Sustainable sourcing: how to anticipate climate change?

Guidance in identifying risks and opportunities of climate change for sustainable import of fruits and vegetables

LEI
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Contents

Preface

There is growing evidence that climate change will globally affect the production of fresh fruits and vegetables in the coming decades. Changing weather circumstances may lead to shifts in growing seasons, changes in quantitative or qualitative yield, or even different crops being produced. These changes will also have consequences for the sourcing and supply of commodities that are imported from elsewhere in the world. Climate change may increase or decrease the sustainability of production, e.g. by affecting the availability and use of resources, and ultimately lead to a shift in sourcing regions.

While the potential impacts of climate change are obvious, it often appears difficult to translate generic insights into specific current practice of food supply chains. This complicates strategic decision-making and hinders anticipation of stakeholders on climate-induced risks and opportunities. Accordingly, there is a need for guidance in the identification of potential impacts of climate change, and the possible actions that stakeholders can take in anticipation of these impacts. This is particularly true for supply chains of fresh produce, due to its relatively short shelf-life, high quality requirements, and seasonality of supply.

This report fulfils this need by presenting a generic approach for qualifying the impacts of a changing climate on production, marketing and trading of fruit and vegetables produced in African countries. The approach does not aim to support detailed, accurate prediction of impacts in time and space. Rather, it positions climate change in a dynamic physical, socio-economic and institutional environment, and offers guidance to stakeholders in defining their roles and responsibilities for achieving a sustainable supply chain that is resilient to climate change. The approach is illustrated by applying it to three case studies: oranges sourced in South-Africa, oranges sourced in Egypt, and green beans sourced in Kenya.

We deeply acknowledge the role of Mr. Roland Waardenburg (The Rock Group) and Mr. Sjoerd Croqué (Dutch Ministry of Economic Affairs) in the initiation of this study. Also, we would like to thank Mrs. Eunice Mwongera from Kenya and Mr. Amr Mahmoud from Egypt for their contribution to the case studies. Our special gratitude goes to the members of the advisory board, Mr. Kees Rijnhout (Jaguar TFC), Mr. Rik van Keulen (SNV), Ms. Janny Vos (CAB), and Mr. Hans Brand (Dutch Ministry of Economic Affairs), for their valuable advice and feedback throughout the project.

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Summary

Main results

The possible impact of climate change on sustainable sourcing of fruits and vegetables depends on its effect on four dimensions (Figure S1). Effects of other mega-trends such as technological change should also be accounted for.

Application of this conceptual design to three case studies yielded the following overall insights:

- Whether climate change affects the relative competitiveness of sourcing countries, and in which direction, depends on many other factors, some of which are at least as important as climate change.
- The adaptive capacity of a supply chain to climate change is mainly determined by knowledge and technology transfer, political environment, and financial capacity. Timely anticipation of possible impacts requires cooperation and organisation that is robust to the dynamic environment.

Additional results and insights

The possible consequences of climate change are largest at the level of primary production, and gradually decrease when moving downstream along the supply chain. Yet the action potential of individual farmers is restricted in time and scale. Climate-smart agriculture in sourcing countries therefore requires joint effort of actors along the supply chain up to the level of consumers. Specific actions are defined in Appendix 1.

The interaction between climate change and sustainable sourcing is bidirectional: climate change affects sustainability of sourcing and vice versa. Efforts should therefore not only be targeted to adaptation, but also to mitigation, which requires different actions from stakeholders.

This study focused on stakeholder dynamics and responsibilities with respect to climate change, rather than aiming to facilitate detailed, accurate predictions of impacts in time and space. As a result, the approach and case studies are restricted in terms of accuracy and geographical scale.

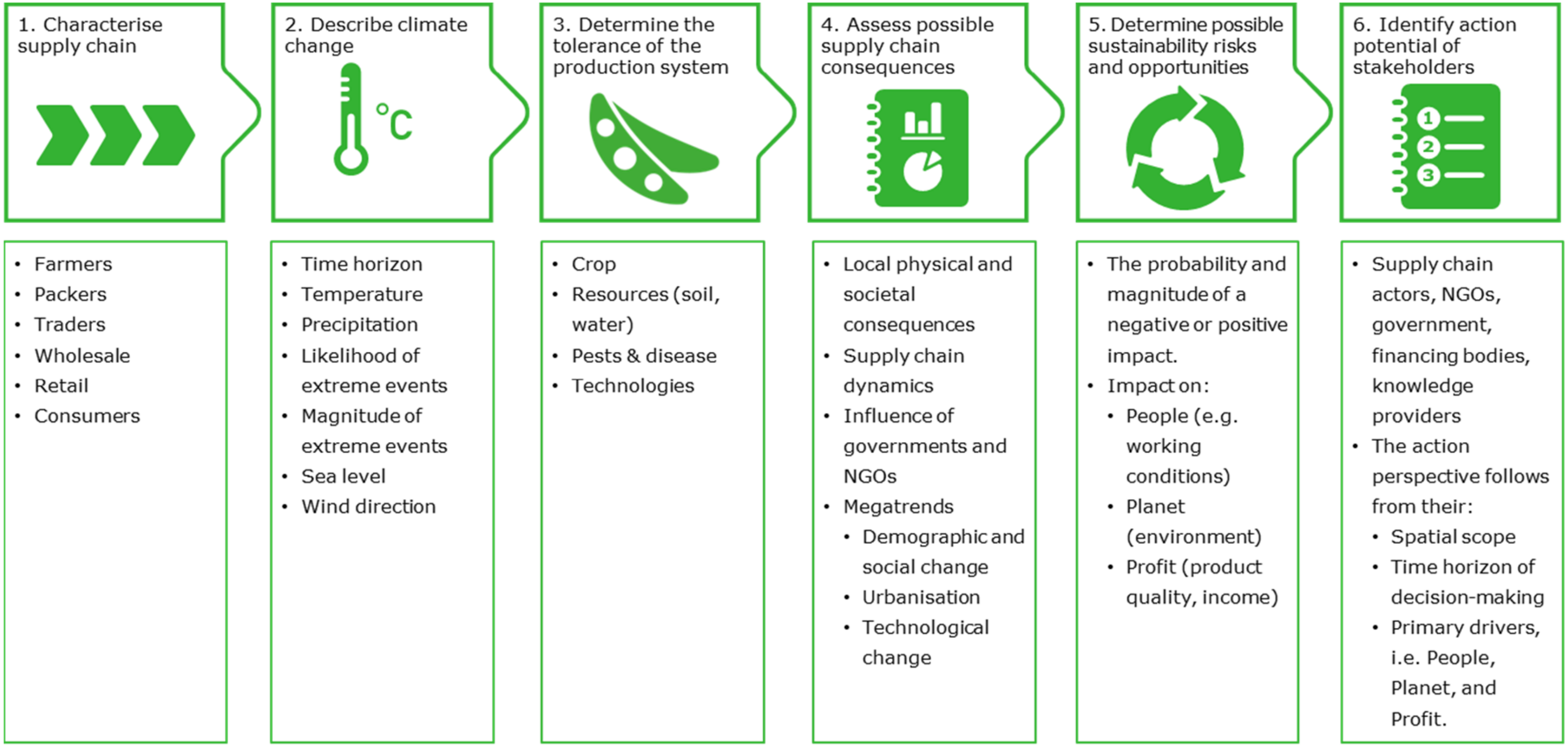
Background and objective

There is growing evidence that climate change will globally affect the production of fresh fruits and vegetables in the coming decades. These changes inevitably also have consequences for the sourcing of such commodities. Accordingly, there is a need among supply chain partners and other stakeholders to better understand how climate change interacts with sustainable sourcing ambitions, as affected by strategic decisions and activities of individual actors.
This study develops a generic approach that may guide stakeholders of fresh fruit and vegetable supply chains in how to anticipate on climate change while realising their sustainability ambitions. We illustrate the approach by applying it to three case studies.

Method

The approach and overall insights presented are the result of iterative co-creation in a multidisciplinary team of researchers. Through desk study and several work sessions, empirical observations and scientific theories were translated into a functional, stepwise approach and recommendations. The case study analyses are the result of literature review, where necessary supplemented with expert knowledge.

Figure S1 Schematic representation of the four dimensions to be considered in assessing risks and opportunities of climate change *
* Boxes in each dimension are illustrative and not necessarily inclusive.



1 Sustainable sourcing and climate change

Sustainable sourcing and climate change

Towards 100% sustainable sourcing in 2020

The sustainable sourcing of raw materials is a key priority for supply chain partners. Companies are already monitoring and reporting the impact of supply chain activities on the three dimensions of sustainability: environmental, social and economic. Implementing strategies to safeguard the sustainable sourcing of their raw materials is an integral part of the corporate strategy, and is often done via certification and verification.

These strategies are increasingly looking at long term consequences of climate change on sustainability targets. Climate change has not only added to sustainability challenges via resilience and greenhouse gas (GHG) emissions but also tends to reduce the effectiveness and efficiency of activities trying to reach these sustainability targets.

In 2012, the Sustainable Trade Initiative (IDH), Dutch retailers, traders in the sector and civil society organisations signed a covenant, which aims to make imports of fruits and vegetables from Africa, Asia and South America 100% sustainable in 2020. This covenant is to put into practice by the SIFAV programme (Sustainability Initiative Fruits and Vegetables). As part of its activities, SIFAV provides support to local farmers in creating a more stable and sustainable production environment.

While SIFAV intends to realise its ambitions in a few years from now, it is important to look beyond the 2020 time horizon in order to remain sustainable in the long run, and to understand the future challenges of sustainable sourcing.

