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Understanding climate risk to South Africa's agri-food system

A commodity value chain analysis of apples

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ABOUT THIS STUDY

WWF received funding from the British High Commission to establish a research programme exploring the complex relationship between food, water and energy systems from the perspective of a sustainable and secure future for the country. This paper is one of three commodity value chain analyses.

PAPERS IN THIS STUDY

1. *Commodity value chain analysis for wheat*: Stephanie J.E. Midgley
2. *Commodity value chain analysis for dairy*: Stephanie J.E. Midgley
3. *Commodity value chain analysis for apples*: Stephanie J.E. Midgley

ABOUT WWF

The World Wide Fund for Nature is one of the World's largest and most respected independent conservation organisations, with almost five million supporters and a global network active in over 100 countries. WWF's mission is to stop the degradation of the Earth's natural environment and to build a future in which humans live in harmony with nature, by conserving the world's biological diversity, ensuring that the use of renewable natural resources is sustainable, and promoting the reduction of pollution and wasteful consumption.

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1. SUMMARY

Apple production in South Africa and its value chain are focused on the export market and the product makes a sizeable contribution to national agricultural exports. Just less than half of the production is exported, with the rest divided between domestic markets and processing. The supply value chain consists of suppliers of farming inputs, producers, fresh produce markets, retailers, processors, cold storage and packhouse operators, transporters, exporters, quality control and certification agents, and terminal and port operators. On arrival in foreign countries, importing agents, distributors, market agents and retailers then supply the apples to consumers. Within the export value chain, about half of the income accrues within South Africa (at delivery to port). A large part of this must cover production and packaging costs. The producer's share (net farm profit) is around 11% of the foreign sales price. Supply and demand determine price and profit throughout the value chain. Significant changes and variability in supply/quality and price are also transmitted through the chain.

A combination of production (tonnes) and price determines the overall value to the producer and those who follow in the value chain. While variability of production can be problematic, variability in quality and price often causes greater problems. Shifting fruit meant for the export market to the domestic and processing market because of quality problems can be very disruptive, as it puts prices under pressure and dramatically reduces profits. Given the industry's dependence on exports, global competitiveness must be maintained and increased. The impacts of climate change will be felt most in greater variability of production and quality, and thus of price and income.

The rand value of the apple industry has grown over the last 10 years, supported by strong import demand in foreign markets and increasing prices, a drop in the value of the rand and improvements in fruit quality. Year-on-year declines in production in some years were mainly the result of unfavourable weather conditions, including drought, heat waves and hailstorms. Domestic demand and prices have also increased. These positive trends are expected to continue over the next 10 years, assuming stable weather conditions as well as social, economic and political stability. Increases in production and value will have to come from yield and quality improvements rather than from an increase in hectares under production.

Climate extremes and climate change have the potential to severely disrupt apple production and income. Negative impacts on quality will put pressure on the domestic market and demand greater absorptive capacity for fresh consumption and processing of second- and third-grade fruit. The key climatic risks for production are lack of winter cold units, particularly in the warmer areas; heat stress and unfavourably warm weather during key developmental stages; conditions that promote pests and diseases; lack of water for irrigation; and hailstorms and flooding. Impacts are felt on the value chain through reduced production and quality, as well as direct damage to transport, energy and water infrastructure, buildings and ports.

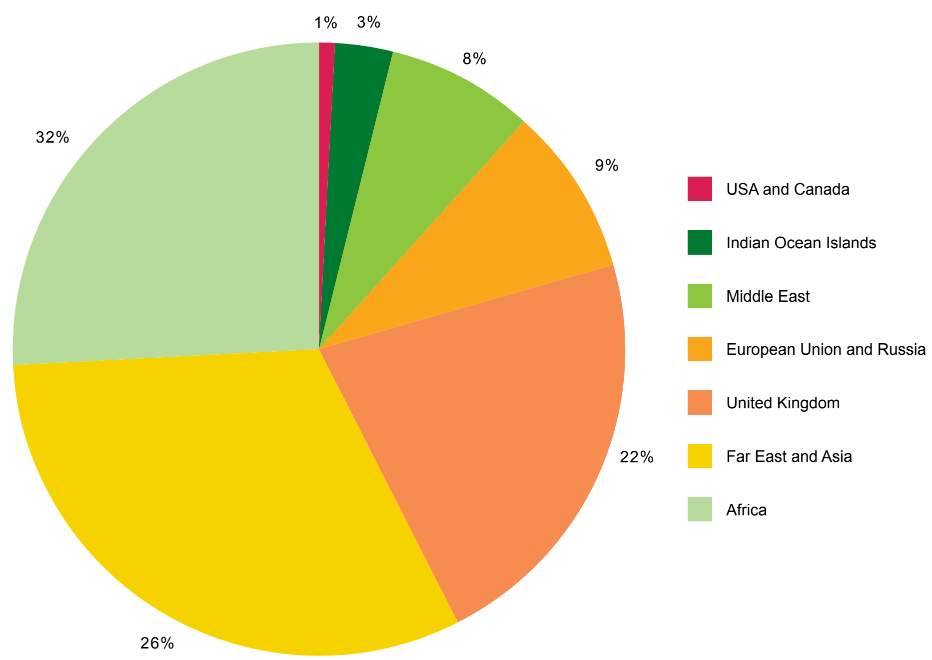
Climate change in the core apple production regions is projected to bring about warming and shifts in seasonality and rainfall characteristics, with both more and less rain being possible, according to a range of climate models. Changes which could cause the most damage to apple farming are significant reductions in winter chilling; increased heat stress; more frequent shortages of water in the storage dams, leading to irrigation water restrictions; increased postharvest problems such as bitterpit and scald (symptoms appear after harvest); and changing risks of hailstorms and pest outbreaks. Shifts in flowering and harvest dates could disrupt marketing windows. A warmer climate will also increase the demand for and cost of energy for production (irrigation pumping), packaging, cold storage, refrigerated transport, processing and cooling of retailer shelves. The current situation, where increasing risks and costs are either absorbed by farmers or passed on to retailers and ultimately reflected in the price of fruit, is expected to continue. Farmers and consumers are likely to be the value chain members who are most negatively affected.

Timely investment in adaptation measures can nevertheless cushion the expected increasing variability in production and quality. Currently, risk reduction is handled almost solely by the farmers themselves. However, the capital outlay needed (e.g. for installing shade netting or replacing orchards with climatically better suited cultivars) will put effective adaptation beyond the reach of many apple farmers. A partnership approach between multiple agents in the value chain and farmers would benefit the whole system. This could take the form of supporting on-farm technology developments, supporting investments in renewable energy and greater energy and water use efficiencies, and partnering with the apple industry to lobby government to create a stronger enabling environment for growth and adaptation to the impacts of climate change.

2. ROLE OF THE APPLE VALUE CHAIN IN THE AGRICULTURAL ECONOMY

The South African apple industry plays a key role in the country's agricultural economy. It is one of the top 10 agricultural export commodities in terms of production and value. On average, 43% of the production is exported, 28% enters the domestic market and 29% is processed (HORTGRO, 2014). South Africa is the second largest apple exporter from the southern hemisphere, after Chile. Among all the world's exporting countries, it ranks seventh in volumes. Over the last three seasons, exports have varied between 340,000 and 480,000 tonnes. Export destinations have shifted over the last decade, with Africa now being the largest export market (Figure 1). South Africa has the largest share of apples imported into African countries. Other growth markets are the Far East, Asia and Russia. Volumes of apples exported to the UK have decreased since 2007 as demand from emerging markets in Asia and Africa has grown and they have become accessible and profitable. Even so, the UK remains a key market for South African apples.

