction to the implementation of the SMASH program in Rwanda. The report is a result of desk research, as well as field visits and interviews during a visit to Rwanda from 21st – 24th of May 2013. In the annex, a list can be found of the different parties that have been interviewed throughout the visit. The assignment for the visit and the report were commissioned by the Royal Netherlands Embassy in Kigali, Rwanda.



General information

Rwanda is located in East Africa, sharing borders with the Democratic Republic of Congo (DRC), Tanzania, Uganda and Burundi, making the country land-locked. The country's total land area is 26,338 km². In comparison, it is approximately the size of Belgium and it is the most densely populated country in Africa, with currently around 12 million inhabitants. The country is green, located in a mountainous region and called the 'land of a thousand hills'. The official languages are the national Kinyarwanda, French and English.

The climate is of the temperate tropical type with an average annual temperature of 19°C and an annual rainfall ranging between 900 and 1,600 mm. The country experiences a short rainy season from September to November and a long rainy season from February to May. The short dry season runs from December to January and the long dry season from June to mid-September.

Economy

The Rwandan economy displays a mixed image. On the one hand, Rwanda officially is a low-income country. Poverty is still widespread with almost half (45%) of the population living below the poverty line. On the Global Hunger Index, Rwanda ranks 15th. On the other hand, Rwanda displays a steady economic growth with annual GDP growth rates between 6 and 11% over the last ten years, reaching a GDP of \$ 6,4 billion in 2011 (up from \$ 1,8 billion in 2003), making the Gross National Income (GNI) per capita rise from \$690 in 2003 to \$1270 in 2011.¹

One of the underlying factors for this change in economic growth since the beginning of this millennium could be the steady change in the business environment in Rwanda. On the World Bank Doing Business Index, Rwanda currently ranks 52 (out of 185) and is the fourth African economy with the most ease of doing business. This position was achieved thanks to several reforms in the first decade of this century. For instance, the number of procedures to start a business was brought back from 9 in 2004 to only 2 in 2010, bringing back the number of

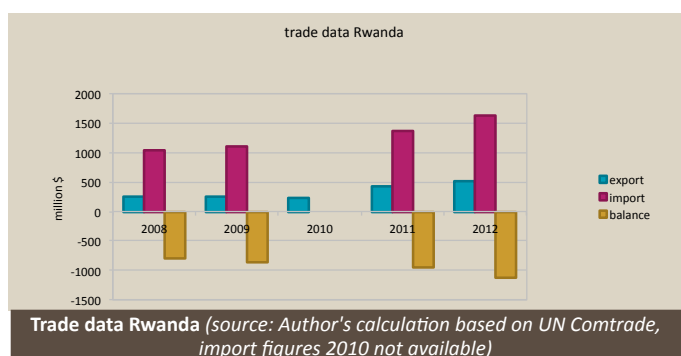
days required to start a business from 18 to 3.

To further improve this situation, with support of the World Bank and IFC, the Rwandan government started the RDB (Rwandan Development Board) bringing together all government agencies dealing with investments procedures such as business registration, investment promotion, environmental clearances, privatization, and others into one one-stop-shop, modeled after the Singapore Development Board. The establishment of RDB was a key driver for private sector growth in Rwanda.

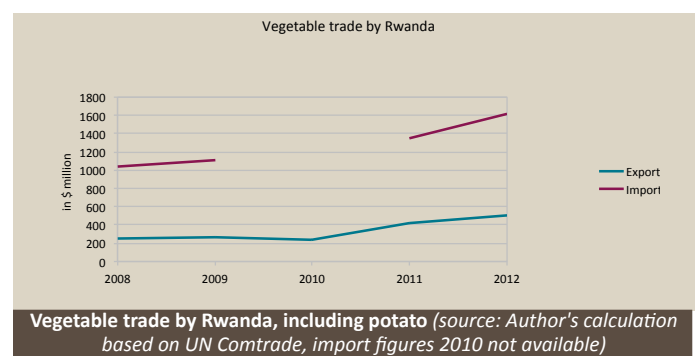
As with many developing countries, the agricultural sector is the backbone of the national economy. It accounts for more than 34% of the gross domestic product (GDP), provides 70% of exports, employs 80% of the workforce and provides raw materials to industries and a market for manufactured goods.² Agricultural products are not only dominant export but also imports; where coffee and tea are the main export products, food items dominate the import flows. Rwanda's international trade position is becoming worse as the trade deficit is steadily increasing, for a large part due to the increase in imports of food items. Development of the own food production capacity in Rwanda could be an important means to improve this situation.

To further stimulate the international trade position in agricultural products, the National Agricultural Export Board (NAEB) was established. The NAEB focuses mainly on promoting the export of tea, coffee and horticultural products. NAEB works closely together with other agencies such as RDB in order to ensure that other policies to stimulate agricultural development also benefit the export position of Rwanda.

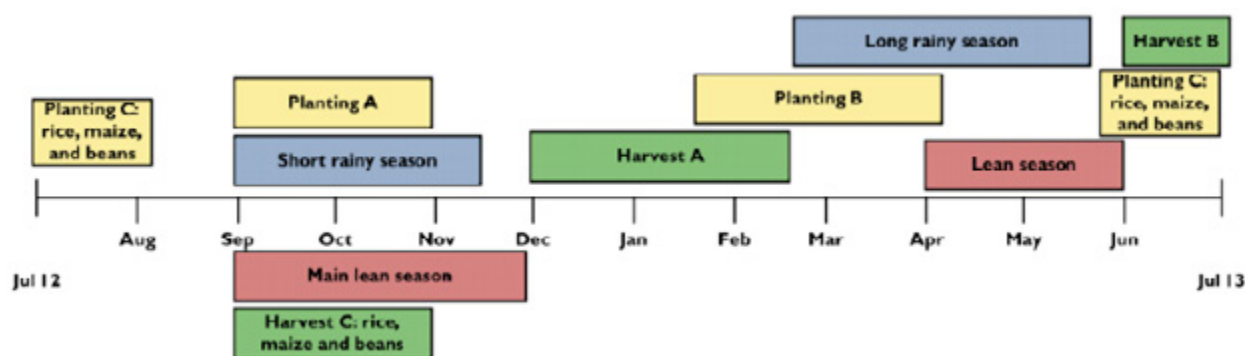
Next to a focus on European markets for exports (which currently accounts for 10% of total exports), emphasis is also put on the region as a stimulus for the Rwandan economy. The East African Community was established in 2000, an intergovernmental organization of the governments of Rwanda, Burundi, Kenya, Uganda and Tanzania, focusing on social, economic and political cooperation between the five countries.



1. World Bank Development Indicators, accessed through databank.worldbank.org on 4-6-2013



2. Minagri, Trends in Key Agricultural and Rural Development Indicators in Rwanda, 2012, www.resakss.org/index.php?pdf=53112



Source: FEWS NET

Typical agricultural season in Rwanda (Source FEWSNET)

One of the main accomplishments of the EAC is the establishment of a Common Market, which entered into force on 1 July 2010. It officially provides for free movement (duty-free) of goods, labor, services and capital, but practice shows this is not always the case. This will be elaborated on later in this report. Also trade with other countries in the region that do not fall under the EAC, such as DR Congo, Gabon and South-Sudan, is increasing.

Another initiative to promote local East African trade is the establishment of TradeMark East Africa. This NGO is funded by several donors and is represented in all 5 EAC countries as well as in South-Sudan. Its aim is to increase market access, enhance trade environment and increase product competitiveness between the six countries. Despite all these efforts, trade within the EAC is still rather limited, despite the elimination of tariffs. Officials indicate that this results from the high level of non-tariff barriers that the individual member states implement against one another.³

Agriculture

As mentioned, the agricultural sector is the backbone of the Rwandan economy and society. The total amount of arable land is 2,29 million hectares, of which on average 0,9 million hectares is cultivated (depending on season).⁴ Most of this arable land is located in the valleys (marshlands) of the mountainous countryside of Rwanda. There is very little, if at all, room for expansion of agricultural activities: only replacement of activities is possible. The marshlands are usually flooded during the rainy season, making year-round cultivation impossible.