Climate change & sustainable sourcing

Climate change and sustainable sourcing of agricultural products have a dual relationship. First, there is clear evidence that climate change will affect agricultural production in the coming decades. Changing weather patterns may lead to shifts in growing seasons, changes yield levels and yield quality, or even lead to structural changes in cropping and farming systems. These changes can bring along risks and opportunities for the sustainability of sourcing of the respective commodities. Yet, the actual impact depends on how the supply chain is able to anticipate on these changes (Figure 1).

Second, greenhouse gas emissions are generated by supply chain activities and climate changes impact on these sourcing activities. For instance, we can think of soil management affecting the CO_2-buffering capacity of the soil, energy use during storage and transport, and consumer preferences influencing the demand for fresh produce from particular regions. Because the relationship works in both directions, the mitigating or accelerating effect of the supply chain on climate change is - in itself - affected by climate change, causing a feedback loop.

A similar interaction occurs between the supply chain and sustainability, which covers issues such as resource conservation, product quality and workers' conditions. Sustainability is primarily determined by the activities in the supply chain. Yet, insight into the performance on particular sustainability themes may induce stakeholders to switch to more sustainable practices. Moreover, the importance of sustainability themes changes over time, e.g. due to political or social pressure or resource depletion. As a result, the practical meaning of sustainability today is different from that 10 years ago and will be different 10 years ahead.

Specific challenge

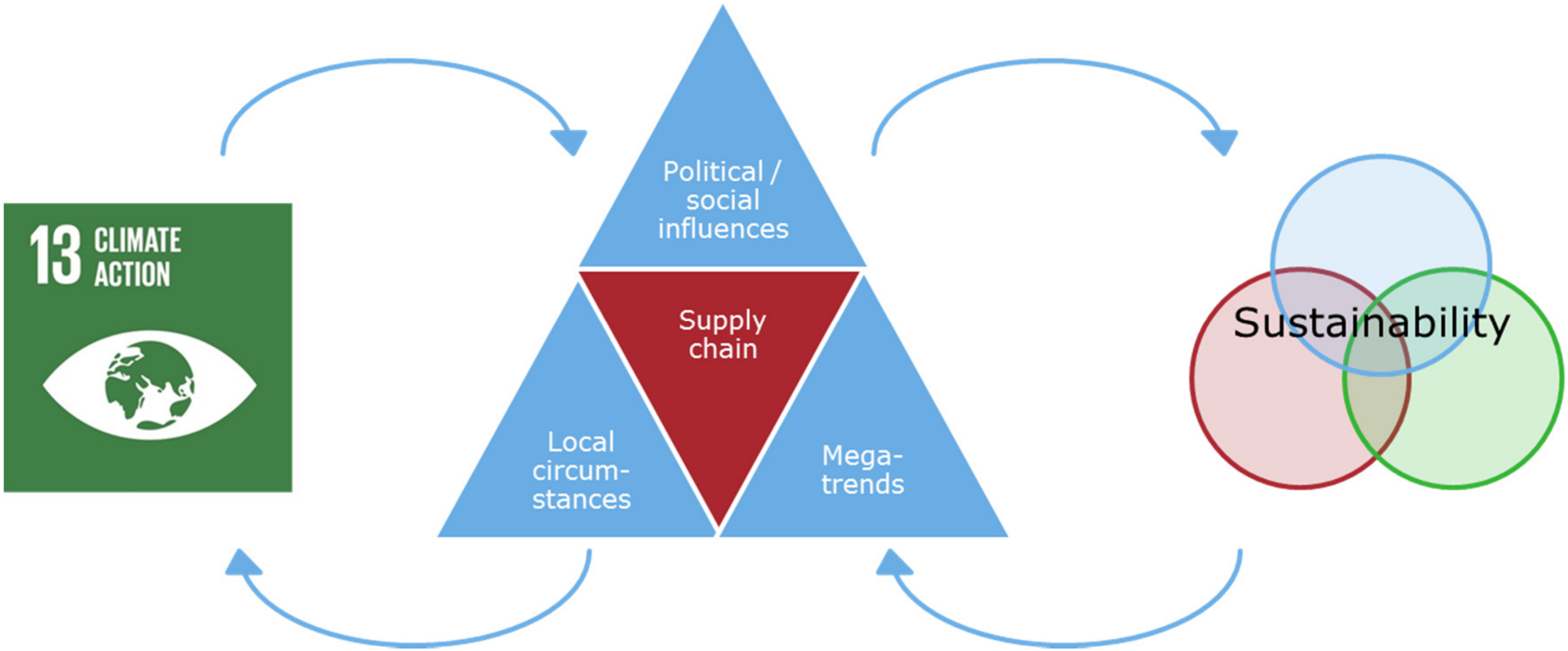
To facilitate strategic investment in sustainable sourcing, supply chain stakeholders should be able to anticipate on the expected impacts of climate change. Yet, insight into the actual risks and opportunities of climate change on the sustainability of the international supply chains is still often lacking. To the extent that evidence is available, it is difficult to put hypothetical effects into the perspective of other global trends, feedback loops described before, and the dynamics between stakeholders that are inherent to supply chains.

This report aims to provide guidance to stakeholders in achieving the SIFAV ambition of 100% sustainable sourcing under a changing climate. It provides a stepwise approach in the identification of risks and opportunities following from climate change. The approach applies a holistic perspective and accounts for the interactions between climate change and sustainable sourcing in a dynamic and changing socio-economic environment. As such, it enables stakeholders to determine the need to anticipate on climate change and the possible role they can play in this process.

Outline

The remainder of this report is structured as follows. In the following pages, a generic approach to determine the risks and opportunities of climate change for sustainable sourcing is presented. This approach is then illustrated by three case studies, followed by key findings from these case studies.

Figure 1 Relationship between climate change and sustainable sourcing



Generic approach

2

Generic approach

Six steps in assessing climate risks & opportunities

In determining whether the movement towards sustainable trade might be affected by climate change, we distinguish the following six steps:

1. Characterise the supply chain
2. Describe climate change
3. Determine the tolerance of the production system
4. Assess possible supply chain consequences
5. Determine possible sustainability risks and opportunities
6. Identify action potential of stakeholders

Each of these steps is further explained in the sections below.

1. Characterise the supply chain

A general description of the supply chain is required to understand its main challenges in terms of sustainability and its vulnerability to climatic circumstances. Supply chains generally comprise more or less the segments illustrated in Figure 2; however, large variation exists in terms of e.g. level of horizontal and vertical concentration or integration, infrastructure and logistics, and market structure. Also, there may be diversity within segments such as regional differences in production systems or circumstances, or segmentation of product characteristics such as quality or seasonality. Furthermore, the positioning of the supply chain in a global context should be described.

Important notes:

- Apart from the stakeholders in the supply chain, other actors play a role, including for instance policy makers and NGOs. The interaction of such actors with the supply chain will be addressed in step 4.
- In line with the objective of this report, impact assessment is restricted to production destined for export. Production for the domestic market is not taken into consideration, although we acknowledge that in practice these two markets are often not isolated from each other.

2. Describe climate change

To determine the impact of climate change, scenarios are an important tool. For the latest report of the Intergovernmental Panel on Climate Change (IPCC) a set of four representative concentration pathways (RCPs) was developed (van Vuuren *et al.*, 2011). These are not defined by socio-economic narratives, but rather by particular outcomes of radiative forcing. Using the emissions and greenhouse gas concentration time series from the RCPs, climate modellers calculate new climate scenarios.

Following the choice for a particular scenario, a description of climate change starts with defining the time horizon. For the given time frame, climate change should at least be characterised in terms of expected changes in temperature and precipitation. Insight into the likelihood and magnitude of extreme events such as storms and flooding is also important, though less easily available. Other effects, such as changes in sea level or wind directions may be relevant on a case-by-case basis.

Figure 2 Generic structure of an international supply chain of fresh fruits and vegetables

3. Determine the tolerance of the production system

Agriculture is a climate-sensitive sector. Therefore, determining the impacts of climate change on crop production is an important first step. Beside the increase in CO_2 concentration, changes in temperature and precipitation are important. Indirect impacts such as sea-level rise and changes in occurrence and abundance of pest and diseases and extreme events such as drought and flooding can locally be more important but are in general more difficult to obtain.

For other segments of the supply chain the impacts of climate changes may vary. Higher temperatures may in some areas increase the need for cooling; in combination with more humid conditions mould may become a larger risk during storage of fresh produce. Increased flood risk, storms and fog may hamper transportation.

4. Assess possible supply chain consequences

The key question is how the information obtained in steps 1 to 3 affects crop production and activities downstream in the supply chain. Answering this question requires an understanding of the interaction between the crop production system and three other dimensions: the local environment, the supply chain, and the global society (Figure 3).

Climate change is not the only driver of change; a number of other global mega-trends affect future crop production and activities downstream in the supply chain. Three mega-trends in foresight studies stand out (Oxford Martin Commission, 2013; PBL and CPB, 2013):

1. Demographic and social change
2. Urbanisation
3. Technological change

These are in many cases key drivers and should be taken into account when assessing the possible risks and opportunities of climate change.

Local physical and societal circumstances

Farmers will respond strongly to market incentives and consequently, if household and other local conditions allow, will also look for opportunities to obtain income via cash crops. In areas in which cash crops are successfully established, changing to other crops will not always be easy. Uncertainty related to seeds, logistics, stable market demand will be factors to be considered, especially for perishables such as fruits and vegetables. So even if climatic conditions become unfavourable, changes may be gradual and investments in adaptation measures may pay off even in the long run. It should however be noted that surprises such as breakthroughs in technology, extreme weather events, and political change have the potential to upset and alter entire supply chains.