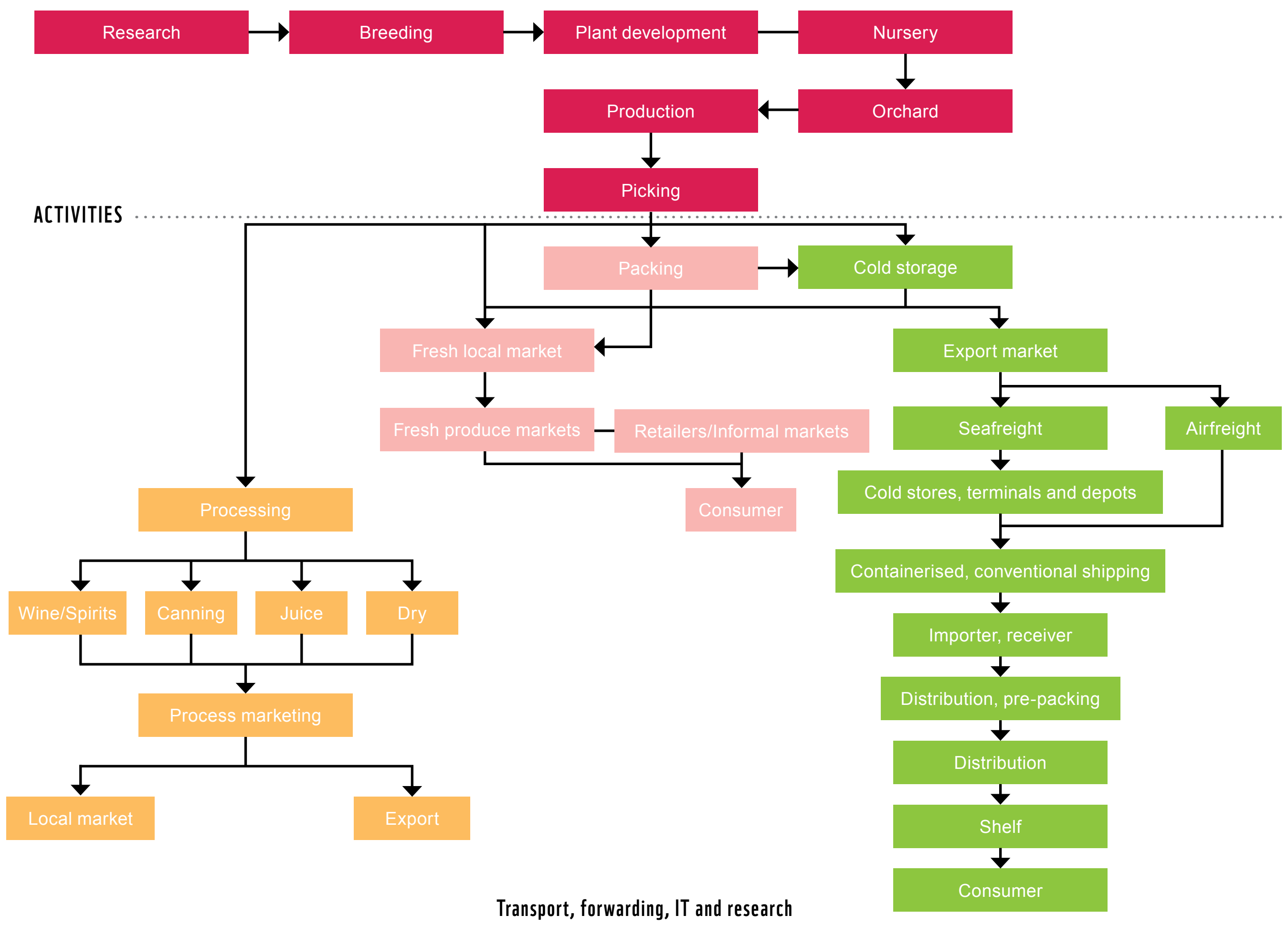
FIGURE 1: SOUTH AFRICAN APPLE EXPORTS PER MARKET SEGMENT, 2014



Source: HORTGRO (2014)

The apple value chain (Figure 2) is a complex system of production and operational agents, starting with producers and their suppliers and service providers. Following the harvest, the apples are either packed and distributed for immediate sale on the local and export fresh produce markets and to retail outlets, or sent to commercial cold storages. From there they are removed for packaging and distribution for up to eight months after harvest. Fruit that does not meet the quality requirements of the fresh apple market is sent to processing factories where it is juiced, canned or dried. Transporters (road trucks, ocean cargo, air cargo) play a role in each distribution option. The supply value chain

FIGURE 2: DECIDUOUS FRUIT SUPPLY VALUE CHAIN



Source: OABS, in DAFF (2014)

for export fruit includes exporters, the Perishable Products Export Control Board (PPECB) and other certification agents, terminal and port operators, foreign market importers, distributors, market agents, and retailers at the destination.

The economic value of apples is spread throughout the supply chain in South Africa and in the receiving markets globally. Within the export value chain, about half of the income accrues within South Africa (at delivery to port). A large part of this must cover production and packaging costs (HORTGRO, 2014). The producer's share (net farm profit) is about 11% of the foreign sales price (Table 1). In 2014, the value of exports to the local economy (up to the delivery of fruit to the port) was R2.9 billion. This grew to R6.1 billion (foreign sales price) at the export destinations, the difference representing the value to service providers and agents after delivery to port (but not the value to retailers).

TABLE 1: EXPORT PERSPECTIVES AND VALUE OF THE APPLE INDUSTRY, 2014 (RAND)

	RAND	RAND (MILLION)	%
SALES PRICE	225.12	6,111.1	100
RECEIVER COST	41.78	1,134.1	18.6
RECEIVER COMMISSION	15.51	421.0	6.9
DELIVERY PRICE RECEIVER	167.83	4,556.0	74.6
DELIVERY COST	11.98	325.2	5.3
CIF	155.85	4,230.8	69.2
SHIPPING COST	32.23	875.0	14.3
FOB	123.62	3,355.8	54.9
EXPORTER COMMISSION IN RAND	12.35	335.2	5.5
LOCAL COST	5.29	143.6	2.3
DIP	105.98	2,876.9	47.1
PPECB INSPECTION LEVY	0.53	14.4	0.2
HORTGRO LEVIES	0.80	21.7	0.4
PRODUCTION AND PACKAGING COSTS	80.41		36.0
NFI	25.57		11.4
CARTON SIZE	12.5		
CARTONS PER TONNE	80		
EXPORT VOLUME (TONNE)		339,321	
SALES PRICE PER TONNE (RAND)		18,010	100
CIF PER TONNE (RAND)		12,468	69
FOB PER TONNE (RAND)		9,890	55
DIP PER TONNE (RAND)		8,475	47

Source: HORTGRO price model in HORTGRO (2014)
Note: CIF = Cost Insurance and Freight, FOB = Free on Board, DIP = Delivered in Port, NFI = Net Farm Income