After a fall in agricultural production in the period 1996-2001 (negative growth of -1,3% per year) agricultural production steadily grew in the period thereafter, with an average annual growth of 3,4% for the period of 2001-2006 and 4,7% for 2006-2011. In volume, the main crops that are produced are the staple crops plantains, cassava and potatoes. The vegetables that are mostly produced are pumpkins, cabbage, avocados and tomatoes.⁵

One of the main characteristics of agriculture in Rwanda is the small size of land plots, which are scattered throughout the country. The main reasons for this are the mountainous environment of the country as well as the high population density (the highest in Africa). There are some land consolidation

programs, but plots remain small. Of the estimated 2,1 million households in agriculture, only 1,9 % own land larger than 3 hectare. The average land size per household is 0,59 hectare.⁶ Because of these sizes, average production per farmer is small, making them mostly produce for own needs. On average, 15% of fruits and vegetables production is brought to market; the rest is for own consumption.⁷

An average agricultural year in Rwanda roughly has two rainy seasons, which accommodate at least two agricultural cycles, and three for staple crops as rice maize and beans.

3. <http://www.trademarka.com/intra-regional-trade-in-eac-still-low-despite-elimination-of-tariffs/>

4. <http://www.statistics.gov.rw/publications/statistical-yearbook-2012>

5. FAOstat country profile 2011, for full overview see <http://faostat.fao.org/site/339/default.aspx>

6. <http://www.statistics.gov.rw/publications/eicv-3-thematic-report-agriculture>

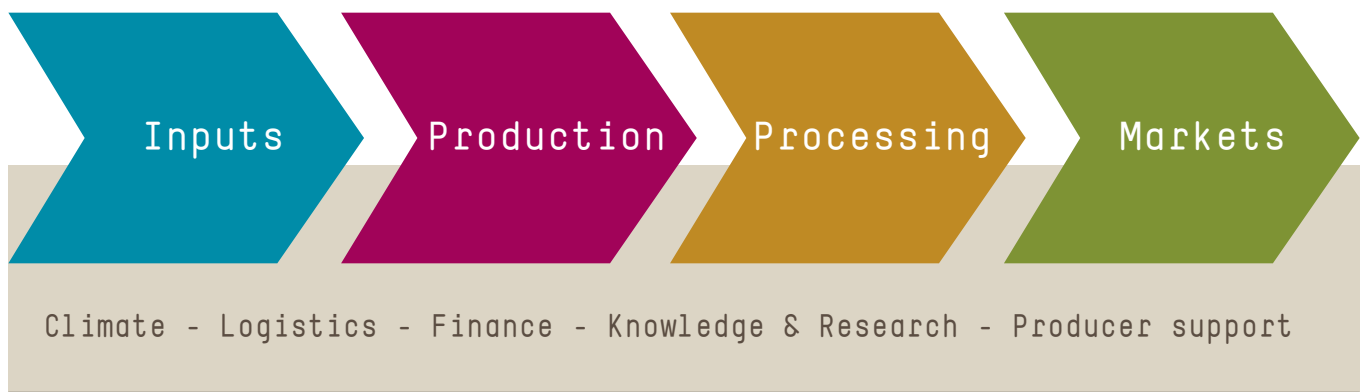
7. <http://www.statistics.gov.rw/publications/eicv-3-thematic-report-agriculture>

The Horticulture Value Chain

As was briefly indicated, the horticulture sector is still a rather small sector within the entire agricultural sector when it comes to total share in agricultural production and total share in agricultural land. Because of the dense population and the limited amount of available agricultural land in the marshlands, the Rwandan government wishes to focus on horticultural production given its higher productivity per m², higher value per kg and a higher share on the export market, in relation to the key staple crops. The total area under vegetable and fruit production in 2011 was respectively 41.721 and 34.495 hectares. For vegetables, this is almost a doubling of hectares in relation to 2008. Total production of fruits and vegetables combined in 2011 was 1,12 million tons.⁸

Greenhouse Horticulture

The following is a further analysis of the horticultural sector in Rwanda, with a special focus on greenhouse horticulture. It is based on the different parts of the value chain, as well as the enabling environment in which it operates. This is depicted below in a simplified way:



8. <http://www.statistics.gov.rw/publications/statistical-yearbook-2012>

Inputs

Plant material

Vegetables in Rwanda are mostly grown from commercially available seeds, which are unfortunately not always of consistent quality. Most relevant are high germination and being virus-free, which is guaranteed by established seed companies. The number of seed suppliers in Rwanda is low (AgroTech, Balton), who represent only a limited number of breeding companies, and the availability of well-coated seeds of improved hybrids is limited. Regularly, seeds of unknown quality or with unknown origin are purchased at a local shop.

It is often claimed that new hybrids are required to replace existing, supposedly low-yielding open pollinated varieties or old hybrids. Whether true or not, it would be good realize a more diverse availability of varieties, and offer farmer the opportunity to select the variety of their preference. The import of seeds of new varieties must be approved by the Ministry of Agriculture. There is a check on diseases through trials on test sites by the General Directorate of Agriculture and Livestock Inspection and Certification Services in cooperation with the Rwanda Agriculture Board (RAB). It would be useful to also evaluate the production and product quality, and provide the information to the farmers.

One of the problems with the import of seeds is that farmers buy relatively low quantities, which makes import relatively expensive. Arrangements must be made to overcome this, and to enable the availability of the latest varieties. Joint purchasing by private parties could be a solution. Attention should also go out to quality marketing towards farmers, as they are mostly motivated by price, not quality (this also goes for other inputs). Main competition in the seed market comes from East Africa Seeds (from Kenya), who sell somewhat higher quality products (coating, germination), but also at a higher price.

Greenhouse construction

Rwandese vegetable cultivation is characterized by mixed farming systems and small plots. The basis of the farming system is diversification order to spread risks: various plots along the hill slope and in the valley, and per plot a variety of different crops. This implies that a greenhouse has to be similarly small, and has to contribute to the diversification, if it is to fit in the current farming system.

The basic functions of a greenhouse are:

- 1 Keep out insects;
- 2 Protect the crop against harsh weather conditions;
- 3 Create favorable growing conditions inside.

In order to keep out insects, the greenhouse construction must

be impermeable for insects, which can be achieved by a proper netting structure. Other measures, such as a sluice construction must also be implemented. Sanitation measures during the growing season must complement this. An important issue to take notice of is the insect pollination of some crops, for example tomato. Use of insect nets also requires that the pollination must be done manually (which is certainly an option in Rwanda) or through the introduction of bees in the greenhouses.

Protection against harsh weather conditions is offered by plastic cover in the top that stops hard rains, and the overall construction that limits wind speed. A problem in Rwanda is the localized hailstorms that can seriously damage the plastic greenhouse cover. As there is very little that can be done against large hailstones, a certain risk does exist. Glass greenhouse cover is for financial reasons not an option, and glass is also vulnerable to hail.

A favorable growing climate primarily means that the temperature must be kept sufficiently low. The construction requires a top opening (with insect nets) to enable hot air leaving the greenhouse. The temperature is further managed by the cooling effect of crop transpiration and sufficient lateral air movement through the side nets. The greenhouses in Rwanda that are currently used for vegetable production do not have a top opening; hence do not qualify for realizing a favorable growing climate.

Greenhouses do exist in Rwanda. Two types of small-sized greenhouse models have been placed in the recent past, the greenhouse currently marketed by Balton and the greenhouse that was designed in the BTC/RHODA program a few years ago. Both designs are small indeed, measuring 120 to 320 m². The Balton greenhouses, which include a basic irrigation installation, inputs and monthly support by an agronomist, cost € 3000 (\$4000) for the 8 x 15m = 120 m² version, and € 3400 (\$4500) for the 8 x 24 m = 192 m² version. This is € 25 and 18 m⁻², respectively. An important aspect with regard to greenhouses is the absence of a construction industry. All materials for greenhouses have to be imported from Kenya. Apart from services offered by Balton, greenhouse constructors also often come from Kenya or further abroad. This makes the greenhouses and greenhouse construction relatively expensive.

In our opinion, both greenhouse types are not suitable to the Rwandan climate. The main problem is the fact that the greenhouses do not have a top ventilation opening, leading to high inside air temperatures. Admittedly, a top opening makes the greenhouse construction slightly more complex and expensive, but it is a necessity.