Supply chain dynamics

The response of farmers to climate change is shaped by interactions within the supply chain. Product prices are determined by supply as well as demand. Both can be affected by impacts of climate change in the country of observation or other sourcing regions. Here, it is not only the volume that matters, but also aspects such as quality and seasonality. It is therefore important to consider other important current and future sourcing regions.

In parallel with climate change, mega-trends will lead to changing consumer preferences, which may also be reflected in demand. General trends in consumption patterns can reveal at least to some extent the current and future role of the studied commodity in consumer diets. For instance, a shift towards consumption of luxury goods may stimulate the import of fresh products, while a trend towards local-for-local has the opposite effect.

Furthermore, supply chain dynamics may be influenced by impacts of climate change on segments other than primary production. For instance, a rise in sea level may have consequences for the shipment of fresh produce, and changes in temperature affect the cost of climate control during storage. Again, such impacts can affect the competitiveness of a particular sourcing country.

Influence of the global society

Sustainable agricultural production and trade embodies public goods, which are different from, and sometimes even conflicting with private interests of supply chain stakeholders. This justifies the strong involvement of governments and NGOs. Depending on the national agricultural policy, legal requirements may exist regarding e.g. the use of natural resources or external inputs (fertilisers, pesticides). Local governments often play an important role in issues such as spatial planning and infrastructure. NGOs often raise awareness and protection of particular sustainability themes, e.g. through political lobbying, media campaigns or capacity building.

Apart from policy makers and NGOs, other parties can play an important role in sustainable development, such as knowledge providers, financing bodies, and stakeholders in other, interacting supply chains (e.g. water supply chain). All these actors can influence the possible impacts of climate change on sustainable sourcing by increasing or restricting the possibilities of stakeholders to anticipate on expected changes, or by pushing them in a particular direction. This holds for mitigation as well as adaptation. Another way in which these bodies exert their influence is by framing sustainability; the relative importance of different sustainability themes is value-loaded and subject to change, in line with mega-trends including the ones mentioned above.

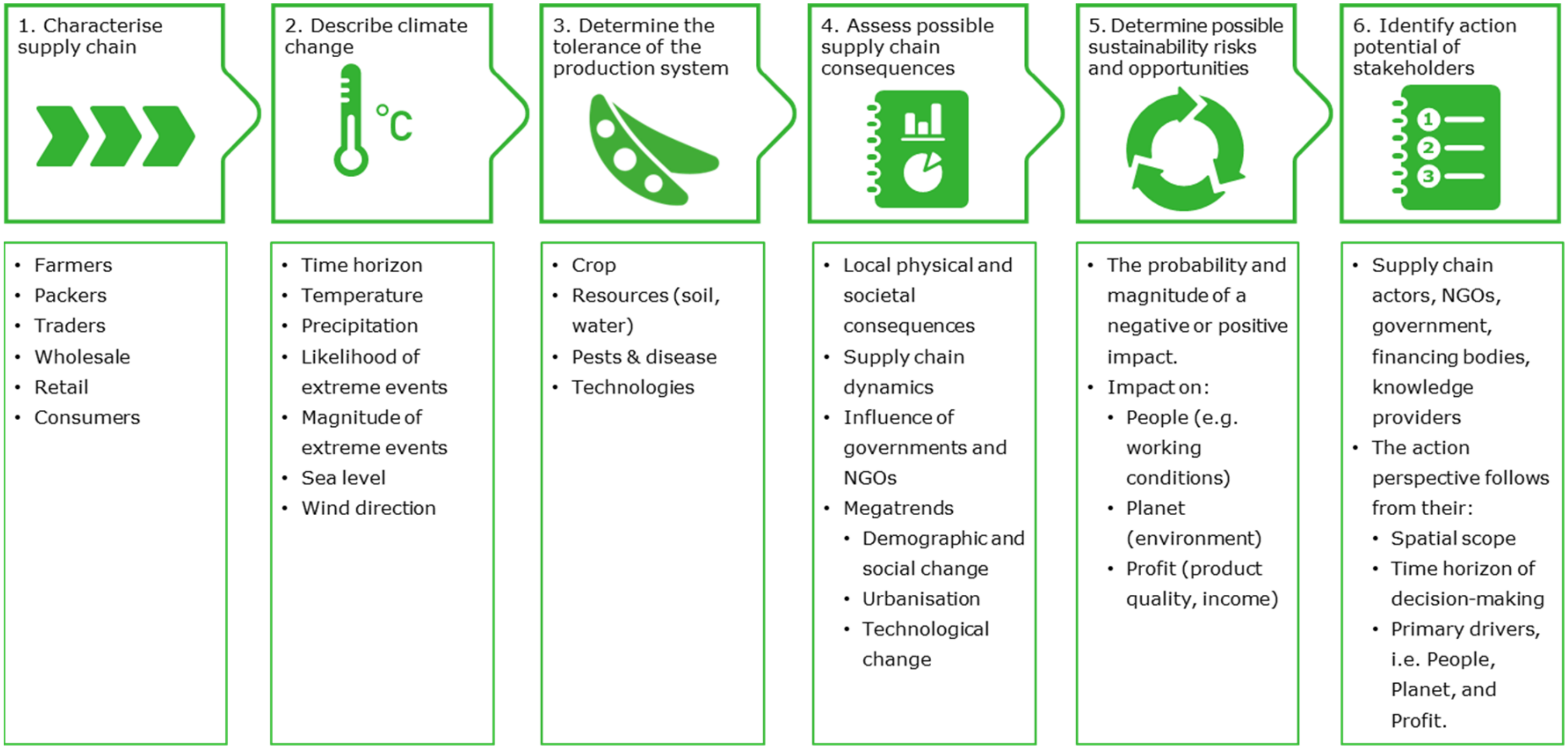
5. Determine possible sustainability risks and opportunities

The supply chain consequences at different spatial and supply chain levels identified in the previous step together determine the potential impact of climate change on sustainability of sourcing. A common way to structure sustainability issues is by means of the three Ps: People, Planet, and Profit (Kuhlman and Farrington, 2010). These dimensions cover, respectively, themes related to human wellbeing (e.g. health, food security), environment (e.g. biodiversity, resource conservation), and economic welfare (e.g. income, competitiveness). The actual set of sustainability themes may vary depending on the purpose of the study and domain of application. The ‘triple P’ concept of sustainability monitoring in the supply chain is currently implemented amongst others by The Sustainability Consortium.

As opposed to this rather generic approach, the SIFAV covenant focuses particularly on production circumstances in sourcing regions, i.e. the segments early in the supply chain (SIFAV, 2015). This focus is driven by an increasing consumer demand for products that are produced and traded according to ‘fair’ and ‘responsible’ standards. Specifically, the SIFAV themes are: employment and working conditions, environmental impact, product traceability, and product quality. Compliance with these themes is measured amongst others by means of certification and product labelling.

Climate change impacts on sustainability of sourcing are highly uncertain. Models are able to explore overall trends, and provide insights into direction and the order of magnitude of the consequences of climate change. Yet, empirical evidence of future events is by definition not available. Consequently, it is more appropriate to frame the effects in terms of risks and opportunities. Risks and opportunities are characterised by the probability and magnitude of a negative or positive impact.

Figure 3 Schematic representation of the four dimensions to be considered in assessing risks and opportunities of climate change *
* Boxes in each dimension are illustrative and not necessarily inclusive.



6. Identify action potential of stakeholders

A timely anticipation of identified risks and opportunities can increase or decrease their likelihood of occurrence. This final step addresses the possibilities and limitations of different actors to do so. Actors include supply chain stakeholders as well as other groups, such as NGOs and policy makers. The action perspective of these actors follows from:

- their spatial scope (local, national, international),
- their time horizon of decision-making, and
- their primary drivers, i.e. their 'raison d'être'. Here, drivers are interpreted as the three dimensions of sustainability: People, Planet, and Profit.

Appendix 1 provides a description of the stakeholders according to these three factors.

Illustrative case studies 3

Illustrative case studies

The objectives of the case studies are to illustrate the generic approach and its practical value, as well as to identify challenges and restrictions of its use. The analysis is based on a literature review; case-specific references are listed in the chapter 'Literature cited' at the end of this report.

Selection of case studies

The following three trade pathways were selected as case studies:

- Common (green) beans from Kenya
- Oranges from South-Africa
- Oranges from Egypt

This selection was based on a number of criteria regarding the commodity and country of production.

Commodity criteria

Selected commodities had to include fruits and vegetables, in line with the scope of the SIFAV covenant. This category was further demarcated to fresh produce, which has a shorter shelf life and is more vulnerable to (changes in) climatic circumstances. The selected commodities have a considerable share in the Dutch market, throughout the year or in particular seasons. To cover a diversity of crop characteristics, the selected commodities include a vegetable and a fruit product, and an annual and perennial crop.

Country criteria

In agreement with the client's request, the scope for sustainable sourcing of fruits and vegetables was demarcated to Africa. For practical reasons, only countries that are politically and societally stable were taken into consideration. Further selection was based on an analysis of trade volumes of specific commodities, applying the following two criteria:

- The trade flow from the selected country is of significant importance to the EU (and preferably the Netherlands) as compared to total import of a commodity.
- The trade flow into the EU is of significant importance to the country of origin as compared to the total export of the commodity.

Assumptions and demarcations

Given the scope of the project, assumptions and demarcations were made with respect to climate change and its impacts.

Climate change scenario choice

To get a rough indication of changes until *2050* in temperature and rainfall, we used the projections of the Intergovernmental Panel on Climate Change (IPCC) (Table 1). These projections were compared with data form the WorldClim database on the current situation in the selected countries to obtain an indication of actual climate conditions in 2050.