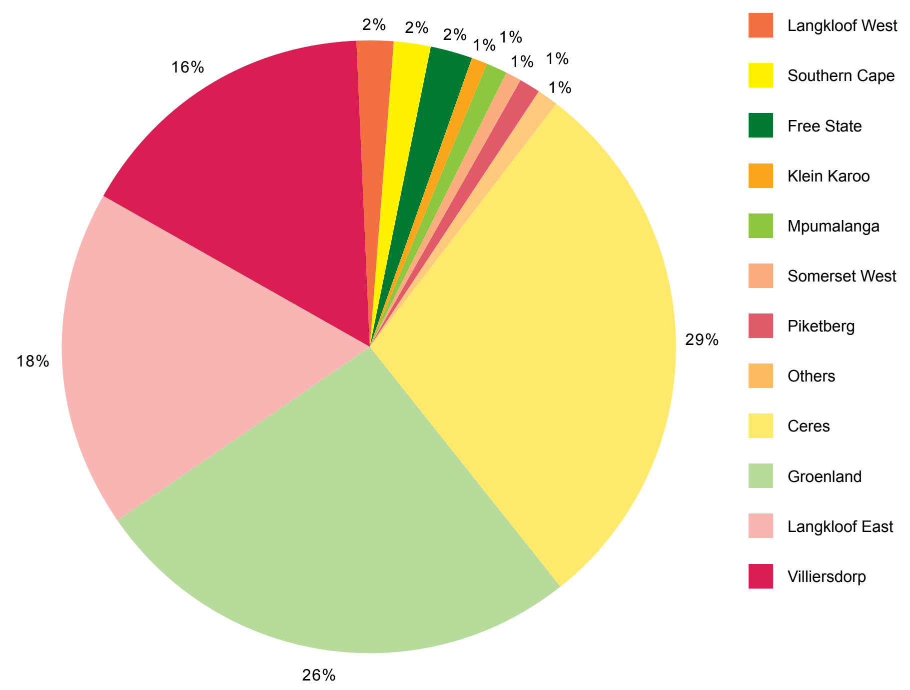
Each part in the value chain requires costly infrastructure and actors who make decisions based on changes in supply and demand, as well as fluctuating local and international prices. Significant changes in supply affect the entire value chain. Since value is added at every step in the chain, producers and all other actors, including local and foreign market retailers and consumers, feel the impacts of variable production and product quality. These impacts ultimately affect price and profitability, impacting both consumers and businesses.

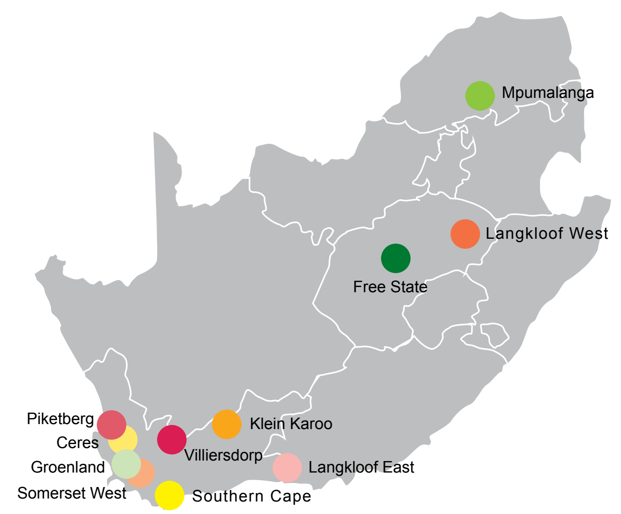
The fate of an apple following harvest is determined mainly by its quality. If the strict quality requirements are met, farmers take advantage of the higher prices offered by foreign markets (currently ±R10,000/t but depending on supply and demand and exchange rate) compared to the local market (±R5,000/t). A combination of production (tonnes) and price determines the overall value to the producer and those who follow in the value chain. While variability of production can be problematic, variability in quality and price often causes greater problems. Total crop losses are extremely rare and localised. However, shifting fruit meant for the export market to the local fresh market and processing can be very disruptive, since the local oversupply puts prices under pressure. On the other hand, saturation of some foreign apple markets leads to preferred sales of desirable cultivars of supreme quality. All other non-premium apple cultivars struggle to fetch a price needed for profitability to the producer. Thus, these (usually) older markets have become a higher risk for the South African apple industry. Considering the industry's dependence on exports, competitiveness must be maintained and increased – there is no margin for undue variability. The impacts of climate change will be felt most through greater variability of production and quality (see below).

Between 200,000 and 250,000 tonnes of apples unsuitable for fresh consumption (about 29% of total production) are processed every year. They are canned, juiced or fermented (cider, vinegar), pureed, dried, and used in prepared desserts and bakes. Processing requires a reliable source of energy and clean water.

Apples are grown mainly in the Western Cape (Groenland – 26%, Ceres – 29%, Villiersdorp – 16%) and the Langkloof (Langkloof East – 18%), which straddles the Western and Eastern Cape (Figure 3). The total apple production area in 2014 was 22,925 hectares, representing 29% of the area planted to deciduous fruit trees in the country (HORTGRO, 2014). Old orchards are being replaced at a sufficient rate to secure consistent future supply of the best cultivars. The industry directly employs 26,823 labourers for production and processing. They in turn support 107,290 dependents (HORTGRO, 2014). Seasonal labour, mainly for harvesting or fruit packing, is contracted for a fixed period of time. There are many indirect employment opportunities in support industries in the production areas, and in the post-production value chain.

FIGURE 3: THE APPLE PRODUCTION AREAS OF SOUTH AFRICA (ABOVE) AND A MAP OF SOUTH AFRICA SHOWING CORE APPLE PRODUCTION AREAS (BELOW)





Source: (above) DAFF (2014) based on HORTGRO Tree Census, 2013; (below) DAFF (2015)

South Africa produces about 800,000 tonnes of apples per year, making it the fourth largest producer in the southern hemisphere after Chile, Argentina and Brazil, and the 16th largest producer globally. Production efficiencies and overall competitiveness are quite high, ranking in the top 15 countries (World Apple Review 2014 in HORTGRO, 2014). According to the Bureau for Food and Agricultural Policy (BFAP), the South African apple industry was outranked in competitiveness only by Chile in the southern hemisphere from 1990 to 2011. It vastly outperformed its northern hemisphere counterparts (BFAP, 2015).

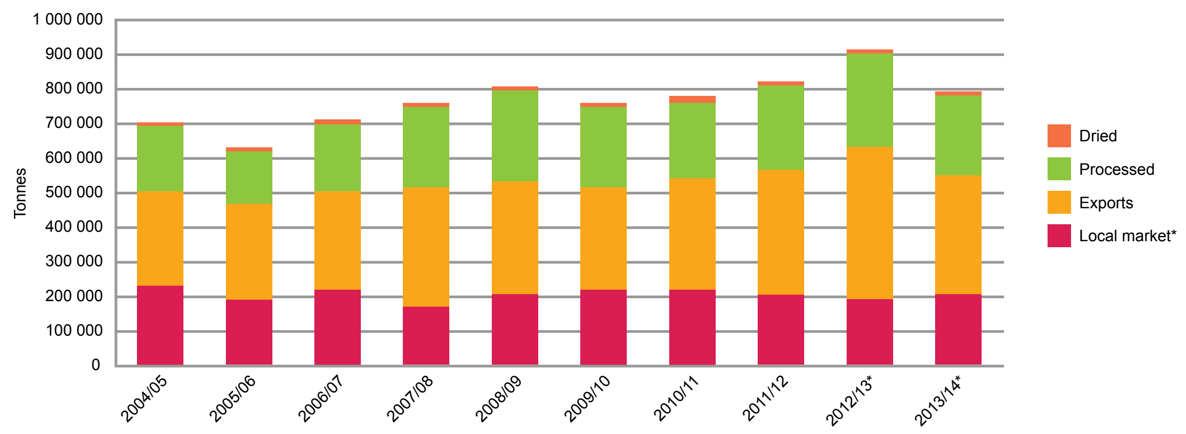
Between 2004/05 and 2013/14, production varied between 627,092 tonnes (2005/06) and 908,240 tonnes (2012/13). Year-on-year declines in 2004/05 (–15%), 2005/06 (–10%), 2009/10 (–6%) and 2013/14 (–13%) were mainly because of unfavourable weather conditions, including drought, heat waves and hailstorms.