Example of a medium-tech Kenyan greenhouse

With regard to the profitability of a greenhouse, a very rough and indicative computation shows the following payback periods at values of a productivity of 20 kg/year/m², variable costs of € 1/m² and a selling price of 500 rwf per kg.⁹

Investment costs in € per m ²	Pay-back period in years
15	2
19	3
22	4

payback period greenhouse investments (Source Author's calculation)

A greenhouse cannot be placed in valleys if these are periodically flooded. Therefore, other pieces of flat land should be selected, preferably close to the roads because of the supply of construction materials and supplies, and transport of produce. Or measures should be taken (integrated water management) in order to counter the effects of flooding.

It is recommended to design a simple and small greenhouse for vegetable production adapted to Rwandese conditions. Use can be made of designs for other African and Asian countries. It is also recommended to interest a Rwandese manufacturer to construct the greenhouses and the greenhouse materials, therewith avoiding import and possible taxation.

Greenhouse installation

The greenhouse installation consists of the hardware inside and outside the greenhouse that is required to realize good crop growth and production:

- Water tank
- Nutrient tanks
- Pumps, tubes, valves
- Thermometer and possibly other sensors
- Substrate
- Depending on technology level, other devices

As rain cannot reach the crop inside the greenhouse, an irrigation system is required. This may consist of:

- Manual irrigation with a watering can.

- Drip irrigation: a water tank that is filled with river water and from which tubes run towards the plant; the water flow is manually activated. The quality of the tubes and valves requires attention, and the blocking of openings must be checked regularly.
- Drip irrigation: a similar water tank; the water flow is activated with an electronic device, for instance a simple time clock.
- Chemical nutrients can be added to the soil or to the water tank (in which case more advanced nutrient product are required).

Plants can be grown in the soil, which has the great advantage that the water holding capacity of the soil realizes more robust water availability to the crop. Furthermore, crop growth can rely to some extent on the natural nutrient availability in the soil. The growing conditions can be better controlled if plants are grown on substrate, but then water supply must be continuous, and proper nutrients must be mixed to the water. In addition, substrate must be available. This can be natural soil, but it is better to use a substrate such as coco or burned rice husks. The supply companies Balton and Agrotech could seize the opportunity to supply the installation parts, and to guarantee maintenance of the supplies.

Greenhouse horticulture in Rwanda is just beginning, and the levels of technology and knowledge are low. It is therefore recommended to develop greenhouse systems at a low technological level. This does not imply that future technological developments are not possible; depending on the economic situation (especially price and product quality developments) and increase in knowledge level, more advanced greenhouse systems might be feasible.

Water and nutrients

As mentioned above, water should be continuously available, and of good quality. In general, water availability in Rwanda is sufficient in quantities, but there is no clear image of the quality of this water. Most farmers get their water from nearby streams or lakes, and do not necessarily rely on water utilities that are constructed by the government. Therefore, water is free to use for most farmers, but quality control often lacks.

Nutrient supply in Rwanda is inadequate: NPK 17/17/17 is the only available type, whereas the nutrient demand of the crop determines the nutrient type supplemented to the soil or substrate. The nutrient demand of the crop is by definition variable, just as is the natural nutrient availability of the soil. Soil testing is hardly done, only some soil tests by research institutes.

It is recommended that a wider variety of chemical fertilizers are made available in Rwanda, and that soil samples are analyzed periodically to enable a proper fertigation¹⁰ strategy.

Crop protection agents

The greenhouse itself is a very effective crop protection agent, as it prevents insects from reaching the crop, if the greenhouse construction and management is adequate. Sanitation is the second important preventive measure. Curative measures are measures such as removing infected plants and applying biological or chemical control agents. In Rwanda, the availability of chemical control agents appears to be adequate (although no

9. Further assumptions costs per year: interest rate 5%, maintenance costs 4%, depreciation 15%

10. Fertigation = irrigation + fertilization



full check was done). It was however not possible to assess the effectiveness of the active ingredients. Biological control agents are not commercially available in Rwanda, and no applied research has been done. A number of companies trade in biological control agents, also operating from Kenya. Another option is the use of biological control agents that naturally occur in Rwanda, and introduce small-scale rearing techniques for example at the cooperative level (large-scale rearing is more complex).

From a food safety and nutrition perspective, society as a whole demands continuously lower chemical residue levels (certainly in export markets). In an approach such as Integrated Pest Management (IPM), chemical control agents are used as a last resort. It is therefore recommended that the effectiveness of available chemical control agents is independently assessed, and that biological control agents are made available. It is very important to have sufficient tools available. Each separate greenhouse needs its own set, in order to prevent transmission of diseases among greenhouses. Sanitation rules should be taken very seriously.

Basic input prices

Most water used in horticulture in Rwanda is free of charge as it is often drawn from creeks and ponds. Also little to no energy is used in greenhouse, as the technology level in existing greenhouses is low. To give an indication of energy prices, both electricity as well as gasoline is relatively expensive. Whereas a KWh of electricity costs \$ 0,20 dollar, a liter of gasoline is about \$ 1,60 dollar.

Production

With regard to land, all land in the marshlands is property of the government but can be leased for periods of up to 49 years. Land can be leased for as little as 2000 rwf per hectare per year, but this amount can increase to up to 200.000 rwf/hectare for fully equipped land. On average, the tariff generally applied to farmer's cooperative is 20.000-25.000 Rwf/ha/year. Currently, the Rwandan Parliament Land Commission is revising the existing land law to incorporate possibilities for foreign investors to own land.

Labor costs in the agricultural sector range from \$ 1,7 dollar/day for unskilled labor, \$ 4 dollar/day for semi-skilled labor up to \$ 8 dollar/day for specialist staff.

Approximately 1,228,000 ha of land are under cultivation, of which only 3% is irrigated. Most households produce at least one staple crop. The majority also produces a wide range of fruit and vegetables, but only in small quantities. For example, 66% of the households produce fresh beans. This diversification of production mainly seems to be a risk mitigating strategy.

The most popular crops are dry and fresh beans, maize, sweet potato, Irish potato, cassava, and banana. Most of these crops are staple foods, which are popular because of the subsistence style of farming. According to the EICV 3 thematic report agriculture, the main vegetables produced are:

	In 1000 MT	In 1000 households
Cabbage	71	300
Tomato	57	239
Fresh beans	49	1379
Squash	33	548
Eggplant	30	349
Peas	18	822

Production levels per household for tomato are difficult to obtain. Information provided to us by greenhouse farmers point towards a fresh production of some 10 kg per plant per year, which is equal to approximately 20-25 kg per m² per year. Outside production is expected to be lower (certainly if the fields are flooded for a part of the year), while the production potential for greenhouse cultivation is higher if the proper cultivation methods are implemented. The total acreage on which tomatoes are grown in 2012 was 3436 hectare.

There is no information on how much acreage is under greenhouse production. The only figures that are available are for the Balton greenhouse, which was sold about 300 times since 2010. Assuming that both Balton models are sold equally, this would mean that a little less than 5 hectares of land is cultivated under Balton greenhouses.

The low level of technology implemented in horticultural production in Rwanda can be illustrated by the fact that only 3 % of households use irrigation systems. On the use of fertilizers and pesticides, the majority of households (85%) use organic fertilizers (such as chicken manure), 22 % use inorganic fertilizer and 14% use pesticides.¹¹

There is great potential for increasing productivity in vegetable production. Besides general interventions such as knowledge transfer, increasing concentration of production (less products per producer), expanding the acreage under vegetable production (currently about 2%) and an increase in the use of irrigation and proper fertilizer would greatly help vegetable production in Rwanda. The introduction of more greenhouse production could have an important impact on the productivity for tomatoes.



Processing

For perishable products such as vegetables, the opportunity to process the product to extend shelf life is key to get all produce to market and to minimize the level of losses in the chain. It also provides a market mechanism to balance the periods of over- and under supply throughout the season, thereby also providing more stable market prices. Not only in the national market, but also in the region (most notably DR Congo) there is a clear demand for processed food.