Table 1 IPCC projections for climate change a) in Africa until 2050

	Kenya	Egypt	South Africa
Observed increase in temperature 1901-2012	0.5-1°	0.5-1°	0.5-1°
Projected increase in temperature until 2050	1-2°	1-2.5°	1-2.5°
Observed change in precipitation 1951-2010	Trends vary per region within each country, no statistically significant changes		
Projected change in precipitation until 2050	Negligible / slight increase	Negligible / slight decrease	Negligible / slight decrease

a) Based on the IPCC scenario RCP2.6 and scenario RCP8.5, and relatively to the average of 1986-2005.

Source: Niang *et al.* (2014).

Climate change impacts

Although climate change can act on each segment of the supply chain, particularly primary production is vulnerable to its impacts. Therefore, the case studies focus on the interaction between climate change and primary production. The consequences this haves for other segments of the supply chain are, however, taken into consideration.

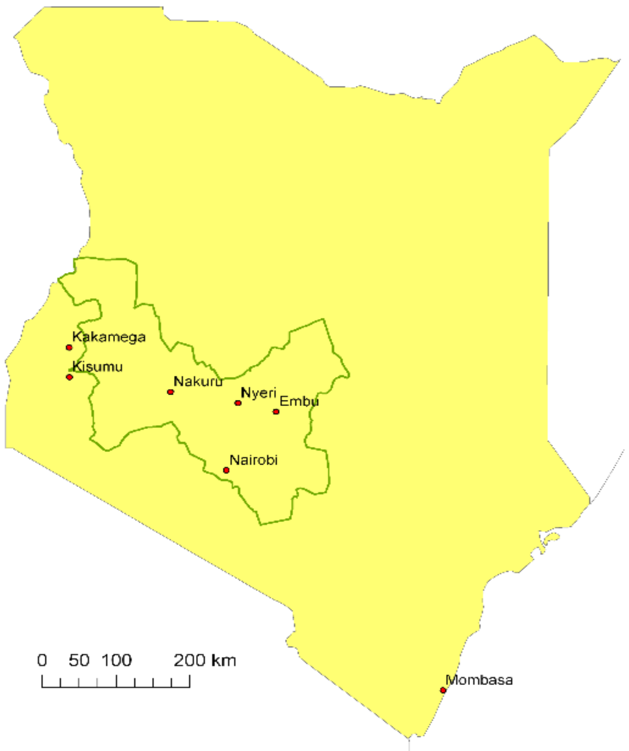
In assessing possible impacts of climate change on sustainable sourcing, the SIFAV sustainability themes are acknowledged. Where relevant, impacts not covered by these themes (e.g. economic welfare) will be addressed as well.

Case study I: green beans, Kenya

Supply chain characteristics

Green beans are grown in a relatively narrow range of temperatures (17.5-25°C) and are susceptible to drought and waterlogging. In Kenya they are produced in the well-watered highlands, i.e. excluding the northern and coastal regions which are too hot and dry. Production is concentrated in the more densely populated counties, such as Murang'a, Machakos, Nakuru and Kisumu (Figure 4). As Kenya has two rainy seasons, two crops of green beans can be produced per year under rainfed conditions. With irrigation they can be produced continuously, with up to five crops per year.

Figure 4 Main production areas for green beans in Kenya
Source: LEI

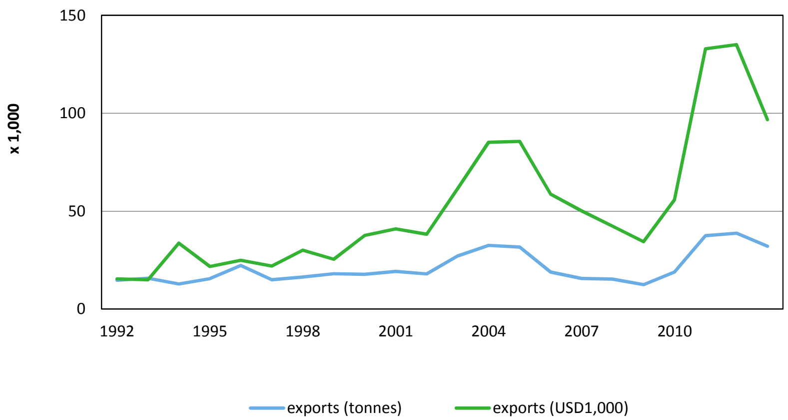


Green beans are grown by three types of farmers:

- Large numbers of smallholders, for whom green beans are only one of many crops. They grow the crop in open fields, either rainfed or with supplementary irrigation. They sell to local traders, who pass on the beans to exporters when the traders are not the exporters themselves.
- Smaller numbers of small and medium-sized specialised growers. They work under contract for trading companies.
- Large farms, either exporting themselves or working under contract with exporters.

It is difficult to provide adequate figures on green bean production, because statistics appear unreliable. It is evident, however, that a large proportion of green beans is exported - probably over half of total production. Some 90% of this export has the EU as its destination until 2010. Figure 5 shows volume and value of green bean exports. The export decline after 2010 is explained by an increasing number of rejected green bean consignments exceeding pesticide Maximum Residue Levels (MRLs). This resulted in increased inspections of green bean consignments at EU points of entry and a decrease of export and production volumes.

Figure 5 Exports of green beans from Kenya
Source: FAOSTAT



The crop has to be transported to processing centres, where the beans are cleaned, packaged and cooled. In the case of smallholders, the beans are transported by pickup trucks, whereas the smaller specialised growers may sort and prepack the beans in cartons, after which they are picked up by the trading company with which they have a contract. Large farms may have the processing facilities on the farm. The processed beans are exported by air cargo. Although the beans can be grown (with irrigation) throughout the year, the preferred season is from September to March, when fresh beans cannot be produced in the EU.

Climate change towards 2050

Until 2050, the following changes are foreseen:

- Temperature increase of 1 to 2°C, as compared to the average over the period 1986-2005.
- Zero to slight increase in precipitation.

It is generally believed that extreme climate events become more likely, but their frequency cannot be predicted with sufficient accuracy to be applicable in this case study.

Tolerance of the production system

Green beans in Kenya can only be grown at altitudes above 1,000 metres, which is the case in a large part of the country. Maximum temperatures in the lower parts (i.e. around 1,000 metres, such as in Kisumu County) will become too high for green beans (Figure 6). On the other hand, high-altitude areas which are presently too cold for green beans will become less restrictive, causing a shift in production towards higher areas.

A possible increase in irrigation in the eastern part of the main production area is foreseen, as the availability of surface water is likely to increase). However, in terms of crop management a (slight) deficit in precipitation is preferred over risk of waterlogging. Available data are too scarce to accurately predict any changes in pest and disease pressure, although a temperature increase will often be in favour of pest and disease development.

Figure 6 Number of months per year with maximum temperatures above the tolerance threshold for bean production, over the period 1950-2000 and the worst-case scenario for 2050.
Source: data from WorldClim database, processed by LEI

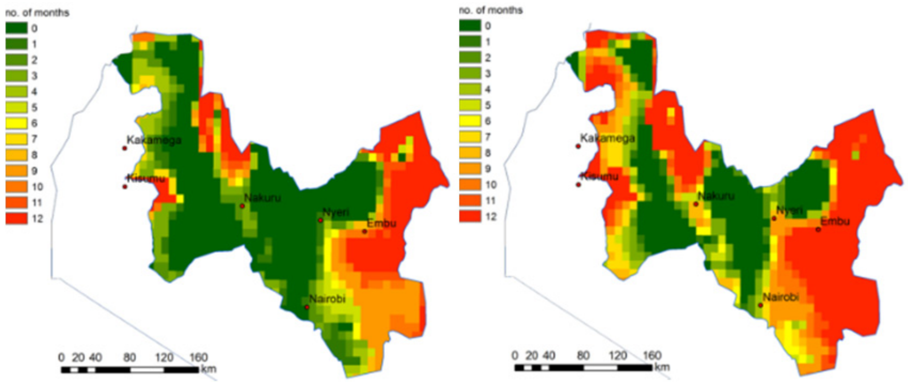
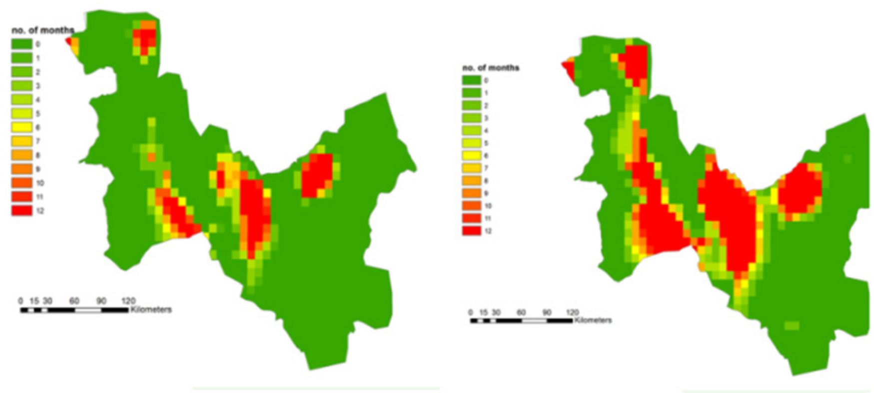


Figure 7 Number of months per year with minimum temperatures below the tolerance threshold for bean production, over the period 1950-2000 and the worst-case scenario for 2050.
Source: data from WorldClim database, processed by LEI



Consequences for the supply chain

Influence of physical & social environment

Even if climatic circumstances in the upper parts of the highlands become suitable, green bean production may be technically restricted by other factors such as soil type. Highland farmers will substitute their current activities (e.g. potatoes or dairy) for bean production if it increases their profitability. Since the uplands are smaller in area than the lower parts of the highlands, the production area of green beans may slightly decrease.