3. RECENT TRENDS AND OUTLOOK FOR THE APPLE VALUE CHAIN

The rand value of the apple industry has grown over the last 10 years, supported by strong import demand in foreign markets and increasing prices, a drop in the value of the rand and improvements in fruit quality. The 2012/13 season was a particularly strong one. This was followed by a drop in production and value in 2013/2014 (Figure 4) owing to serious hail damage, reduced fruit quality and higher stock levels from the northern hemisphere. Prices in the export market have risen slowly, with a more rapid increase over the last two seasons (Table 2, Figure 5). Thus, both local and export rand values keep increasing, but this does not necessarily mean that production volumes are increasing. The complexity of price and exchange rate blurs the real variability of the production record.

> "The pome fruit industries in South Africa recorded a remarkable crop in 2013 which was associated with record production volumes, high prices and good quality attributes. Unfortunately, unfavourable climatic conditions in the Western Cape, particularly severe hailstorms that struck the Witzenberg area in November 2013, impacted negatively on the 2014 harvest. Some of these production regions suffered … further hailstorms in 2014 and the effects of these severe climatic occurrences remain evident in the 2015 harvest as bearing spores (sic) were also affected" (BFAP, 2015).

FIGURE 4: VOLUMES (TONNES) OF APPLES PRODUCED IN SOUTH AFRICA OVER THE LAST 10 YEARS, SHOWING PROPORTION SOLD FRESH IN THE LOCAL MARKET (MARKET SALES AND DIRECT SALES TO SUPERMARKETS) AND EXPORT MARKET, AND PROPORTION PROCESSED (JUICED, CANNED) AND DRIED



Source: DAFF/PPECB, in HORTGRO (2014)

Note: * The last two seasons are subject to possible adjustments.

TABLE 2: HISTORICAL PRICE TRENDS, GROSS VALUE AND YEAR-ON-YEAR CHANGE IN VALUE OF PRODUCTION FOR SOUTH AFRICAN APPLES

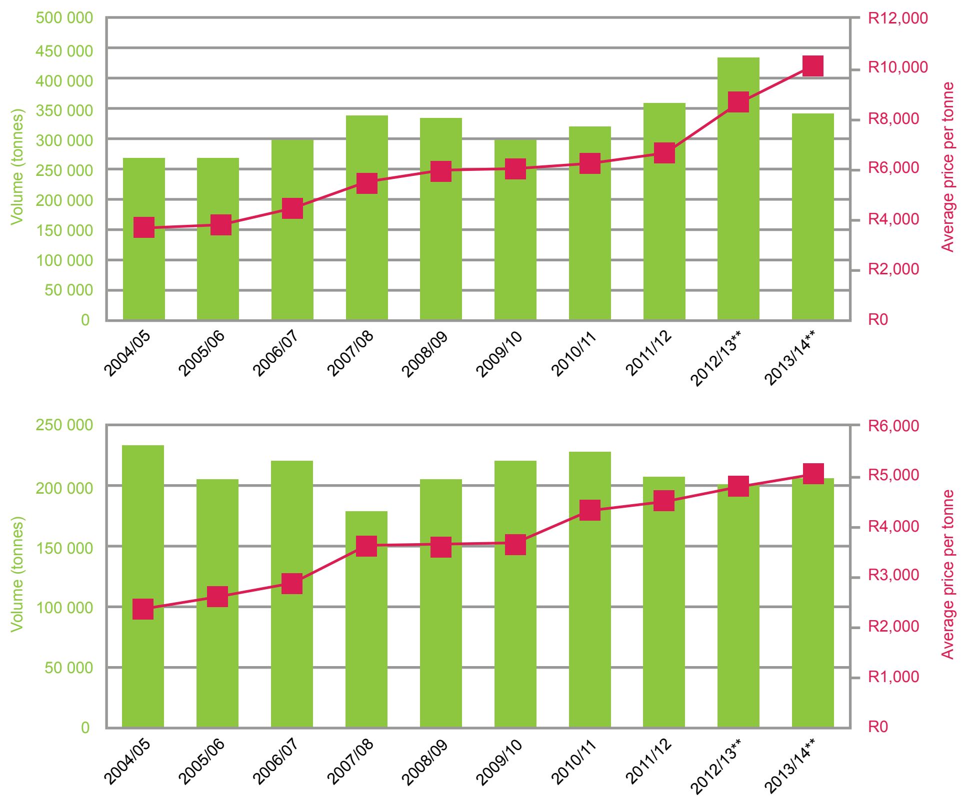
YEAR JAN-DEC	SALES ON MARKETS*	EXPORTS NET REALISATION	PROCESSED	GROSS VALUE DRIED	GROSS VALUE FRESH	TOTAL VALUE OF PRODUCTION	CHANGE IN TOTAL VALUE OF PRODUCTION
	(R PER TONNE)	(R PER TONNE)	(R PER TONNE)	(R1,000)	(R1,000)	(R1,000)	%
2004/05	2,310	3,638	341	1,462	1,528,541	1,595,385	-
2005/06	2,580	3,791	373	438	1,549,040	1,606,498	1
2006/07	2,799	4,363	447	2,972	1,920,454	2,007,786	25
2007/08	3,618	5,419	1,071	4,266	2,488,018	2,746,037	37
2008/09	3,568	5,834	786	3,136	2,675,172	2,883,711	5
2009/10	3,656	5,881	534	2,610	2,564,279	2,691,142	-7
2010/11	4,326	6,210	737	5,800	2,981,589	3,146,817	17
2011/12	4,470	6,531	1,146	2,976	3,276,158	3,559,296	13
2012/13**	4,845	8,658	1,137	7,936	4,747,979	5,060,122	42
2013/14**	4,944	10,136	1,141	16,119	4,479,272	4,768,856	-6

Source: DAFF, in HORTGRO (2014)

Notes: * "Markets" refers to sales on major local fresh produce markets.