In Rwanda, processing opportunities for agricultural products are still rather limited. There are some companies that focus on the processing of cereals for flour and beer (a.o. for the Bralirwa/Heineken brewery) such as the partly Dutch company Minimex. Also there is some experience with processing fruit into fruit juices, for example by one of the largest private entrepreneurs in Rwanda, Sina Gerard, through his company Urwibutso. Another example of this is the company Inyange.

In processing vegetables, there is little experience. Two companies that have somewhat of a track record in this are Sorwatom and Shekina. Sorwatom is a processor of tomatoes into paste. The company struggles to get their processing facility fully operational. Besides lack of experience, the main issue is getting enough raw materials to get production to full capacity. This is mostly due to price competition and low productivity. On supply side, sourcing tomatoes for processing has to compete with sourcing fresh tomatoes to local markets. Sorwatom offers growers 100 rwf/kg, whereas they can most often fetch a higher price when selling the produce at local markets. On the marketing side, the end product has to compete with cheap imports for the local market, and low world market prices for the international market, making it very difficult for the company to make a profit. Farmer cooperatives supplying Sorwatom complain that they do not get paid. Where the company used to

flourish, in the last years it has been on the brink of bankruptcy, only kept alive by financial injections of foreign investors.

A more successful story is Shekina. Here, mostly cassava leaves are processed (blanched and dried) to increase the shelf life up to 2 years. Shekina is an important and steady buyer of cassava leaves in the Rulindo area, improving the income of many farmers that cannot always sell all their cassava leaves or are unable to bring them to market. Shekina also provides farmers with new seedlings. The company has some experience with drying fruits and vegetables, but struggles to determine the right varieties and further develop the product.

Important for further development of vegetable processing in Rwanda is to consolidate a market position. There is a clear demand in regional markets (for example in DR Congo) to buy dried tomatoes. A clear understanding of market demand to come up with the right product proposition is important. Another way to consolidate the market position is to focus on low-income consumers for the national market. Competition with the imports that service the higher end of the market seems difficult, but there is no foreign competition in the specific targeting of low-income consumers. Even if those low-income consumers have little to spend, together they can form quite a market. However, this does require product development and specific marketing.

On the supply side, in order to secure a steady supply to keep processing facilities utilized to capacity, it is important to establish a more formal sourcing of produce with producers and cooperatives through grower contracts, which promote the confidence with growers that they get paid for their products. In return, processors can demand a certain product quality through these contracts.



Markets

National market

To get a good idea of national market demand, it is important to know consumption figures. Figures from the national EICV 3 2010-2011 household survey show that a total of 753 billion rwf is spent on food. This implies that an average household spend 39% of its total expenditure on food.¹²

Below is an overview of the top 10 food products purchased by Rwandan households, as surveyed in 2010/2011.

Commodity	Total spending in million Rwf	Total consumption in million Rwf	Share from own production	Share of food purchase	Share of all purchase
Irish potato	57100	100000	43,2%	7,6%	3,3%
Dry Beans	53400	118000	54,7%	7,1%	3,1%
Beef meat	37300	37400	0,2%	5%	2,2%
Restaurant food	35200	35200	0%	4,7%	2%
Peanut oil	28700	28700	0%	3,8%	1,7%
Local rice	27800	31700	12,4%	3,7%	1,6%
Corn (flour)	24100	30700	21,6%	3,2%	1,4%
Imported rice	23200	23200	0%	3,1%	1,3%
Banana (cooking)	21900	65500	66,6%	2,9%	1,3%
Tomato	21600	23600	8,3%	2,9%	1,2%

Figure 5: Consumption figures for key food products
(source EICV 3: Thematic report on consumption (2012))

It shows that, after several staple crops, tomato is the most important vegetable that is consumed, and that unlike most staple crops, most of tomato consumption is not from own production, but is purchased elsewhere.

In the survey, there is also some information on the main market outlets for key staple crops. Even though this gives no information for main market outlets for vegetables, it does give an indication of where most Rwandese buy their food.

	Local rice	Dry maize	Irish potato	Sweet potato	Cassava root	Cassava flour
Small shop	52,4	5,5	26,5	6,1	2,8	0,7
Supermarket	0,2	0	0	0	0	0
Food shop	0,1	0,2	0,5	0,3	0,2	0
Market	10,5	29,7	51,5	51	46	22,7
Mobile seller	0,1	0,6	0,4	0,6	1,4	0,1
Health service	0,2	1,2	0,9	1,1	1,3	0,7
Individual service provider	36,1	62,2	19,3	39,8	46,7	74,3

To generalize this and to specify it qualitatively to the vegetable and fruit market, in the national market a rough distinction can be made between local market, the formally constructed fresh markets, the supermarkets and hotels.

Most produce is sold at the local market. These are often not much more than local gatherings along the roadside where farmers sell their excess produce to other villagers. This is often

done early in the morning, so afterwards farmers can go back to the fields. Prices are relatively low, but there are also no costs for getting to the market since transport is mostly done by bike or by foot, and no fees are paid for a place on the market. These local markets can vary greatly in size. They sell not only directly to customers, but also to small shop holders.

Next to that, there are larger, formally constructed markets in the Kigali area. The three largest are the Kimoronko, Kimisagara and Nyabugogo markets. These markets are the main market outlets for consumers in the urban areas for fresh produce. Quality here is often higher than in supermarkets and prices lower. Most vendors in these markets are women. They rent a stand for 20.000 rwf per month. A vendor tends to sell the same products every day. The product that is sold depends on the cash flow. Vendors that don't have much to spend are more likely to sell low value products like cassava, tubers etc. Others sell more high value crops such as vegetables. Most tomatoes on these markets are grown in the field. Tomatoes from greenhouse are often sold to higher value markets such as supermarkets and hotels.

The prices in Kigali are established by bargaining at Nyabugogo wholesale market between 3am- 6am. In those hours vendors come to Nyabugogo to buy new stocks of fresh produce. This market is an important place for market transactions and price setting and the storage of produce for further sales. Traders in these markets often use so-called scouts that travel throughout the country to find the right produce at the right time, and to secure the sourcing of this product to Nyabugogo market. They are an important source of market information when it comes to supply. On average, consumer prices for tomatoes from the open field can vary between 200-600 rwf/kg depending on seasonal availability. Consumer prices for greenhouse tomatoes vary between 400-1000 rwf/kg. However, most greenhouse tomatoes are not sold at these markets but are sold directly to hotels and supermarkets.

The more "high-end" of the market in Rwanda are the supermarkets and hotels. Supermarkets are slowly gaining ground in Rwanda, mostly in Kigali. The main example is retail chain Nakumatt from Kenya, which have now two supermarkets in Kigali and planning a third. Another notable example for fresh produce in Kigali is FRULEP, a privately owned supermarket that used to specialize in fresh fruits and vegetables. A large part of the clientele of these supermarkets seems to be expats and other foreigners. Most Rwandans, also the more wealthy Rwandans, buy their fresh produce at the markets. Hotels are also increasingly demanding fresh produce as they slowly but steadily grow with the increase in tourism and business.

Supermarkets and hotels tend to spend more on the sourcing

12. National Institute of Statistics of Rwanda (NISR) EICV3 Thematic report on consumption (2012) <http://statistics.gov.rw/publications/eicv-3-thematic-report-patterns-consumption>



of their products. Interestingly, supermarkets and hotels buy most of their fresh produce directly from the farmer, not through markets and middlemen. This seems to be to ensure that farmers keep their highest quality produce for sales to this segment so they can get a higher price. However, on first sight, there does not seem to be a large difference in quality between produce sold in the markets and in the supermarkets (while products in the supermarket are much more expensive). One supermarket manager indicated that he would not pay a higher price for higher quality produce.

In all these different segments of the markets, the so-called middlemen fill the gap that exists because of the limited linkages of farmers to markets. Based on rent-seeking behaviour, they travel around with trucks to buy products from farmers and cooperatives and sell this at the larger Kigali markets or to supermarkets and hotels. On the one hand, these middlemen are important in the sense that sometimes they are the only means by which farmers can sell their produce, if distances to markets are too large. On the other hand, this position gives them a bargaining power that can force the farmers to sell their produce at low prices, making the largest part of earnings go to the middlemen, not to the farmer.