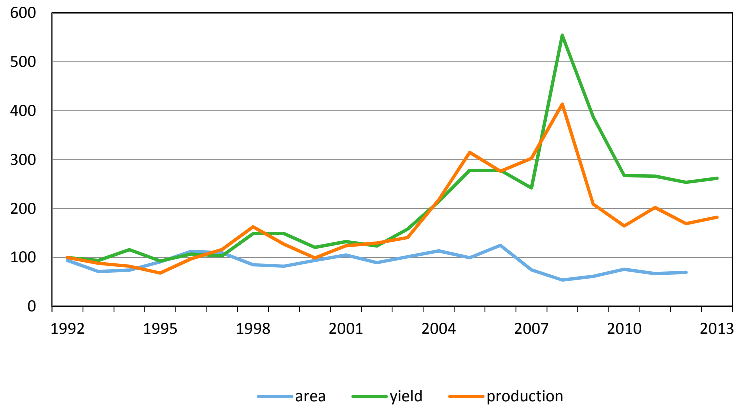
Such a shift towards green bean production at higher altitudes could have negative environmental impacts: these areas have traditionally served as water catchments for the rest of the country. Until recently they were mostly covered in forest. Nowadays, large parts have been deforested. The result will be water shortages at lower altitudes in the dry season and floods during the rainy season, accompanied by accelerated soil erosion. More agriculture in these highlands will aggravate this process.

Interactions between stakeholders

As Figure 5 shows, price developments have been favourable in recent years, although (as is usually the case in agriculture) they remain volatile, which can undermine profitability. The situation is difficult for smallholder farmers, who have to buy their own inputs and lack the access to capital needed for investment in facilities (such as cooling houses). The small and medium-sized specialised growers, who obtain their inputs from the trading companies, may also sometimes be tempted to sell to these small traders, when they offer a higher price, and thus not adhering to their contract with the trading company. Both the large farms and the medium-sized growers benefit from improved financial services, which make it possible to invest in irrigation, cooling houses and processing facilities.

A major unknown factor is the importance of the domestic market for green beans. Traditionally these are a minor item in the Kenyan diet, although as the middle class grows in size, consumption of green beans increases. A trading company we spoke to foresees local and regional consumption of green beans to increase because of such developments. According to available statistics, about 50% of the harvested volume is exported as fresh produce to European countries. And, whereas the volume of exports has grown at only a modest rate (Figure 5), total production appears to grow much more rapidly, mostly through higher yields (Figure 8).

Figure 8 Evolution of production of Kenyan green beans, 1992=100
Source: FAOSTAT



Future prospects, of course, depend also on developments in other countries. Total world production of green beans began to rise significantly from 1995, at first mostly by increasing the area but since 2000 also by sharply increasing yields. Judging by Figure 5, Kenya started that phase a few years later. In recent years the area under crop has been more or less stable, while yields continue to rise - except for the steep decline in 2009 and 2010, from the peak in 2008. The decline in production volumes is explained by the increased rejections of green bean consignments exceeding pesticide MRLs as explained earlier. This resulted in a decrease of exported and production volumes.

Influence of the global society

Apart from prices and market demand, technology is a key driver for green bean production. In general, technological change (e.g. new varieties) in combination with improved management (farmer skills) result in higher yields. Both are also highly necessary in view of the stringent controls on provenance, agro-chemical residues and worker welfare imposed by the EU, the principal market. The extent to which Kenyan bean growers can benefit from improved technology depends on public and private R&D investment, establishment of tailor-made educational programmes and access to credit facilities. It is likely that these benefits will accrue primarily to large and medium-sized farms, while smallholders may have difficulties to maintain or improve standards due to their difficulty in getting access to credit, training and inputs (e.g. seed of the appropriate varieties) as well as in complying with EU regulations. On the other hand, the larger farms employ large numbers of labourers, who benefit from employment opportunities.

Global market trends are probably favourable to green beans: population growth in combination with economic growth is likely to increase the demand for fresh vegetables, also elsewhere than in the EU.

Possible sustainability risks and opportunities

For the green bean sector in Kenya, climate change is not a major concern at the moment; the major concern is the treatment of pests with banned chemicals and rejections of green bean consignments because of MRL exceedance. Other concerns are a soil quality deterioration because of overproduction, and (emissions from) waste.

That said, climate change may lead to an increased availability of surface water for irrigation, which works in favour of horticultural crops such as green beans. But it also may lead to increased pest and disease pressure which increases the importance of implementing good agricultural practices to not exceed pesticide MRLs.

A shift of production to higher altitudes in response to climate change would impose risks on the environment, including erosion and biodiversity. At the same time, such a shift means a reduced availability of land for other uses in these areas; although the area cultivated with green beans is very small compared to the total land under crops.

Changes in crop productivity and acreage are likely to have an effect on prices and farmers' revenue. However, the net effect critically depends on global trends in green bean production. Since climate change in Kenya is unlikely to affect green beans negatively on balance, Kenya's relative competitive position is not likely to worsen because of it.

Identify action potential of stakeholders

Since green bean farming for export is a fairly high-tech and high-risk undertaking, knowledge on good agricultural practices and capital is critical, which could especially be problematic among the limited group of smaller and medium-sized commercial farmers. Large farms already have good access to knowledge and capital, while smallholders face too many constraints to be able to benefit much. The bulk of export-quality beans comes from specialised commercial farms anyway.

Research and extension should focus on a more efficient use of water (e.g. drip irrigation), fertilisers and pesticides. The trend towards integrated pest management should be strengthened, especially in the light of the recent increased rejections of green beans because of MRL exceedances. This will both enhance Kenya's competitive position in the EU and reduce pollution in the country itself.

Encroachment of farming in strategic water catchments should be counteracted, although this may be difficult to realise in practice, depending amongst others on (successful implementation of) environmental policy strategies. This is true not only for vegetable cropping, but for all forms of farming.

Where farming is already taking place in ecologically sensitive areas (erosion-prone areas or water catchment), measures should be taken to reduce erosion and surface runoff, such as agroforestry, buffer strips or intercropping.

Case study II: oranges, South Africa

Supply chain characteristics

South Africa grows over 40,000 hectares of oranges, most of which by far are destined for export. South Africa is the second largest exporter of oranges in the world (after Spain), with Europe being its largest export market.

Exports to Europe predominantly comprise Navel oranges, which are grown in the Western and Eastern Cape provinces (Figure 9). In total there are about 1,400 citrus farms in the country producing for export, most of them large and white-owned. There are also black farmers growing oranges on a much smaller scale, but these are for the domestic market. Efforts are being made to promote citrus production by black farmers, including the transfer of ownership of commercial farms to black entrepreneurs.

The citrus industry is highly organised, with a powerful network of farmers and traders. This network is also active in overseas marketing, political lobbying, research and extension. More than a million households depend on the South African citrus industry for their livelihood. Transport of oranges takes place by ship, under cooled conditions.

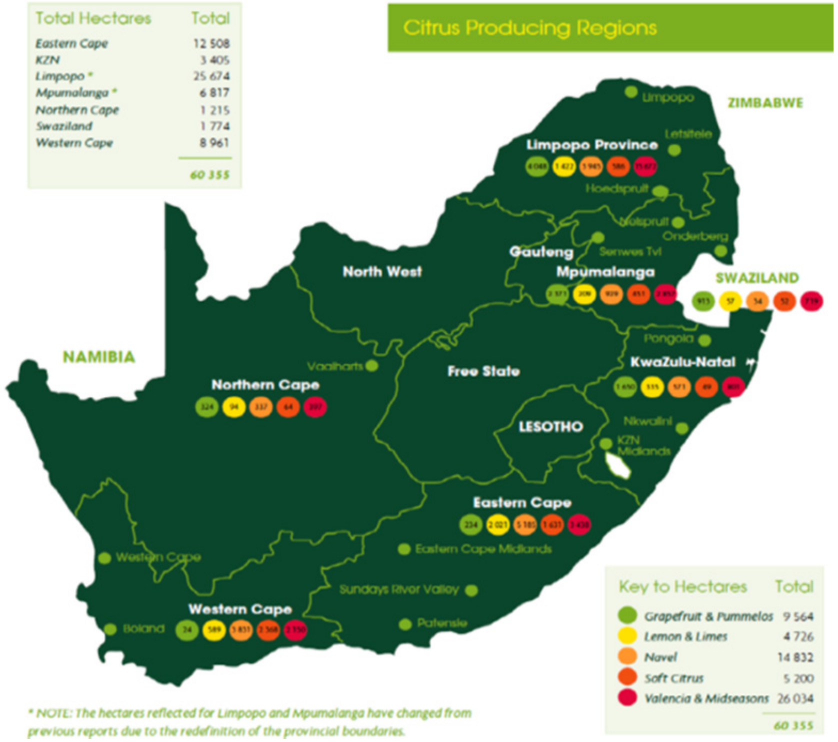
Climate change towards 2050

Until 2050, the following changes are foreseen:

- Temperature increase of 1 to 1.5°C in the south, possibly one degree more in the northern part of the country
- Possible decrease (up to 20% in the worst-case scenario) in precipitation in the western part of the country; little or no change in the eastern part.

Changes in the likelihood of extreme events could not be predicted with sufficient accuracy to be applicable in this case study; however, it is generally believed that climate change will lead to an increasing frequency of such events.