** The last two seasons are subject to possible adjustment.

FIGURE 5: APPLE EXPORT (ABOVE) AND LOCAL MARKETS (BELOW) HISTORICAL SALES OVER THE LAST 10 YEARS



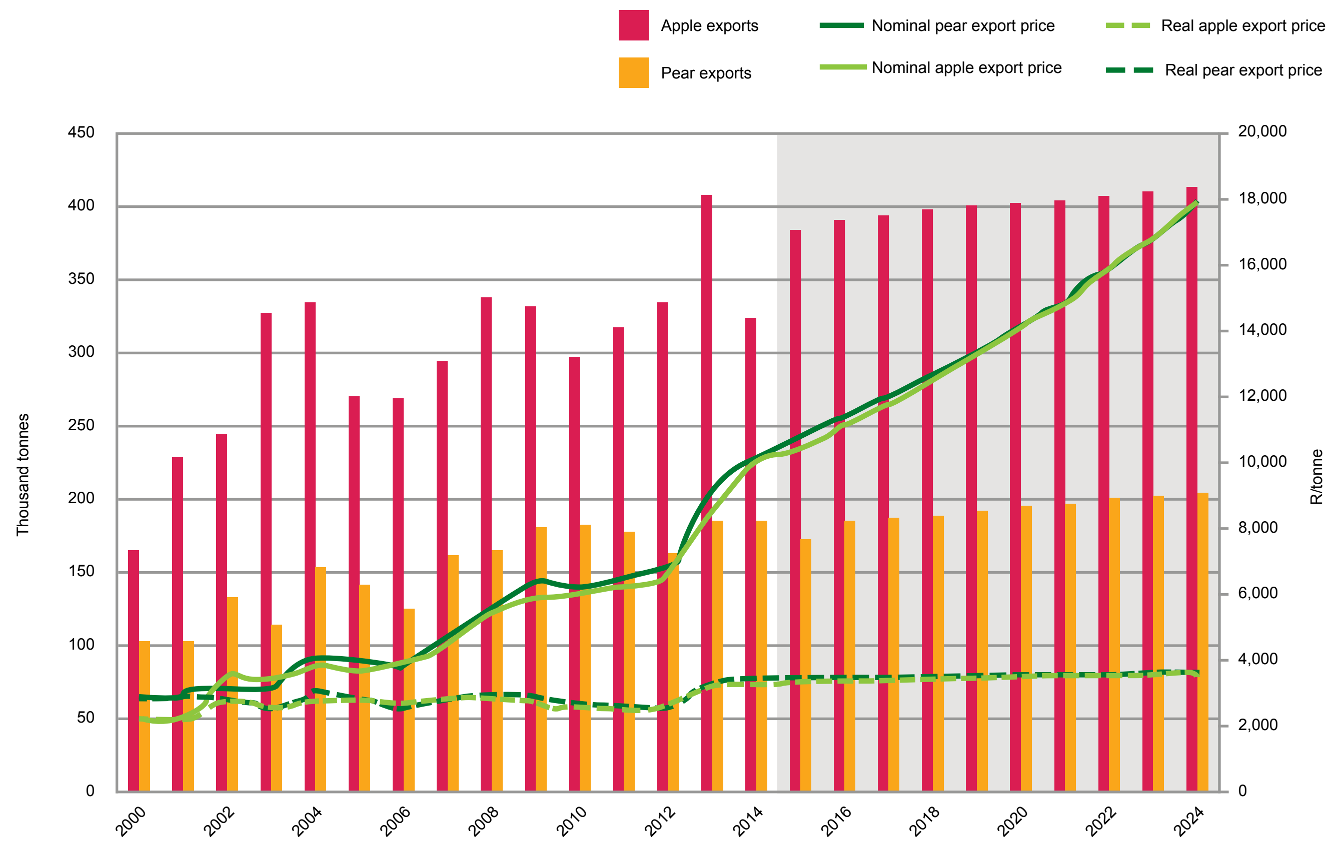
Source: HORTGRO (2014)

Note: ** Last two seasons subject to possible adjustments.

The volume of apples sold annually on the local market is variable and linked to export volumes. For example, during the strong 2012/13 export season, the local market remained flat (Figure 5). The damaged fruit of the 2013/14 season was marketed locally and processed. Over the last 10 years, the trend has been a steady increase in local market prices. Local prices are also influenced by seasonal supply (i.e. large supply during harvest periods) and distance of the market from the apple-producing regions. Cold storage facilities allow for year-round supplies. Distance from the market causes greater price variability on the Johannesburg, Tshwane and Durban fresh produce markets than in Cape Town. Retailers generally get their apple supplies directly from packhouses. Temperature-controlled transport and storage for national distribution is therefore an important part of the local value chain.

The deciduous fruit sector is expected to increase in relative economic rand value in the foreseeable future (Figure 6) (BFAP, 2015; WCG Provincial Treasury, 2014). Although there was a 41% increase in apple production between 2006 and 2014, the area under production expanded by only 11%. Thus, most of the production increase was due to yield improvements. Climatic conditions, especially insufficient chilling, lack of water and poor soils, restrict further expansion of the apple production area. Further growth of the industry will rely on additional technology-driven increases in yield and efficiencies of production, as well as a continued focus on fruit quality to achieve the best possible prices in the export market. Some producers are already achieving very high yields (>100 t/ha). BFAP projects an increase of about 16% in apple production over the next 10 years and a stable export share of 42% of total production, assuming "normal" weather conditions and stable yields and fruit quality. Export markets to absorb the growth will continue to be pursued in Africa and the Middle East, with the traditional European and UK markets remaining stable as long as market access conditions do not deteriorate.

FIGURE 6: POME FRUIT EXPORTS, VOLUMES AND PRICES – HISTORICAL AND PROJECTED



Source: BFAP (2015)

Note: Nominal export price refers to the price expressed in historical nominal monetary terms. Real export price is the inflation-adjusted price over time.

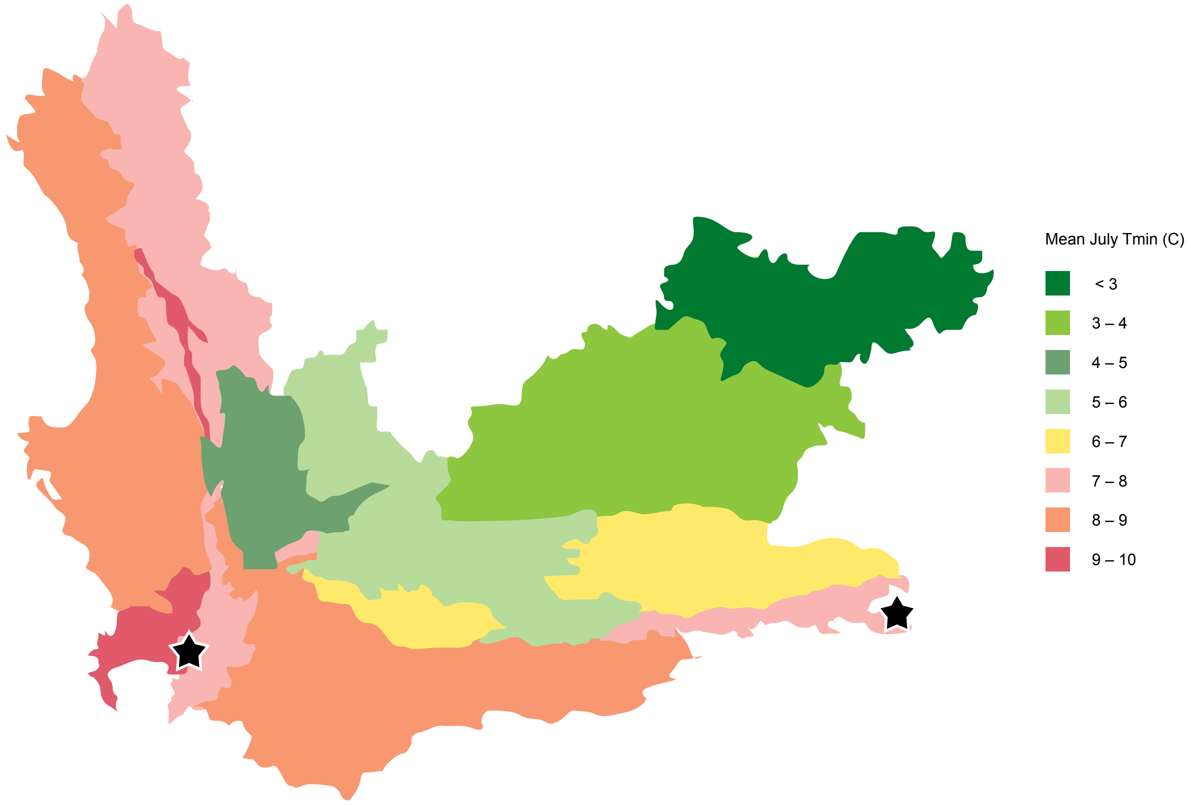
The local apple market is relatively flexible and can absorb a fair amount of produce not fit for export, although quality does determine price. Lower prices were obtained in 2013 and 2014 for fruit damaged by hail and the *Fusarium* fungus, respectively. Domestic per capita apple consumption is expected to remain fairly constant and growth of this market will come from population growth (BFAP, 2015). The domestic market has traditionally not featured highly in industry strategy, but climate change is expected to alter this:

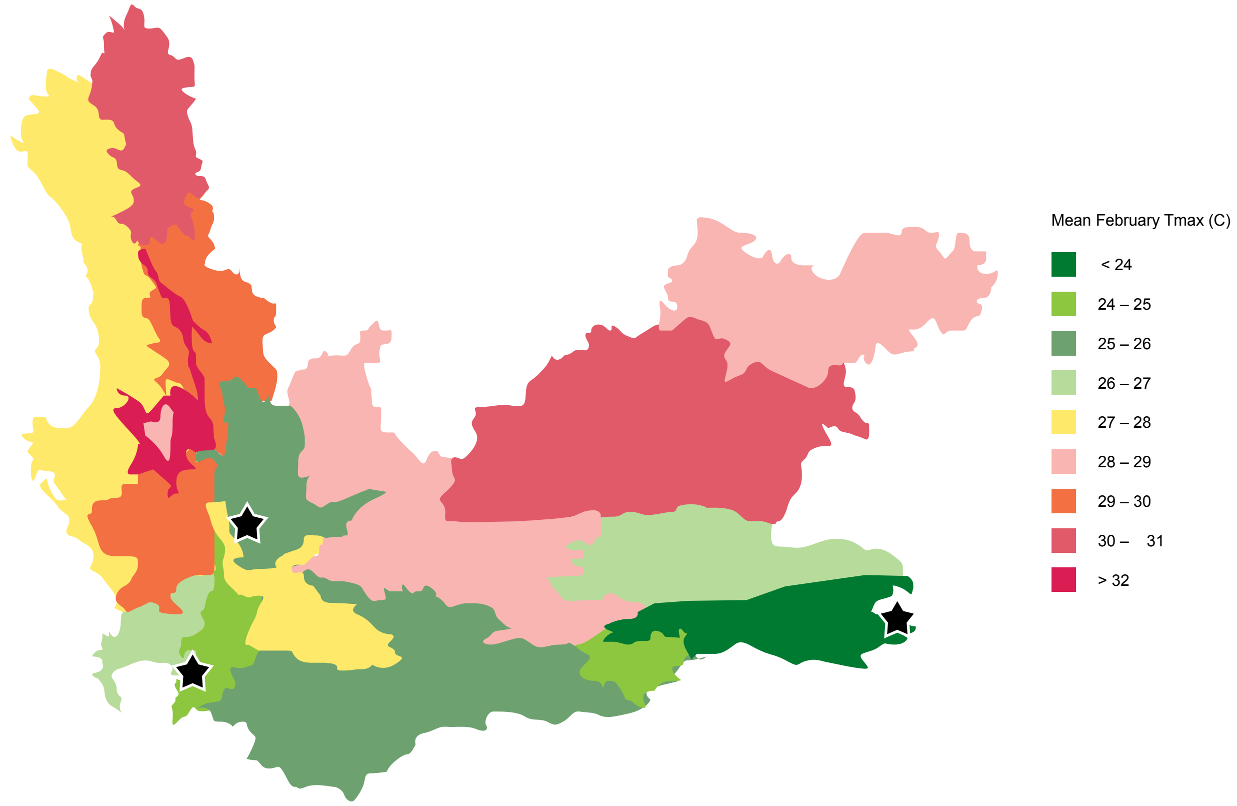
> The impact of climatic conditions in shifting produce originally destined for the export market into the domestic market has highlighted the need for the establishment of stronger domestic marketing programs. The ability of such programs to increase the quantity of produce that can be absorbed throughout the marketing season will guide the extent to which profit margins can be recovered following adverse climatic conditions. (BFAP, 2015)

4. WHAT ARE THE RECENT HISTORICAL AND CURRENT CLIMATE RISKS TO THE VALUE CHAIN?

The Western Cape's apple production potential is determined by local climate (Figure 7), ocean and mountain influences and soils. Each production region has a unique climate, but in general they are relatively warm with cooler and wet winters. The Koue Bokkeveld region near Ceres, a major apple production centre, is considerably higher-lying and colder in winter and completely dependent on local (farm) dams. The Elgin-Grabouw-Vyeboom-Villiersdorp (EGVV) area is warmer. Water for irrigation comes from the large public dams connected to the Western Cape Water Supply System (WCWSS), a number of medium-sized dams and many small private farm dams. The Langkloof apple production region has a cooler winter and tends towards year-round rainfall, but with high variability. This is made worse by a low water-storage capacity, which makes it vulnerable to periods of low rainfall. Recent history has also shown storage dams in the area to be vulnerable to damage from heavy rainfall and flooding.

FIGURE 7: MEAN MAXIMUM DAILY TEMPERATURES IN FEBRUARY (OPPOSITE) AND MEAN MINIMUM DAILY TEMPERATURES FOR JULY (THIS PAGE), AVERAGED OVER 23 AGRO-CLIMATIC ZONES ACROSS THE WESTERN CAPE. APPLES NEED MILD SUMMERS AND COOL/COLD WINTERS. WINTER TEMPERATURES IN THE EGVV (SOUTH-WESTERN) AREA ARE ALREADY SLIGHTLY TOO WARM.





Source: Midgley et al. (2014)

Note: Stars indicate the three main apple-producing regions.

The key current climate risks for apple production include:

- Insufficient cold units in autumn and winter (accumulated "chill units" below the minimum needed for commercial apple cultivars) lead to poor flowering, yield and fruit quality (especially in the EGVV area). Apples have a relatively high chill requirement.
- Heat waves and very high maximum temperatures lead to sunburn damage on the fruit surface. This can result in 20–30% of the fruit being culled in the orchard and up to 10% of packed cartons being rejected thereafter. Water stress aggravates sunburn development.
- Very warm temperatures during the period of red colour development lead to insufficient red colour at harvest. Colour development requires low night-time temperatures followed by warm days, but hot days reduce colour formation.
- Climatic conditions in the early season that promote fungal diseases and outbreaks of pests that reduce yield and fruit quality.
- Climatic conditions during the flowering and fruit set period that reduce the success of pollination and fertilisation, thus reducing yield.
- Water stress from insufficient water for irrigation leads to reductions in growth, yield and fruit quality. In areas where the water supply is shared with growing urban settlements, agriculture is under pressure to use water more efficiently. Under conditions of drought and low dam water levels, agriculture is not assured its usual water supply. Another risk is the high levels of water pollution in some localised areas, which threatens the export market.
- Hailstorms and strong winds damage the trees, destroy flowers and fruit, or cause external blemishes on fruit.
- Heavy rainfall leads to localised flooding for an extended period (in areas of poor drainage), with negative impacts on trees and fruit.
- Frost (only in the coldest areas and very occasional) kills flowers and young fruit.
- Variable and hot weather conditions during the growth season can trigger disorders like bitterpit during the postharvest storage period.

The most damaging current climatic risks are those which are consistently problematic – sunburn (everywhere), poor red colour (everywhere) and insufficient winter chilling (in EGVV) – and those which are acute, i.e. they are unpredictable and have high impacts which are often quite localised: outbreaks of pests and diseases, cut-off low weather systems causing flash floods and sometimes heavy snowfall in high-lying areas, and hail (Midgley et al., 2014). In recent history, hail damage has had the most impact across the value chain (Box 1). Reduced irrigation levels during the 2003/04 dry period also caused problems such as small fruit size and poor flowering the following spring.