For the development of the horticulture sector, it is important that the farmers can get a fair price so that they can make a living and are able to invest themselves in increasing their productivity. The basis for this is their bargaining power in the market, through improving their position in the value chain, and link up with upstream value chain parties. The larger farmers have the capacity to organize this linkage to markets through their own trucks, information systems and networks, but the smaller farmers lack these means. There are some examples in which this problematic position of small farmers could be overcome.

One example is the construction of a local market place by the organization CEFAPEK in Kamonyi. This marketplace gives seven nearby cooperatives the opportunity to sell their produce at one fixed location. The concentration that this provides, gives these farmers more collective bargaining power, and makes them more convenient to middlemen since they can buy all their supplies at one location.

Another example with regard to value chain transparency through improved information access is the E-Soko system,

which was set up by the Ministry of Agriculture. This system is accessible via mobile phone and via internet, and gives farmers access to up to date price information on any product. The system replies with the price of the product. In this way, the Ministry of Agriculture wants to inform the farmers about the prices to increase bargaining power. Some farmers complained that the information on E-Soko was not up to date. The continuous development of these services is important to keep quality up to standards and information up to date. Experience in other countries shows that involvement of private parties in delivering these kinds of services can improve quality.

International markets

Even though exports of horticulture products are very limited at the moment, it is the strong desire of the Rwandan government to expand exports of fresh produce, following the strong export position in coffee and tea, and inspired by the rapid growth in exports in nearby countries such as Kenya and Ethiopia. Often, the Western (EU, US) markets are targeted, but there is also an increasing interest in the Middle-Eastern markets.

There are some examples of companies such as PEBEC and Shekina that export dried vegetables to Western markets. The company FreshPak is one of the few which manages to reach the quality levels needed to export fresh produce to Western markets, and the Kenyan company East African Growers tries to set up export oriented production of fresh produce in Rwanda. Through targeted interventions such as improved logistics, the Rwandan government wishes to reach a situation in which roughly 20% of fresh produce is of such a high quality that can be exported, 20% can be processed for exports, and the remaining 60% is sold in the national market.

Another important market opportunity are the nearby markets. There is a strong increase in sales to neighbouring countries, mostly to DR Congo, but also to countries such as Gabon and South-Sudan. The demand in these large markets is rapidly growing. Transport to these countries is easier and cheaper than to western markets, and quality requirements are often much lower, making these export markets more accessible than Western markets. With regard to quality requirements, the same goes for the markets in the Middle East.



The enabling environment

Many processes enabling the proper development of the horticultural sector, especially when it comes to greenhouses, can be influenced by men. One main process that cannot, is the climate. Therefore, the first process that will be described in this chapter is the climate. After that, logistics, finance, knowledge & research and extension services/producer support are discussed.

Climatic conditions

Proper climatic conditions are essential for horticulture and greenhouse development. In general, the climatic conditions in Rwanda are suited to horticulture and also to greenhouse production, provided the proper greenhouse design is used. Most critical are temperature at daytime and relative air humidity in the early morning in higher altitude regions. Without mechanical climate control (which would be very costly in terms of fossil energy), natural ventilation is important to manage both temperature and relative air humidity.

Air temperature, among others, depends on the altitude. Towards the east, where altitudes are relatively low, maximum temperatures vary between 25 and 30 °C, with lower or higher values during short periods. At higher altitudes, the average temperature varies between 20 and 25 °C.

In a greenhouse, temperatures may reach even higher values due to the heat load of the solar radiation. A greenhouse construction with maximum ventilation capacity is needed under such circumstances. Experiences in African countries such as Kenya and Ethiopia, and also Asian countries such as Indonesia and Malaysia, show that such greenhouse constructions are possible.

Relative air humidity can be very high at all locations, regularly approaching 100%. This can induce the spread of fungi and bacteria. Maximum early-morning air ventilation in greenhouses is an important prevention measure.

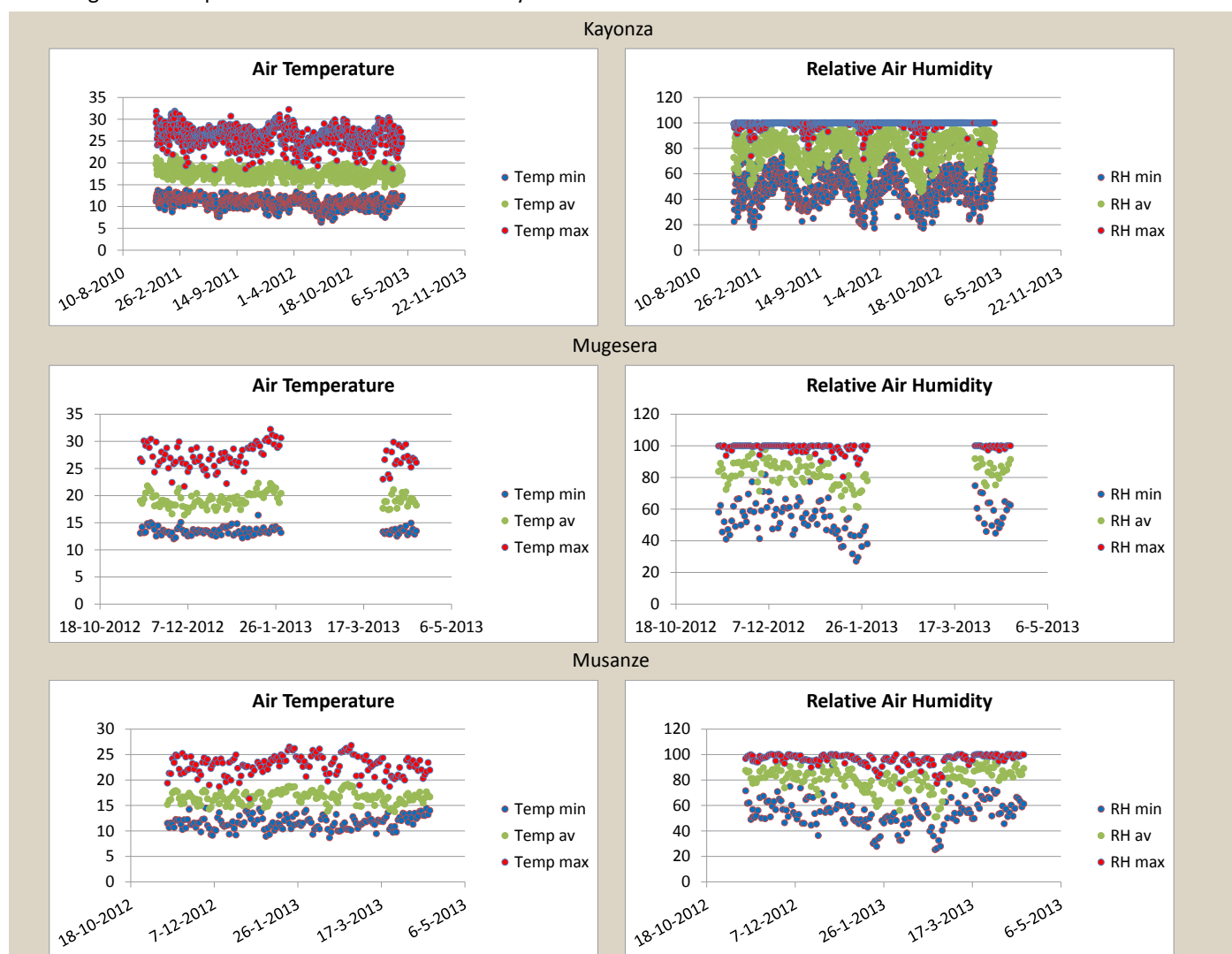


Figure 6: Climatic profiles. (source: Ministry of Agriculture and Animal Resources Rwanda)



Logistics

National

Rwanda is a rather small country, which makes logistics in the country itself relatively manageable. At the same time, the mountainous nature of the countryside poses a serious challenge. This double nature is reflected in the network of roads. Whereas the general network of roads is relatively well maintained and connects to most villages and cities in the country, the access of farmers to these main roads is more problematic, especially for the farmers that manage their fields in the marshlands in the valleys. An often heard comment in this regard is that there are too little so-called “feeder roads” that link the fields to the main road.