Figure 9 Map of orange production in South Africa
Source: Agriculture, Forestry & Fisheries Department, 2011

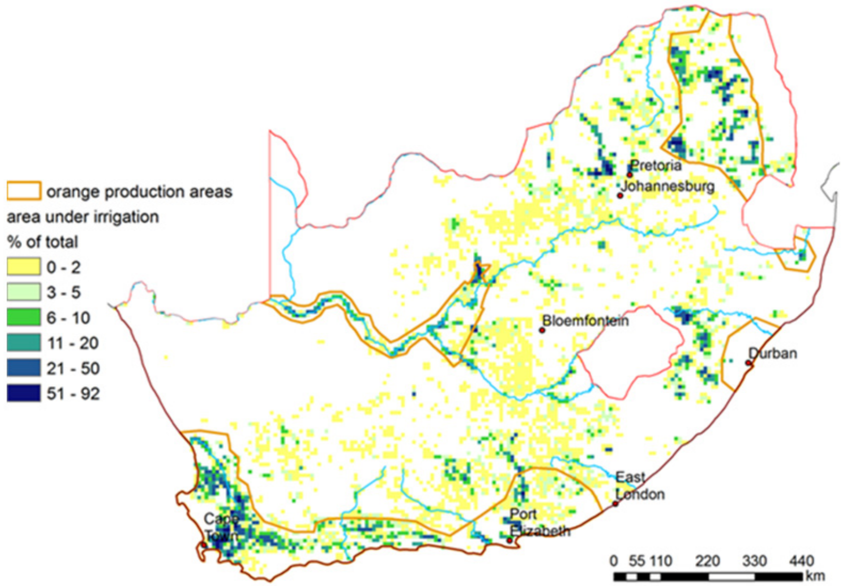


Tolerance of the production system

Temperature increase is not likely to have a significant effect on the acreage or productivity of orange cultivation, as temperatures will remain well between the upper and lower tolerance threshold of orange trees. For precipitation, the situation is different. Orange production depends entirely on irrigation. In the Western and Eastern Cape regions, the only rivers originate within these regions, so there is no source of water from elsewhere (Figure 10). Current production systems in the west are already stressed for water; this problem may well increase in the future due to a decrease in rainfall.

Changes in temperature may have an impact on the abundance of pest and diseases but we have insufficient information to predict any such changes with any degree of accuracy. Citrus black spot, a fungal disease, has been a major problem in South Africa in recent years, and has a major effect on export potential due to EU phytosanitary regulations.

Figure 10 Irrigated areas in South Africa
Source: data from Global Map of Irrigation Areas version 5, processed by LEI



Supply chain consequences

Influence of physical & social environment

The main problem related to climate change is the uncertainty about the availability of irrigation water, as the rivers in the respective region derive their water from the same climate zone.

- Time horizon: the acreage of orange production is not likely to respond quickly to climate change as orange trees remain in production for a large number of years. Between 2006 – 2013 the area planted with oranges grew by 12%. In the longer term, if and when the decrease in rainfall in the western part of South Africa does become a reality, the area under production will of course necessarily decrease – unless other less profitable crops are outcompeted by citrus.
- There may be scope for shifting production to other parts of the country, such as the north-eastern part of the country (Limpopo and Mpumalanga provinces), where the prospects for rainfall are brighter. The Orange River valley in Northern Cape province, while having a dry climate, derives its water from the eastern parts of the country; however, this is a relatively small production area.
- A crucial issue in the social environment is land reform: most productive land is in the hands of white farmers. Since the country changed to majority rule in 1994, the people were promised that land would be transferred to the black majority. However, this has happened only piecemeal and moreover many of the lands that have been transferred have become less productive. This is an explosive issue which is likely to influence the future of the citrus industry.

Interactions between stakeholders

South Africa has been very successful in expanding and maintaining orange exports. A major factor behind this success lies in the strong cooperation within the value chain, which has promoted efficient marketing and research. Another factor has been the decline in the value of the rand (the South African currency) in recent years, which has made exports cheaper. South African exporters benefit from the high quality which they are able to guarantee, and consequently from buyer loyalty.

The most important threats to the current success of South Africa's orange exports are the environmental problem of irrigation water and the social problem of land reform. The former may lead to conflicts with other water users, especially in view of growing population and rising demand for water.

Influence of the global society

As mentioned before, the EU is the largest market for South Africa's oranges. However, it takes less than half the total, and South Africa is busy developing other markets too – notably the US and the Far East. Thus, South Africa depends on the European market, but probably to a declining extent. This means it has a strong position vis-à-vis buyers. How much demand for oranges is likely to grow depends on population increase, on economic growth and on changes in diets. These have tended to change away from fruits towards processed sweets and snacks; if this trend can be turned towards healthier foods, South African citrus will benefit.

A major boon to South Africa is its location in the Southern Hemisphere, which means that the production season is complementary to that in European countries as well as in the US and East Asia.

Possible sustainability risks and opportunities

The main environmental problem of the South African citrus industry, particularly in the Western and Eastern Cape provinces, is the fact that it relies on irrigation, which is likely to become scarcer under climate change. This means increased competition with other water users, within and outside the agricultural sector.

The good news for South Africa is that its competitors for oranges in the world market (particularly Spain) mostly face the same problem. In southern Spain the scarcity of water is already a major difficulty.

Concerning the other main risk, land reform and the fear of it among white farmers, this may induce the latter to adopt short-term strategies for the development of their farms, neglecting long-term investment.

South Africa has a relatively large pressure from a diversity of insect pests. Integrated Pest Management is being used to a significant extent, and the potential for this is good, as the natural enemies of these pests are also numerous and diverse.

Identify action potential of stakeholders

- Explore and, where appropriate, promote different ways of land reform, such as transferring land ownership to black communities and then having the land leased back to the commercial farmer.
- In implementation of land reform, pay attention specifically to the factors that inhibit productivity among emerging farmers (skills and credit spring to mind).
- Drip irrigation is already widely used in citrus farms, making for efficient water use as well as sound control of fertiliser supply. Yet, research on further increasing the amount of production per unit of water and on the reuse of water may help to mitigate the looming water shortage in western South Africa.
- Integrated Pest Management may be further promoted, through financial support, farmer training and research. This leads to lower pesticide residues on the crop, which will improve acceptance in exacting markets such as the EU.

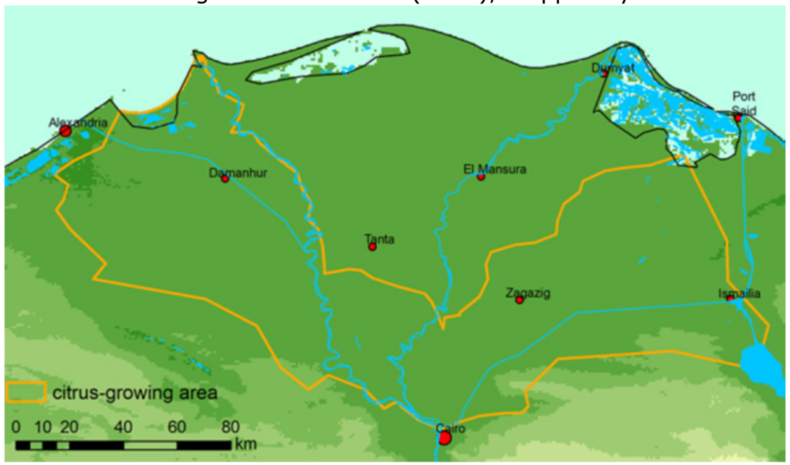
Case study III: oranges, Egypt

Supply chain characteristics
Oranges are grown throughout Egypt, along the course of the Nile. Total orange production area in Egypt is quite stable at 130 to 135 thousand hectares, producing about 2.5m tonnes of oranges. Of this volume, 43% is exported as fresh produce. The main production area of exported oranges is the Nile Delta (Figure 11).

Egypt produces a range of orange varieties, 60% of which comprise Navel oranges. Exported varieties comprise mainly late maturing Navel and Valencia. Egypt is the third largest orange exporter in the world, after Spain and South Africa. Dutch import of Egyptian oranges lasts from January to May and is increasing.

The farmers are mostly smallholders: 97% of farmers have less than 4.2 hectares, and their land represents 75% of all agricultural land. After harvest, oranges are prepared for export in large packing houses, including cold storage. Exporting is done by Egyptian trading firms. Transport mainly takes place by sea, but sometimes also by air.

Figure 11 Nile Delta - main production area of oranges destined for export
Source: list of regions from Hamza (2013), mapped by LEI



Climate change towards 2050
Until 2050, the following changes are foreseen:
- Temperature increase of 1 to 2.5°C
- Zero to slight decrease in precipitation
- Sea level rise

For orange production, it is not the precipitation in Egypt itself which is relevant, but the changes in the Ethiopian highlands: these are the source of most of the Nile water on which orange production depends. In Ethiopia rainfall is not expected to decrease until 2050, after which there may even be an increase. Decreasing fresh water supply in combination with sea level rise may result in salinity problems in the low-lying delta area.

Changes in the likelihood of extreme events could not be predicted with sufficient accuracy to be applicable in this case study.

Tolerance of the production system
Oranges do well in areas with abundant sunshine and temperatures between 20-30°C, with a lower and upper limit of 13°C and 38°C, respectively. As a result, orange production is quite tolerant of the predicted temperature increase.

The expected key impact of climate change to orange production in Egypt is sea-level rise resulting in saline conditions in coastal areas, notably the Nile delta. Citrus trees have a low tolerance of saline soils. The sea-level rise is also expected to accelerate coastal erosion, meaning a possible loss of productive land. Available data were too scarce to predict any changes in pest and disease pressure.