BOX 1

Hailstorms are quite rare and localised in the Western Cape, but when they occur they can cause substantial physical and economic damages. In November 2006, a severe hailstorm in the Langkloof Valley damaged almost 400 hectares of fruit trees and resulted in loss of employment and income for 354 farm workers. Even though the affected area was relatively small, direct damages came to R9.4 million. The Western Cape Department of Agriculture provided financial support to get the orchards back into production in order to keep the farm workers employed. More recently, in November 2013, hail damage wiped out crops (apple, pears, stone fruit, onions) on many farms in the Witzenberg, Ceres and Koue Bokkeveld areas and caused significant damage to much of the remaining crop. Some farmers lost their entire annual crop. Ninety per cent of farms in the Ceres and Witzenberg area, and half in the Koue Bokkeveld and Warm Bokkeveld area, suffered between 50 and 100% damage. It is difficult to predict hail because of the dynamic and chaotic nature of the weather systems that give rise to it.

When extreme weather events damage apple yields and quality, the impacts are felt throughout the value chain. This can happen as a result of loss or damage to infrastructure such as roads and bridges, electricity pylons and lines, dams, irrigation systems, cold stores, packhouse facilities, harbours and airports. Contamination of water resulting from damage to sewage and water treatment plants can affect processing and packaging facilities that require high-quality water. Road closures prevent farmers and distributors from moving perishable fruit. In addition, the direct impacts on yields and quality reduce the value of the crop all through the value chain.

5. HOW IS CLIMATE CHANGE EXPECTED TO CHANGE THE CLIMATE RISKS?

Based on the current understanding of climate processes, climate change will cause shifts in locally important climate systems or processes, such as shifting the rain-bringing frontal storm tracks further south during winter (Midgley et al., 2014). Already, weather data shows that year-round warming has occurred (0.2°C per decade), with more pronounced warming in mid to late summer. There have also been fewer rain days during summer–autumn (January to April) and early spring (August) in some areas, but more rain days in early summer (November–December). This may indicate a progressively later start and end to the rainy season. As yet, there are no obvious trends in total rainfall during the core winter rainfall season or annually across the deciduous fruit production areas.

The climate models used to project climate changes in the Western Cape from 2040 to 2060 (Midgley et al., 2014) indicate the following:

- Higher minimum and maximum temperatures, more so inland than along the coastal areas.
- Increases in annual temperatures of 1.5°C to 3°C, with the Bokkeveld/Ceres and Langkloof areas tending towards the middle part of this range and the EGVV area slightly lower.
- More hot days, and fewer cold and frost days.
- Reduced annual rainfall by mid-century (most climate models agree on this with a stronger indication of drying in the western parts of the region).
- In the short- to mid-term (before mid-century), the possibility of increased rainfall on the windward mountain slopes and in the shoulder seasons (autumn and spring).
- Possibility of increased rainfall in the eastern part of the province, which could include the Langkloof.
- Increased frequency of droughts, floods and heat waves, and possible changing patterns of hail and strong wind (there is greater uncertainty in these projections).

Climatologists are advising decision-makers to consider both increased and decreased rainfall as possible outcomes. Decreased rainfall generally poses the highest risk to apple production.

Under climate warming, accumulation of chill units will decrease, eventually reaching a critical threshold at which apple production would no longer be commercially sustainable in the currently warmer area of EGVV (Midgley and Lötze, 2011). Chill unit accumulation has decreased over the last 40 years, particularly in autumn (May). Even moderate future warming of less than 1°C will have serious implications for continued production in the EGVV area. Warming of 2°C and higher will result in all years receiving less than the minimum chill accumulation threshold (Midgley and Lötze, 2011). At this level of warming, using chemical treatments to offset the low chilling (which is already standard practice) would become ineffectual. Only the introduction of commercially viable low-chill cultivars would allow for continued profitable production. In contrast, under warming of 3°C and possibly higher in the Koue Bokkeveld, total seasonal chill will remain sufficient for apples. Since the Langkloof is not quite as cold as the Koue Bokkeveld, chill unit thresholds would be reached sooner, but not in the near future. Suitable apple-producing climates could become limited to the colder high-lying areas of the Koue Bokkeveld by mid-century (Table 3; Cartwright, 2002).

TABLE 3: SUMMARY TABLE OF CLIMATE CHANGE SENSITIVITIES FOR THE APPLE-PRODUCING REGIONS OF THE WESTERN CAPE, BY AGRO-CLIMATIC ZONE

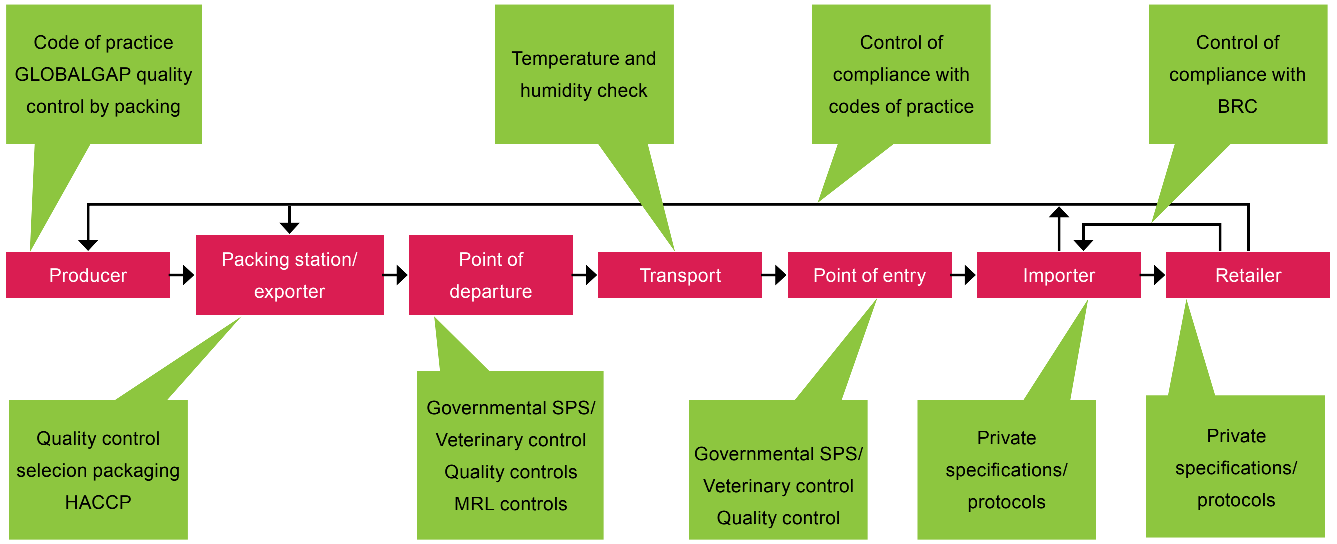
NAME	MAIN WATER RESOURCE FEATURES	MAIN CLIMATIC FEATURES	CLIMATE CHANGE TEMPERATURE PROJECTIONS*	FUTURE APPLE GROWING POTENTIAL**
BOKKEVELD (CERES)	Farm dams, good water resources and large storage capacity***	Winter rainfall, cold winter minimum temperatures, occasional snow	Medium-range warming	Remains high as long as the dams fill up
ELGIN-GRABOUW-VYEBOOM-VILLIERSDORP (EGVV)	WCWSS large dams, farm dams, very large storage capacity	Unique climate; more cloudy, misty and wet than surrounding areas	Low-range warming	Remains high as long as dams fill up, but apples become increasingly unviable due to warming unless low-chill cultivars become available
BO-LANGKLOOF	Dams, insufficient storage capacity, use of groundwater	Rainfall throughout the year with spring and autumn peaks; recent floods, droughts and fires	Low- to medium-range warming	Increasingly marginal, constrained by water availability and extremes, but could improve if rainfall increases

Source: adapted from Midgley et al. (2014)

Notes: * Due to model uncertainties, both decreasing and increasing rainfall scenarios should be considered. ** For the medium-term future, 2040–2060. *** "Storage capacity" refers to public storage capacity; it excludes private farm dams.