Not all fields everywhere can be facilitated with these feeder roads, as this would be practically impossible to construct for the government. The challenge is in prioritizing the construction of feeder roads in certain areas. Both volume and value of the product as well as the perishable nature of the product can do this; the sooner it needs to get to the consumer, the more important are logistics. Horticultural products are often not high in volume (in relation to staple crops) but do have a generally higher value and a perishable nature. It would therefore be recommended to focus the construction of feeder roads to the districts/areas that are targeted for horticultural development.

Another aspect of the logistics for fresh produce is the importance of having a cold chain in order to preserve the products. A large part of post-harvest food losses is caused by the lack of such a cold chain. In Rwanda, this cold chain is almost absent. There are hardly any cooled trucks, as well as cooled storage facilities in the countryside/districts. Also at company level, cooling facilities for horticultural products are virtually absent. In order to improve this situation, the NAEB is working on the construction of one cooled collection center per district. At the moment, three centers have been constructed so far, and a fourth is planned to be constructed before the end of this year.

With regard to these post-harvest losses, there are no official figures, but it can be assumed that general figures (as are present in the 2011 FAO report *Global Food Losses and Food Waste*) of up to 50% loss in fruits & vegetables are also likely to take place in Rwanda. One of the challenges for Rwanda in combating these food losses is the almost complete absence of a packaging industry. An important underlying factor for this is the ban on plastics in Rwanda. It would be recommended to review this legislation based upon the need to develop the Rwandan food sector.

International

As a landlocked country bordered by 4 different countries, international logistics are a challenge for Rwanda. For sea transport, Rwanda has to rely on the ports of Mombasa and Dar Es Salaam. As these are far away, and there are hardly any opportunities for cooled transport by truck to these ports, this mode of transport is currently not an option for the export of vegetables and fruits. There are talks within the EAC to establish a rail link between Kigali via Nairobi to Mombasa, as well as a rail link between Kigali and Dar Es Salaam, but so far no concrete plans have been tabled.

As international transport via road and/or rail is difficult and volumes for the export of fresh produce are limited, airfreight is the most used mode for overseas transport (but also an important means for regional markets). At the moment, KLM cargo offers operations to Amsterdam and Brussels Airlines to Brussels (entry point European market), Ethiopian airlines offers operations to Bujumbura, Addis Abeba and Brazzaville (entry point regional markets). However, because of the limited opportunities for airfreight, the prices for this are relatively high, making competition with exports from Uganda, Kenya and Ethiopia difficult. Currently, prices vary between \$ 1,70 – 2 dollar per kg to Europe, and start at \$ 1,6 dollar/kg to the Middle East.

These prices will decrease as more competition takes place.



This seems to be the case as Turkish airlines has just started operations to Istanbul (entry point to Middle East market) in June 2013, and talks are held between the Rwandan government and a American airline operator to start cargo operations by the end of this year.

At Kigali airport, a 30 tons cold storage capacity is present, divided into several compartments to accommodate the simultaneous storage of different products. The government is offering subsidies to horticultural exporters to use this facility. As the demand for this storage is currently increasing, the government is looking for private investments in additional storage facilities. This will also open the way for private management of the facilities. At the moment, it is publicly managed by the parastatal company MAGERWA (commissioned by the Ministry of Agriculture), and some companies have complained about the bureaucratic way in which the government does so.

Another obstacle in this development could be the limited room for expansion at the current international airport. However, there are plans to construct a new international airport nearby

Kigali in Bugesera. After several postponements of plans, a tender to construct the new airport has been recently awarded to a Chinese construction company, and the final agreement is supposed to be signed soon. In the current plans, the construction of the new airport in Bugesera will start by the end of this year, and is projected to be finished late 2017.¹³

It is assumed that through the establishment of the EAC and the Trade Mark East Africa program, logistics in the region are improved. However, non-tariff barriers still exist and procedures at customs are lengthy. To combat this, special border crossings are being constructed where goods can be cleared for customs more easily. This will however not solve the issue of non-tariff barriers. A sourcing manager from Nakumatt indicated that they import fruits from Kenya via South-Africa, as procedures are easier and duties lower, indicating that the free movement of goods in the EAC is far from a reality.

13. <http://www.theeastafrican.co.ke/business/New-Rwanda-airport-ready-for-take-off/-/2560/1747438/-/oqexn5z/-/index.html>



Finance

Access to finance is a serious issue in the development of the horticultural sector, especially for greenhouse horticulture as this is a rather capital-intensive form of horticulture. Based on statistics, the use of financial instruments seems to be limited. In 2012, only 7,9% of households applied for a loan to implement agricultural improvements. Most loans (49,5%) are used to buy seeds and fertilizers. 8,9% to buy equipment.¹⁴

The main reasons for this limited use of loans can be twofold. Either financial instruments are not properly accessible, or farmers/producers are too risk-averse to use loans to make investments.

With regard to accessibility, as in most other developing countries, commercial banks are hesitant to provide loans to

farmers due to a high-perceived risk. Therefore, interventions from intermediaries are important to cover a part of these perceived risks. In order to facilitate these interventions, the Rwandan government has created the BDF (Business Development Fund) to improve access to finance for farmers. Furthermore, the government is working with IFAD and the central bank on the implementation of the Project for Rural Income through Exports (PRICE) and the Support Project for the Strategic Plan for the Transformation of Agriculture (PAPSTA) to facilitate easier access to finance via commercial banks. For this, IFAD issued a \$39,8 million loan and grant.

The BDF provides guarantees to farmers when they apply for loans at commercial banks in order to substitute the lack of collateral. In horticulture, 50% of collateral is covered by BDF. For women and youth, there is a special facility to which even 75% of collateral is covered. The maturity of the average loan is 5-7 years and interest rates vary between 11-14%. So far, 858 loans have been facilitated by the BDF. BDF also offers advisory service to loan takers in order to help them successfully implement their business plans.

14. <http://www.statistics.gov.rw/publications/eicv-3-thematic-report-agriculture>

For farmers/companies that have difficulty to come up with the other 50% for collateral, there is also the Rural Investment Facility. This facility organizes business plan competitions with a focus on export-related production. In recent rounds, roughly 30-50 of these business plans were focused on horticulture. Business plans that are selected are given cross-equity in order to fill the remaining financing gap. This equity consists of equity/debt constructions at low interest rates.

Prior to the establishment of the BDF, Belgian development agency BTC introduced the Horticulture Investment Fund, which subsidized 50% of the costs for the purchase of a greenhouse. This Fund was an important impulse for greenhouse development in Rwanda. It was also supported by a facility through which short courses of 2 weeks for greenhouse management were held for the buyers of these greenhouses.

At the same time, these kinds of programs with a large subsidy can be conceiving, since the large share of subsidy dilutes the true price of investments in greenhouse development. The BDF is therefore a more proper instrument, as this only provides the collateral and is therefore not “free money”.

Even though the BDF seems to be a proper financial instrument for horticulture and greenhouse development, in different interviews farmers have indicated they believe the access to the BDF is difficult due to bureaucratic procedures, and that some applications are rejected without a clear explanation. It was also noted that a lot of farmers are not aware of the possibility to use the BDF to improve their access to finance. It is therefore recommended that more emphasis is put on awareness campaigns on the availability of the BDF and that application procedures are reviewed and are made more accessible and transparent.

BDF shows that government interventions to promote access to finance are important. At the same time, the company Balton shows that these kinds interventions aimed at bringing down the risk for banks can also be organized in the market. With some banks such as Banque Populaire du Rwanda (BPR), Balton signed MoU's ensuring a financial construction in which the following steps are taken:

- 1 Farmer/producer applies for a loan to buy a Balton greenhouse kit
- 2 The bank reviews the application and sends a letter of approval to Balton about the loan
- 3 Balton constructs the greenhouse and after construction receives payment from the bank for the kit.

The farmer/producer will remain the loan taker. The main improvement is that the banks are confident that the risk of default is lower due to the fact that the farmer invests in a Balton greenhouse, therewith substituting the need for collateral. Of course, these kinds of private sector arrangements are always preferred over public sector interventions as they are more sustainable and market driven.

At the same time, it is also essential to work on the other underlying factor of the limited use of financial products, being the inability of many farmers to overcome their risk-averse attitude towards investments. This has several reasons.