Supply chain consequences

Influence of physical & social environment
The crucial environmental variables for citrus in Egypt are the availability of sufficient water for irrigation and soil salinisation, with the added risk of land loss in the northern Nile Delta as an additional factor. All of these issues are affected by climate change, but also by human activity. Coastal erosion is partially the result of sea-level rise, but partially also of the Aswan Dam, which blocks the sediments that formerly led to coastal accretion - thus

compensating for erosion. Soil salinisation is, in coastal areas, aggravated by sea-level rise, but is a major problem throughout the Nile Valley due to inefficient irrigation methods. Finally, the availability of water is problematic, but this is due to wasteful water systems. If anything, climate change may well lead to higher water flows in the Nile.

Orange production depends entirely on irrigation, as does all agriculture in Egypt. Soil salinisation increases the demand for fresh water. Whether this demand can be fulfilled in the future depends partly on changes in rainfall patterns in the Nile basin, dam building and claims from other countries. If fresh water availability cannot be realised, this may result in loss of land near the coast, reducing the area available for agriculture.

Another risk is the loss of agricultural land to urbanisation. Egypt has a population growth of over 1.6%, and the growth of urban population is 2.3%. Since cities are mostly situated in fertile lands, this means they must encroach on farmland. On the other hand, there is still reclamation of desert land going on. Total agricultural land is therefore not decreasing, but land of marginal productivity is replacing highly productive land.

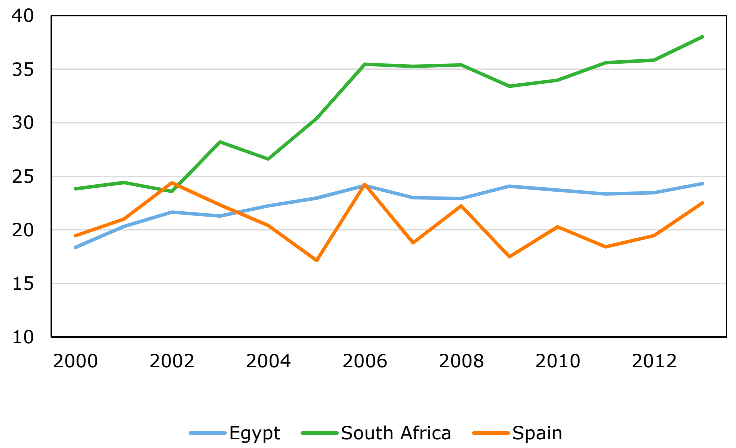
Interactions between stakeholders

Oranges are popular in the domestic market both as fruits and as juice, and exports are less than half of total production. Export destinations are diverse, with Saudi Arabia and Russia as the main markets, ahead of the EU. This makes for a fairly strong market position of Egypt as an exporter.

While the performance of Egyptian oranges in terms of yield is good, Egypt has not done as well as South Africa in increasing productivity (Figure 12). It is believed that horticultural practices should be improved and that many orchards are too old. Other problems are high costs of equipment due to import tariffs. Administrative complexities hamper both imports and exports (application forms for shipments). While in South Africa research and extension facilities are provided by farmers' organisations, in Egypt they are a government responsibility. The government also subsidises the transport of oranges. As a result of these subsidies and of the low wages of agricultural labourers, Egyptian oranges are very competitive in terms of pricing.

If Egypt can succeed in increasing yields at the same rate as South Africa, it will be able to compensate for the loss of land due to soil salinity, urbanisation and coastal erosion. However, much also depends on the competitiveness of oranges vis-à-vis other crops: when both suitable land and irrigation water become scarcer, it will be the most profitable crops that will have continued access to them. To assess these profitabilities is beyond the scope of this study, but the issue needs to be mentioned. However, since at present Egypt can produce oranges at a price well below that on the world market, there is scope for producer price increases and hence for outcompeting other crops. Moreover, orange production is less vulnerable to water scarcity than field crops. The current competitive status of oranges versus other crops is shown by an increase in land dedicated to oranges of 35% over the period 2000-2012, while overall agricultural land increased by about 5%.

Figure 12 Orange yields in three countries (t/ha)
Source: FAOStat



A shift in agricultural land use would have social consequences: on the one hand, it may lead to shortages of staple foods such as rice and wheat; on the other hand, it may also raise the pay of agricultural labour.

Influence of the global society

A major issue for the short and medium term is the extent to which Egypt will be influenced by the turmoil affecting the Middle East. After much turmoil, the country has returned to a regime very similar to that before the Arab Spring of 2011. However, the current political stability remains fragile, and the country suffers from occasional terrorist attacks which scare away tourists as well as some investors. This situation is aggravated by the lawlessness in Libya next door. A risky factor remains high unemployment, particularly among the youth, many of whom are well-educated.

Barring a worsening of the security situation, growth prospects for the medium term are quite good, after the turmoil of the years 2011-2014. Egypt enjoys the support of powers such as Saudi Arabia and the US, as well as having good relations with the EU.

Apart from prices and market demand, technological change is a key driver for orange production. In the short term, the largest gains are likely to follow from improvement in farmer skills, which increase efficiencies and productivity. Innovations in production systems or varieties require a longer adoption time due to the long lifespan of orange trees.

Possible sustainability risks and opportunities

- Soil salinisation is a major problem; it is aggravated, in the Nile Delta, by the rise in sea level, but mainly caused by inadequate irrigation practices.
- The second major issue in the longer term is water shortages. The amount of Nile water available to Egypt is limited by international agreement. While in theory sufficient, wasteful use of water leads to shortages.
- Third, several processes lead to shrinking of the area of productive land. One of these is coastal erosion, partially climate related (rise in sea level) but partially also a consequence of the fact that most Nile sediments no longer reach the Mediterranean because they are blocked by the Aswan Dam. Another factor is urban growth, which takes agricultural land out of production. In total area, these losses are more than compensated by reclamation of desert lands; however, these soils have much lower agricultural potential. Oranges command some of the best land, meaning that other crops are pushed out towards more marginal soils.

Identify action potential of stakeholders

- Research should focus on the development of salt-tolerant tree varieties. This is already being done in several countries, but no such varieties are currently on the market.
- Incentives could be offered to promote the replanting of old orchards. This will become particularly relevant as and when salt-tolerant planting material comes onto the market.
- Agricultural and environmental policies should incorporate, and anticipate on possible long-term effects of climate change (and other factors) on land use.
- Improving the water infrastructure to reduce losses and competitive pricing of water for both farmers and other users will make the use of water more efficient. The higher price of irrigation may be compensated by other fiscal measures.

Key findings

4

Key findings

Overall conclusions

Considering the generic approach and its application to the three case studies, we highlight the following two key insights:

- Climate change can affect the relative competitive advantage of sourcing countries in a positive or negative way, depending on the specific changes in climate variables and crop requirements. However, competitiveness is determined by many other factors as well, some of which are likely to be more dominant than climate change.
- The adaptive capacity of a supply chain to climate change is mainly determined by knowledge and technology transfer, political environment, and financial capacity. Timely anticipation of possible impacts requires cooperation and organisation that is robust to the dynamic environment.

For the selected case studies, identified risks and opportunities for sustainable sourcing that can be specifically attributed to climate change are modest. Any required anticipation remains within the range of 'doing things differently' (as opposed to 'doing different things'), and the gradual occurrence of these changes over a period of many years allows stakeholders to adapt accordingly.

This conclusion cannot be extrapolated to sourcing of fresh fruits and vegetables in general. Possible factors that have determined the outcome of the presented case studies are:

- *The resilience of the current production systems*
  In the investigated case studies, climatic circumstances subject to change in the next decades were not, not yet, or only in some regions, restrictive for cultivation of beans or oranges. For crops which are produced under circumstances that are at the edge of what is biologically, technologically or economically feasible, climate risks will be higher.
- *The scope of the analysis*
  Climate change was only considered in relation to overall sustainability of sourcing. Impacts were assessed for the sourcing country and the supply chain as a whole; we cannot exclude the possibility that individual stakeholders are disproportionally affected by climate change.
- *The level of detail*
  The case study analyses were performed under time and information constraints, and should be regarded as illustrative and at most indicative. A complete and precise prediction of possible risks and opportunities in terms of space, time, and magnitude requires a different approach. We address this aspect in more detail later in this chapter.

Stakeholders' drivers and responsibilities

Coming back to the objective of this research, the key question is how to deal with climate change in order to maintain or improve sustainable sourcing. Box I lists a number of actions that can be taken by stakeholders, given their spatial and temporal scope and primary drivers (see Table 1).

Sustainable sourcing starts with sustainable production that is resilient to climate change. For farmers to anticipate on climate change in a responsible manner, they need to have local access to, and be trained to use technologies and varieties that are tailored to the (future) local climatic circumstances. Farmers should be offered financial buffers (e.g. loans, insurance) to allow for strategic decision-making which pays off in the longer run, but requires investment in the short run. Increases or shifts in demand for natural resources, notably water and land, need to be managed in an appropriate way to maintain or increase resource use efficiency.

At the supply chain level, traders and other stakeholders involved in transport, processing and distribution of products can contribute to global resource efficiency by sourcing products from regions where they can be produced most efficiently. This requires strategic decision-making based on likely and foreseen shifts in production regions caused by climate change and other drivers. While anticipating on climate change, companies have to maintain their licence to operate by operating according to the guidelines of CSR (Corporate Social

Responsibility) and possibly other standards or covenants, SIFAV being one of them. Continuity of supply can be enhanced by diversification in terms of sourcing regions and long-term relationships between stakeholders, which may also enhance investment opportunities for stakeholders in the country of origin (e.g. infrastructure, storage facilities).