Higher temperatures under climate change will also lead to more sunburn and poor red colour development, and there could be impacts on fruit size (Gindaba and Wand, 2005; Gouws and Steyn, 2014). Some of the largest and most disruptive impacts could result from changing patterns of hailstorms, strong winds, and pests and diseases, which are currently not predictable. The increasingly strict non-tariff barriers to exporting apples (e.g. phytosanitary, minimum residue levels) could represent a significant risk to the industry if climate change leads to outbreaks of known and new pests and diseases. Monitoring and quality control systems at multiple points along the value chain (Figure 8) will require closer cooperation between the various agents.

FIGURE 8: FOOD SAFETY AND QUALITY CONTROL IN THE FRUIT AND VEGETABLE SUPPLY CHAIN



Source: DAFF (2014)

Note: BRC = British Retail Consortium (Global Standard for Food Safety), HACCP = hazard analysis critical control point, MRL = minimum residue level, SPS = phytosanitary standards

All commercial apple production in the Western Cape is under irrigation (Dzikiti et al., 2014). Under climate change projected for the south-western parts of the province, irrigation water demand to maintain current production levels is expected to increase by about 10% by mid-century (DEA, 2013). This is due to the projected rise in plant transpiration and soil water evaporation caused by warming. Projected decreases in winter and annual rainfall, the possibility of more frequent and/or severe droughts and the risk of dams not filling sufficiently, would lead to more frequent restrictions of irrigation water. This would put orchards under stress and reduce yields and fruit quality. Water prices will almost certainly rise.

Farmers are already adjusting orchard management practices and introducing new technologies to deal with these risks. These include more efficient irrigation technologies such as drip systems; more precise scheduling methods; mulching to preserve soil moisture; chemical agents to overcome insufficient chilling; the use of shade and hail netting; integrated pest management, which includes careful monitoring practices and in some cases additional pesticide and fungicide applications; and improved and more resilient cultivars and rootstocks (Midgley et al., 2014). These adaptive responses all increase the costs of producing a tonne of apples, thus reducing the profit margin for farmers.

Greater irrigation and cooling demand will increase energy use and costs. Maintaining the cold chain is exceedingly important in the fresh apple value chain: from cooled storage and packhouse, refrigerated container truck, cold store at the South African port, to refrigerated containers on ships, cold store on arrival in a foreign port and refrigerated distribution to markets and retailers (DAFF, 2014). During this journey, the fruit pulp temperature must be kept at –0.5°C. Higher temperatures cause accelerated ripening (yellowing and softening) and disorders like bitterpit, reducing the postharvest life of apples. It is thus essential to maintain this temperature. Under warmer ambient temperatures, much more energy will be required to cool the stores, trucks, containers and retail shop shelves. This increases costs, especially given the expected future rise in energy costs. Increasing frequencies and intensities of heat waves could place the grid under pressure and put strain on air-conditioning machinery, thus increasing the risks of power outages and fruit spoilage.

Postharvest disorders that develop in the cold storage period and on the shop shelf risk increasing in incidence and severity. These disorders are not visible at harvest but can cause significant losses in price, sales and supplier reputation once they become noticeable.

Processors (juicing and canning) will experience higher risks through increasing water scarcity, which will increase water pricing and possibly water allocation decisions, as well as through energy prices. The national requirement to reduce the energy demand and transition to a low carbon economy will lead to an increasing cost of energy. This will also affect the transport sector of the value chain. Switching to cleaner affordable fuels will be one way to deal with potential price increases while contributing to greenhouse gas emissions reductions.

Climate change is expected to shift the timing of key climatic events and the seasonal cycle of fruit growth, for example the start and end to the rainy season, the flowering period, the start and rate of fruit ripening and the optimum harvest time (Midgley et al., 2014). The most likely scenario is for earlier flowering, more rapid fruit development and earlier harvest than currently experienced, but the responses will be cultivar-specific. This could lead to changes in the seasonal supply of apples and disruptions to overlapping and sequential supply of key cultivars. Prices will drop in periods of oversupply. These impacts will interact with the local climate change impacts on other apple-producing and -exporting countries, particularly in the southern hemisphere (e.g. Chile, New Zealand). The current situation, where increasing risks are carried through to retailers and ultimately reflected in the price of fruit, is expected to continue. Farmers and consumers are likely to end up being the value chain members who are most negatively affected.

There has been a recent trend in decreased purchase of insurance cover for apple crops, caused by the rising costs of insurance products. Farmers are absorbing the greater impacts of year-on-year and multi-year climate and yield variability. Many are turning to various forms of “self-insurance”, including erecting hail/shade netting, diversifying farms across different climatic zones and establishing contingency savings accounts.

6. WHERE ARE THE OPPORTUNITIES FOR STRATEGIC RESPONSES IN THE VALUE CHAIN?

Future apple production in South Africa is expected to grow gradually and keep its position as an important export product (BFAP, 2015). Local demand will rise with population growth, and global demand is also expected to rise. However, climate change will add an element of uncertainty and increasing variability in production and quality. This will lead to greater year-on-year variability in marketing decisions and the risk of instability in the supply chain. The impact will be felt throughout the supply chain and will demand flexibility and a variety of marketing options on both the export and domestic markets.

Timely investment in adaptation (well-suited cultivars, more efficient use of water, installing hail/shade netting, etc.) can nevertheless buffer the increasing variability in production and quality and could in fact reduce it below current levels if applied optimally. Currently, risk reduction is financed almost solely by the farmers themselves, sometimes with the assistance of bank loans. However, the capital outlay required or interest-bearing loan repayments will put effective adaptation beyond the reach of many apple farmers. A partnership approach between multiple agents in the value chain and farmers would benefit the whole system.

Opportunities for greater support from the value chain actors lie in:

- Supporting effective knowledge and extension to farmers dealing with climate stress
- Participating in partnership research models to support locally relevant on-farm technology development and more “climate-smart” ways of farming
- Developing innovative insurance models and products to provide affordable options for farmers or supporting farmers in implementing “self-insurance”
- Supporting investments in renewable energy for on-farm energy needs (e.g. irrigation pumping) and for packhouses, cold storage and processors

(All of the above should consider linking farmer-favourable supply contracts with buyers along the value chain.)

- Supporting the drive towards greater energy efficiencies along the value chain through reliable energy audits and technical/operational responses
- Supporting the industry in ensuring a minimum level of water supply for apple farms in times of scarcity, maintaining minimum water quality standards and continuing to develop innovative approaches to increase water use efficiency
- Switching the transport fleet to lower-cost greener transport fuels
- Supporting investments in developing the local and processing market for greater absorption capacity and strategies for dealing with periods of oversupply or large volumes of fruit unsuitable for the export market (e.g. hail or pest damage)
- Collaborating with exporters and researchers to monitor possible changes in postharvest storage quality
- Lobbying government to develop forward-looking integrated policies which support effective responses to climate change in the agricultural sector, and incentives for investments in climate change adaptation in the apple industry
- Supporting or even driving (retailers) a consumer awareness and education campaign around fruit quality, encouraging the purchase of high eating quality but externally imperfect fruit; this would be easier with local consumers but could be extended globally.

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