The main reason is that the average farmer has little to no assets. Thinking in terms of cash flow is only present on the very short term. If a farmer invests money, he wants to have immediate returns. From this perspective, making an investment for the long term, say a horizon of more than a year, seems almost impossible. Doing this with other people's money and running the risk that you later on have to pay for that, with interest, is for most farmers impossible.

Another reason is the lack of (financial) literacy. Many farmers lack the capacity to make a basic business plan with a simple cost-benefit analysis for the season. If farmers would manage to forecast their earnings and get an oversight of their costs, they would be more able to assess the possible risk of making an investment. As long as farmers cannot make these kinds of analyses and consequent business plans, banks will remain hesitant to provide farmers with loans, even the banks that have some risks covered by certain government programs. As horticulture (more than general agriculture) depends on investments in good seeds, technologies, etc., financial literacy is very important for the development of the horticultural sector in Rwanda.





Knowledge & Research

Greenhouse horticulture is very knowledge-intensive by nature, requiring knowledge and skills at all levels, from the farm manager to the daily worker (in the case of small-scale vegetable cultivation in greenhouses, these functions are combined). Application of water and nutrients require greater skills, sanitation is very important, etc. As the technology levels advances, the need for knowledge increases.

There is a wide variety of knowledge sources, such as universities, research centers, extension services, the private sector (especially the supply industry), and other farmers. The knowledge infrastructure should be shaped in such a way that knowledge flows freely, while each stakeholder plays its most functional role.

Rwanda has seven public universities that will be merged in the course of 2014 in one national university. ISAE (Higher Institute for Agriculture and Animal Husbandry), one of the current seven, will then be assigned the primary responsibility for agricultural/horticultural education at the academic level. ISAE offers an A0 bachelor degree program, and an A1 advanced degree program. ISAE has one greenhouse and eight laboratories, and possesses a weather station. Laboratories and greenhouse are used for breeding research on beans, rice, maize and potato. There is a quick growth in applicants for the horticulture study. Starting in 2010 with 24 students, they now have 179 students enrolled in the horticulture program.

ISAE is collaborating with several partners:

- Most knowledge coming from the ISAE research is distributed to farmers by RAB. Also in seed enhancement, there is cooperation. For example RAB distributes enhanced potato seeds to farmers, but at the moment they can only supply 2 per cent of the demand. ISAE helps RAB to increase the (public) supply of enhanced seeds.
- ISAE has an active community outreach program (with one dedicated officer) in which lecturers and senior (3rd year) students go out in the field to train farmers in cooperatives (upon request). Sometimes they also do research and demonstration projects with the farmers, for instance with regard to seed cleaning, spacing and the use of fertilizers.
- Since last year, there is a cooperation with the Israeli AgroStudies center (<http://www.agrostudies.com/>), where 14 horticulture students do their research internship (in their last year of study).

- There is cooperation with the University of Gent and support has also been given through the NUFFIC/Niche program (mainly in cooperation with Van Hall Larenstein).
- Sometimes a lecturer from South Korea is on short-term assignments; currently, a South-Korean professor is teaching at ISAE for a 1-year period.

So far all students have finalized their studies at this faculty, there are hardly any dropouts. Most graduates start working for NAEB or other government institutions, some for private companies. In general, salaries for agronomists in the public sector are higher, attracting more graduates. However, at the moment there are hardly any vacancies for government positions, so it is necessary for graduates to look more for private sector jobs, which are also limited. Therefore ISAE started to put more focus on training students to start for themselves (training on business skills).

Classrooms and facilities look quite decent, but there is also a lack of basic facilities such as textbooks. The horticulture department suffers from a lack of senior lecturers and professors to deal with the quick growth in the number of students. Only a few graduates enroll in MSc or PhD programs elsewhere, which would eventually qualify them to become a lecturer or professor.

ISAE plays an important institutional role in the horticultural knowledge build-up. Analytical and systems-oriented thinking (characteristic for higher education) are essential capacities in governmental institutions and management functions to develop a horticultural sector in Rwanda. In addition, BSc students form the backbone of the extension service.

There are also eleven private universities. The Institute for Applied Science (INES) in Musanze is one of them. Being is a private university most students come from middle/higher class. The focus is less on academic research, and much more on applied, market-oriented, research, especially in the fields of data mapping (surveying) and applied statistics. Their strength appears to be in this type of consultancy-type of activities. It also does some applied research in seed enhancement and food preservation technology. Also, it has started working with the Rwanda Bureau of Standards (RBS) on soil analysis in the recently constructed laboratories at (which are more advanced than the ones at ISAE). At the moment they are constructing two greenhouses, designed by their own students.

The private sector possesses much knowledge on greenhouse horticulture. Suppliers, for instance, can provide knowledge with regard to the use of the products they supply. And often, supply companies employ agronomists with a much wider knowledge base than with regard to the product they supply. The business model is usually to provide the grower with a fairly wide range of advices, in order to ensure that the supplied product is applied in a well-functioning farming system. For instance, AgroTech attempts to convince farmers of buying their products through demos that are run by the different branches. They also have a system of lead farmers that they involve in the demos and use as “opinion leaders”. Another example is Balton, which sells the so-called Amiran farmers kit, which includes an entire greenhouse (small size), inputs and monthly support by an agronomist.

This kind of knowledge transfer is very important, since the ownership in these processes lies with the farmer: he/she has bought the product and wants to use it to its potential. Designing a system of knowledge transfer, which improves the facilitation of public-private partnerships, for example through cooperation between RAB and input supply companies, could be an important stimulus.

Producer support

Next to more general agricultural producer support through RAB, cooperatives, NGO's, the only specific organization that targets horticulture is RHIO (Rwanda Horticulture Interprofessional Organization), but they seem to lack the capacity to truly represent their members on the ground and to do effective lobbying. The problem with the current structure of producer support is that within the general agricultural producer support, there is little knowledge of the horticultural sector, and capacity allocated to this seems to be limited. Capacity also seems to be an issue with RHIO. For the development of greenhouse horticulture in Rwanda, it is important that support to vegetable producers in Rwanda should be effective from the beginning onwards. This is a problem, as knowledge on greenhouse horticulture is scarce in Rwanda.

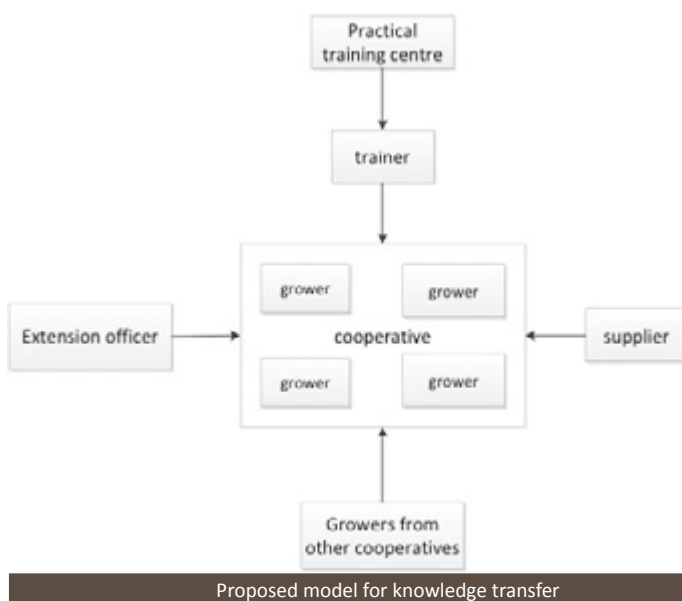
It is therefore recommended to establish a practical training center. Given the large number of growers in Rwanda, it will not be feasible to train the growers directly; rather, a train-the-trainer program needs to be developed in which trainers are provided skills at the training center, and in which the trained trainers subsequently transfer their skills to growers at their own farms, learning directly to deal with their own situation. At various places, positive experiences with this training model exist. Such a practical training center needs to be equipped with classrooms, but certainly also with a greenhouse in which hands-on training can be given. Training programs preferably last an entire growing season to make the trainees acquainted with all aspects of the cropping cycle. These training programs should be developed in close cooperation with institutes such as ISAE in order to promote the transfer of up to date knowledge.