At societal level, NGOs, national and international policy bodies can stimulate the process of supply chains becoming climate-resilient by attaching priority to sustainability themes associated with climate change (e.g. fertiliser use, deforestation). Agricultural and environmental policies and strategies should be adapted to future climatic circumstances and harmonised to stimulate climate-resilient production under efficient use of resources. This applies at different spatial scales, from global to local; under recognition of crop- and region-specific opportunities, needs and circumstances. Policy bodies can further facilitate this process by helping other actors to overcome bottlenecks or deficiencies in the current system; examples are the need for public R&D if the market potential for climate-resilient crops is too small for private breeding companies to invest, or the (re)consideration of supply chain compliance with CSR minimum requirements.

Note that the list of actions in Box I is not intended to be complete; it is primarily based on the insights obtained from the case studies, which focused particularly on the farm level. Moreover, while Box I - in line with the primary objectives of this study - primarily considers adaptive actions to climate change, we acknowledge that climate change in itself is a major theme in sustainable sourcing, requiring also mitigation actions of stakeholders to reduce the magnitude of climate change.

Methodological restrictions

The approach presented and applied in this report has two important restrictions that follow from data availability and system boundaries.

Data: restriction to scale of analysis

The temporal and spatial scales at which the climate information is provided is often not detailed enough for an accurate analysis. This is especially true for information on changes in extreme events, such as storms and periods of extreme drought. However, such events play an important role in sustainable sourcing. Traders strive for continuity in supply of fresh produce in order to meet their obligations towards wholesalers or retailers. Extreme events are likely disrupt this supply for shorter or longer periods, making the country or region less attractive for sourcing.

Regardless of the frequency of extreme events, their impact is strongly region-dependent. Large farms have often adopted strategies to cope with extreme events, which may for instance include advanced irrigation technologies or crop insurance. Smallholders are less capable of doing so, which makes them especially vulnerable to extreme events. Local circumstances may also differ; for instance, remote areas with poor infrastructure run a higher risk of being physically disconnected from the export market than more industrialised and urban regions.
As such, climate change can have a considerable impact on social themes such as market access of smallholders and (local) economic development. Yet, assessing the probability of such impacts and the regions to which they apply requires a more in-depth approach, with more accurate climate data and active involvement of supply chain stakeholders.

System boundaries: vertical vs. horizontal assessment

The approach presented in this report aims to determine possible climate change impacts for a particular supply chain. As such, it focuses on a specific country-commodity combination, of which it addresses possible consequences for each segment in the supply chain. However, as mentioned before and illustrated in the case studies, interactions between climate change and sustainability of sourcing are predominantly associated with the farm level.

The case studies also illustrate the strong dependency of climate change impacts on (changes in) the global export position of the sourcing country. A climate change-induced decrease in productivity in a particular sourcing country may be perceived as a risk at first sight. However, if productivity decreases even more in other major export regions, farmers in the country of interest might actually be better off due to a growing market share or a higher product price.

As a result of the previously mentioned megatrends, the relative competitiveness of a country in a global perspective will become increasingly important in the next decades. This calls for a horizontal assessment of climate change impacts, i.e. one that takes a global perspective on climate change impacts for a particular commodity. Starting at the level of primary production, such analysis reveals possible shifts in production regions and associated changes in sourcing countries.

Sustainability and climate change: current initiatives

Climate change in relation to sustainable production and sourcing is not a new theme. Numerous initiatives have been established in the past decades, which aim to stimulate climate change adaptation, mitigation or both in international supply chains. Here, we mention a few of them.

The Sustainable Trade Initiative (IDH) (NGO)

IDH is an international organisation that aims to accelerate and up-scale sustainable trade by building impact oriented coalitions of front running multinationals, civil society organisations, governments and other stakeholders. It has established sustainable development programs for a wide range of commodities, including agricultural products. The SIFAV initiative is one of them, addressing sustainable development in supply chains of fruits and vegetables. More information can be found on the website: http://www.idhsustainabletrade.com/

The Sustainable Agriculture Initiative Platform (private sector, research)

The Sustainable Agriculture Initiative (SAI) Platform was created in 2002 by Nestlé, Unilever and Danone sharing, with the objective to share knowledge and best practices to support the development and implementation of sustainable agriculture practices. SAI Platform develops (or co-develops) tools and guidance to support global and local sustainable sourcing and agriculture practices. Good Agricultural Practices encompass climate change and the reduction of GHG emissions (i.e. mitigation), for which the platform has developed several general and sector-specific guidance documents. For more information, visit their website: http://www.saiplatform.org/.

The Sustainability Consortium (private sector initiative)

The Sustainability Consortium® (TSC®) is a global organisation dedicated to improving the sustainability of consumer products. TSC members and partners include manufacturers, retailers, suppliers, service providers, NGOs, civil society organisations, governmental agencies and academics, each bringing valuable perspectives and expertise. TSC contributes to mitigation of climate change impact by creating transparent and science based tools to measure impact consistently across the whole supply chain for all consumer products.

Global Research Alliance on agricultural greenhouse gases (research, national governments)

The Global Research Alliance on Agricultural Greenhouse Gases (GRA) was launched in December 2009 and now has 46 member countries from all regions of the world. The Alliance is focused on research, development and extension of technologies and practices that will help deliver ways to grow more food, and more climate-resilient food systems, without increasing greenhouse gas emissions. The GRA is organised in four research groups: paddy rice, livestock and croplands and one integrative research group (http://globalresearchalliance.org/.

Global Alliance for Climate-Smart Agriculture (national governments, private sector, NGOs, research)

The Global Alliance for Climate-Smart Agriculture (GACSA) is a voluntary alliance of partners, dedicated to addressing the challenges facing food security and agriculture under a changing climate. In particular the alliance has the objective of up scaling the climate smart agriculture approach, a concept which was originally developed by FAO. Climate smart agriculture (CSA) is an approach to developing the technical, policy and investment conditions to achieve sustainable agricultural development for food security under climate change. The aims of CSA are to sustainably increase agricultural productivity and incomes, adapt and build resilience to climate change and to reduce and/or remove greenhouse gases emissions, where possible (FAO, 2013).

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Appendix I: Actors & roles

Farmers

Farmers can be distinguished into subsistence farmers and commercial farmers. Subsistence farmers' primary concern is to meet financial obligations and make a decent living in the short run. Most subsistence farmers have a poor liquidity and solvability, causing the farm management to be driven by tactic, rather than strategic motivations. This is reinforced by the fact that they are very vulnerable to shocks: for example bad harvests, illness and medical costs can easily drive their household economy below the poverty threshold. This makes their behaviour highly risk-averse, which limits their capability to invest or to apply new production techniques. Commercial farmers have a longer time horizon, are more sensitive to strategic motivations, and are better linked with outlet and resource markets. In general, farmers are highly dependent on the local availability and quality of resources, which include public goods (e.g. water) and may be owned by others (e.g. land, seeds).

Packers

Local packers often operate in a very dynamic competitive environment, in which their supply can be easily outcompeted by other production zones, or by larger packers connected to the trading houses. Their primary objective is therefore to maintain their position as a preferred supplier to traders (i.e. business continuity), which requires them to anticipate on expected market developments (both on the demand and supply side) in the near future.

Traders, wholesalers and retail

Commercial stakeholders downstream the supply chain strive for profit maximisation, but it also becomes more and more important for them to demonstrate that they operate in a responsible manner. They often comprise large companies with a global network and multiple suppliers. They are to a certain extent flexible as to where they source their products; yet, substituting one supplier with another brings along logistic and operational changes that take time. Therefore, continuity for these companies requires a long-term perspective.

Consumers

Consumer preferences strongly differ per person and are subject to change over time. Consumer behaviour is still mainly driven by price, although other aspects are becoming increasingly important, such as production circumstances and environmental footprint. As a result, certain segments may grow (e.g. organic products) at the cost of others and more and more products are labelled. This is a gradual process, influenced by external forces such as media.

NGOs

NGOs generally devote themselves to long-term challenges or services that cannot, or are not naturally fulfilled by the economy or society itself. Examples of such challenges are the mitigation of climate change. They often operate on an international scale. NGOs may act directly on the supply chain, e.g. by making agreements with traders or other partners, or indirectly, for instance by raising consumer awareness or political lobby.

Government, including water boards and irrigation authorities

National governments are responsible for defining the long-term strategic development in a country, including for instance the agricultural policy. This covers the economic position of farmers, but also other issues such as access to and use of natural resources and labour rights. National policy may also target other countries, e.g. through public investment and capacity building or imposing trade restrictions.
Local governments are concerned with the local interpretation and implementation of public policy. Issues covered by local governments are, for instance, land ownership, infrastructure, and provision of public services. Local circumstances are more subject to change and incidental events than national trends, which requires them to apply a shorter time horizon than national policy. Agricultural use of (natural) resources competes with demand for other uses. Water is a representative example. In regions with water scarcity,

irrigation of crops competes with drinking water supply. Also, water pollution by nutrient or pesticide emission may threaten human health. Stakeholders involved in water management, such water companies and irrigation authorities are likely to exert an influence on water use by farmers and other supply chain stakeholders.

Financing bodies

Financing bodies include amongst others banks, insurance agencies and investment companies, but also supply chain stakeholders who offer farmers a loan in order to have access to inputs such as seeds or fertilisers. We distinguish between local financers who finance farmers and other local stakeholders, and international banks providing services to global traders as their clients. These latter banks monitor sourcing trends because it affects the financing demand from the supply chain under influence of megatrends, competitiveness and sustainability dynamics. Moreover, these banks have a CSR obligation themselves. Local banks have a much shorter time horizon than international banks, particularly when it concerns agricultural financing. Local banks tend to consider agriculture as a risky business, regardless of climate change.

Knowledge providers

Knowledge providers facilitate technological and socio-economic development. Examples are the development of more resilient crop varieties, or assistance in the development of a better investment climate. Knowledge provision may range from consultancy to fundamental research and can focus on local as well as global challenges.

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