The trained trainers subsequently transfer their knowledge to the growers. This can be organized through the cooperatives, which are the main organizational units in rural Rwanda. The cooperatives can also organize the input of other knowledge suppliers, such as the extension service, agronomist from the supply companies, and others. An important aspect in such an approach is clear governance on who employs and who pays these trainers.

The current public Agricultural Extension including the Ministry of Agriculture at National/Zonal level and the Ministry of Local Government at the District, Sector and cell level operate through offices in 30 Districts, 416 Sectors, 1,500 Cells and 14,876 Villages. At the national level, Rwanda public extension comprises 1244 staff members and is managed by a team of 92 senior staff according to the MEAS report (2011).¹⁵ Only one staff member has a Master of Science degree and the rest of the team studied at the bachelor level. There are 175 subject matter specialists to provide backstopping support to the field staff, none of them having a graduate degree. Field level extension workers constitute the bulk of staff (78%), with 87 % of them holding a 2 to 3 year agricultural diploma or less.

Agricultural Service Centres already exist, and the knowledge dissemination with regards to protected cultivation should be incorporated in existing structures. Use can be made of the national road map that has been developed for Agricultural Service Centres, which focuses on the strengthening of existing Agricultural Service Centres and Service Providers with electronic dissemination of information.

The SMASH project could play an important role in the establishment of the practical training center combined with a demonstration greenhouse, and in guiding farmers with regards to their cultivation practices.



Apart from this primary producer support, also the secondary producer support should be realized. In order to effectively organize the horticultural sector in Rwanda, ministries and other governmental agencies must be staffed with knowledgeable staff, the education institutes need to be capable of educating students that are available to the horticultural sector after graduation, and the research institutes need to be capable of conducting research that is relevant to the sector. Relying on international experts is not a sustainable model

Conclusions

Rwanda has a long way to go in advancing its horticultural production. Production figures for horticultural produce are relatively low. Trade figures show that there is still quite a way to go in substituting the relatively large quantity of foodstuffs and fresh produce that are imported. At the same time, this study shows that Rwanda has the potential to increase its production. Even though average land plots are small, the climate is favourable for horticultural production, and the government has put policy in place to stimulate horticultural development. National and regional markets are slowly getting more advanced and purchasing power is increasing. Vegetables are a common element in the Rwandan diet, so with the economic growth of the country, the national demand for vegetables will also grow.

Farmers are relatively unknown with more advanced ways of horticultural production, and this holds the potential for further development. Through the supply of improved and adapted technology and inputs and knowledge transfer, horticultural productivity can increase steadily, and might even reach a level of both quantity and quality for export. In general, the climatic conditions in Rwanda are suited to horticulture and also to greenhouse production, provided the proper greenhouse design is used.

The quality of horticultural products stands or falls with supply of quality inputs in Rwanda. With regard to seeds, it showed that quality of available seed is variable, and the supply is irregular. Arrangements that realize a steady, and a more diverse availability of varieties, and offer farmer the opportunity to select the variety of their preference, are welcome. With regard to fertilizers, it is recommended that a wider variety of chemical fertilizers is made available in Rwanda, and that soil samples are analysed periodically to enable a proper fertigation strategy. Furthermore, independent assessments on the effectiveness of available chemical control agents is needed, as well as the availability of biological control agents.

With regard to greenhouse technology greenhouse horticulture in Rwanda is just beginning, and therefore it is recommended to design a simple and small greenhouse for vegetable production adapted to Rwandese conditions. Use can be made of designs for other African and Asian countries. This does not imply that future technological developments are not possible; depending on the economic situation (especially price and product quality developments) and increase in knowledge level, more advanced greenhouse systems might be feasible.



It is also recommended to interest a Rwandese manufacturer to construct the greenhouses and the greenhouse materials, therewith avoiding dependence on import and possible taxation.

Greenhouse horticulture is knowledge-intensive by nature, and therefore with any approach on developing greenhouse horticulture, a focus on training is essential. This involves the establishment of a practical training centre with a demonstration greenhouse, where following the train-the-trainers approach,

trainers are educated to disseminate knowledge to groups of producers. The knowledge infrastructure should furthermore link up with the private sector, which possesses much knowledge and a good network, the education and research system (for example, ISAE), and the government extension services that are already run by Agricultural Service Centres.

If Rwanda is serious about becoming an important East African player in the export markets for fresh produce, next to improving productivity, it should also put more effort in developing the logistics necessary to facilitate this. A first beginning is made with installing cold storage facilities in all districts, but the pace of development is rather low. Next to the existing cold storage facilities at the airport, it is important that all infrastructure is privatized as soon as possible in order to make fees more competitive and to ensure an effective management of these facilities.

Also, logistics to nearby countries needs to improve, as this development is the most important stepping stone for the development of export to the “West”. Even though Rwanda is officially part of the East African Community, several parties mentioned that free movement of goods is far from implemented, and that several (non-tariff) barriers still exist. The fact that supermarkets are importing vegetables from Kenya via South-Africa is a case in point.

An equally important driver for horticultural production as the development of export markets, are the opportunities for processing of vegetables. As vegetables are perishable by nature, and the sector is still dominated by seasonal productivity peaks (which will be smoothened as more greenhouse production will be introduced), it is essential that growers also have the possibility to sell their produce to processors. This way, less food is discarded, and the market is less flooded during peak moments in the season, which will positively influence market prices. At the moment, there is little to no processing of vegetables in Rwanda. Entrepreneurs should be stimulated (i.e. through favourable financing schemes) to start a business in vegetable processing, and more formalized contracts should be introduced between suppliers and buyers. The establishment of a national packaging material industry is also essential in this.

Finally, all change starts with the farmer her- or himself. She or he should be willing to start horticultural production or increase existing production. For this, it is essential that the farmer is willing to make some sort of an investment in its production, since horticulture is a more advanced sector than more general agriculture. Many farmers still refrain from these investment decision as they can't oversee the long term necessary to judge the financial viability of such an investment. A large part of the risk averse nature of the farmer can be tracked back to a lack of financial literacy. Improving this situation through close cooperation with farmer cooperatives will be essential to convince farmers to invest more. Otherwise, they will remain trapped in a vicious circle of “low input, low output”.

Acknowledgements

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Annex 1

Meetings and interviews held with following people (in random order):

- Dr. Agnes Kalibata, Minister of Agriculture and Animal Resources
- Ernest Ruzindaza, Permanent Secretary, Ministry of Agriculture and Animal Resources
- Evariste Safari, sales & marketing manager Agrotech Ltd.
- Kelvin Odoobo, Manager Agriculture Balton Rwanda
- Mr. Narcis, managing director FRULEP
- Epimaque Nsanzabaganwa, Deputy Director-General NAEB
- Representatives of RAB, NAEB, RBS, DG Inspection of Ministry of Agriculture and Animal Resources (names not known)
- Pascal Furaha, General Manager PEBEC cooperative
- Desiré Nzayisenga, Agronomist at CEFAPEK (Centre de Formation Agricole de Petit Elevage de Kamonyi)
- Dr. Laetitia Nyinawamwiza, Acting Rector and Dr. Obedi Nyamangyoku, Dean of the Faculty of Agriculture & Rural Development and other representatives of ISAE (Higher Institute for Agriculture and Animal Husbandry)
- Dr. Fabien Hagenimana, Vice-Rector and Joseph Munyaneza, Lecturer Enterprise Management at INES (Institute for Applied Science)
- Jean-Claude Ruzibiza, Owner Rwanda Best Company
- Pierre Damien Mbatezimana, Owner Shekina Company
- Meeting with representatives from PSF (Private Sector Federation), Chambre d'Agriculture, RHIO (Rwanda Horticulture Interprofessional Organization) and BDF (Business Development Fund) (names not known)
- Teddie Muffels, agricultural counsellor and Marie Nizeyimana, Agricultural officer at Royal Netherlands Embassy in Kigali
- Maia Gedde, Project Manager Spark, John Veerkamp, Country Rep. IFDC, Andrew Thorburn and John Bosco Kalisa, TradeMark East Africa, Elie Nsabimana, SNV and Tarik Kubach, EU representative office Rwanda
- Simon Shilling, Purchasing Manager Fresh Food, Nakumatt
- Fabrice Mudenge, Manager Spring Farms

