MODULE 6

Subtropical Fruit Production

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Agricultural Research Council – Tropical & Subtropical Crops
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1 INTRODUCTION

Objectives

1. Understand Climate change and its impact on Agriculture.
2. Understand the Greenhouse Effect.

1.1 CLIMATE CHANGE AND ITS IMPACT ON AGRICULTURE

The agriculture industry in South Africa is growing increasingly sensitive to population growth, high input prices, climate unpredictability, and climate change. Agricultural productivity fluctuates significantly from year to year, owing mostly to the country's vulnerability to harsh weather events. Climate change has an impact on agricultural systems in the following ways:

- rain quantity and distribution, and therefore water availability;
- extreme events such as floods and droughts;
- increased temperatures;
- shifting seasons, all of which have a substantial influence on fruit output.

Agro-climatological indicators' frequencies, averages, extremes, deviations, threshold exceedance, regional variability, and trends are essential for monitoring and reducing agricultural risk. Furthermore, climate-related temperature and rainfall fluctuations across South Africa have resulted in altered agri-ecozones. Crops that are now suitable for cultivation in specific locations may no longer be so, and new crop varieties may become suitable for cultivation in areas where they are not currently suitable. These consequences are already being seen in subtropical places.

1.2 GREENHOUSE EFFECT

The 'greenhouse gas effect' is critical for the growth and survival of life on Earth: without it, temperatures on Earth would be 19°C below freezing point on average. The greenhouse gas effect occurs when some of the sun's short-wave energy is absorbed by the Earth's surface and reemitted mostly in the infrared band.

Some gases in the Earth's atmosphere function like greenhouse glass, trapping the sun's heat and preventing it from escaping into space. Many of these gases are naturally occurring, but human activity is increasing their quantities in the atmosphere, particularly:

- carbon dioxide (CO₂)
- methane
- nitrous oxide
- fluorinated gases
Carbon dioxide (CO₂) is the most prevalent greenhouse gas created by human activity, accounting for approximately 64% of man-made global warming. Its concentration in the atmosphere is now 40% greater than before industrialization began.

Other greenhouse gases are released in lesser quantities, but they trap heat considerably more efficiently than CO₂ and are hundreds of times stronger in some circumstances. Methane is responsible for 17% of man-made global warming, whereas nitrous oxide is responsible for 6%.

Human activity has increased the amount of greenhouse gases, particularly carbon dioxide, in the atmosphere. The increased warming generated by these emissions is known as the ‘anthropogenic greenhouse gas effect,’ and it is one of the primary drivers of climate change.

1.2.1 Causes for rising emissions

There are various factors that contribute to rising emissions and they include:

- **Burning coal, oil and gas**: Carbon dioxide and nitrous oxide are produced when coal, oil, and gas are used for transportation, heating, and industrial output.
- **Clearing of forests by humans (deforestation)**: Trees contribute to climate regulation by absorbing CO₂ from the atmosphere. When trees are chopped down, the positive impact is eliminated, and the carbon stored in the trees is released into the atmosphere, contributing to the greenhouse effect.
- **Expanding cattle farming**: When cows and sheep digest their meal, they create a lot of methane.
- **Use of fertilisers containing nitrogen**: Nitrous oxide emissions are produced by nitrogen-containing fertilisers.

1.3 IMPACT ON PRODUCTION

According to FAO (2013), the world’s population will grow by an additional 2 billion people between 2013 and 2050, with the majority of these individuals coming from poorer nations. Based on current income and consumption growth trends, the FAO forecasts that agricultural production would need to expand by 60% by 2050 to meet projected food and feed demand. Using a business-as-usual scenario, an increase in agricultural production of 60% will be challenging owing to the negative effects of climate change. Climate-Smart Agriculture addresses food security and climate issues concurrently, therefore integrating the three pillars of sustainable development (economic, social, and environmental). It is supported by three major pillars.
1. Increasing agricultural production and incomes in a sustainable manner
2. Adapting to and building resilience to climate change
3. Reducing and/or eliminating greenhouse gas emissions when possible.

As a result of a number of technical, political, financial, and socioeconomic limitations, studies pertaining to greenhouse gas reduction, sustainably increasing agricultural productivity and incomes, and adapting to climate change activities are generally not addressed together.

Climate change will aggravate existent patterns of food poverty and vulnerability. Agriculture, rural livelihoods, and food security are closely connected to the issues of climate change in the twenty-first century. The next 50 years are expected to see an overall decrease in precipitation in semi-arid areas, increased variability in rainfall patterns, and a rise in temperature at low latitudes. Agricultural output will have to deal with more unpredictability in water supplies, with the greatest impact felt in food-insecure areas dominated by rain-fed agriculture.

Climate change adaptation for agricultural cropping systems requires greater resilience to both surplus water (due to high intensity rainfall) and scarcity of water (due to prolonged dry periods) (FAO, 2007). To strengthen the resilience of these rain fed production systems, adaptation methods focused on increased water infiltration, soil moisture retention, water collection, and small and dam-based irrigation development would be necessary.

Figure 1 Maximum and minimum temperatures in South Africa with projected changes due to climate change effect.
The following techniques and tactics can help to mitigate the predicted harmful effects of climate change:

- Identifying and implementing local disaster risk reduction activities integrating national and sub-national early warning systems; identifying current vulnerabilities and risk reduction solutions with the participation of the community;
- Increasing communities' abilities to manage their resources (e.g., savings, credit schemes, agricultural inputs, agricultural productivity, land usage, and so on);
- Increasing the use of technology tools to mitigate the hazards associated with climatic variability (for example, disaster information management systems);
- Raising farmer awareness and strengthening local institutions in support of national disaster management policies;
- Establishing partnerships between regional and national research institutes, extension services, and farmers.

Climate change is a serious threat to humanity. No one can avoid its devastating repercussions, and its influence on the plant kingdom cannot be disregarded since humans rely on plants for food security and the preservation of ecological equilibrium. Although perennial crops are naturally resilient, they are unable to offset severe climate change. Among them are fruit trees, which play an important role in global nutritional food security and enrich the environment with their diverse species.

Changes in precipitation patterns, rising temperatures, and uncertainty in climate forecasting all have a significant influence on tree crops. Most fruit crops, including mango, papaya, guava, and others, experience flower drop when severe low temperatures predominate during flowering, reducing fruit output.

Temperature also influences the amount and quality of blooms, which has a direct impact on the season's fruiting potential. Low night temperatures are required by some fruit crops, such as mandarins, to create beautiful fruit skin colour. The sweetness of most subtropical climate fruits rises when diurnal temperature variations grow, which is influenced by unfavourable climatic conditions. These are just a few examples, but the true picture is considerably broader, and if appropriate steps are not done, the situation may worsen.

We must discover ways to produce more food, adapt to shifting weather patterns, and prevent additional climate damage, all while providing opportunities for men and women involved in food production. To tackle these interconnected issues, food systems must become more efficient while also becoming more resilient to changes and shocks. Agriculture must evolve to make greater use of natural resources, producing more with less land, water, energy, and other inputs.
Practical activity 1

Describe how climate change is likely to influence agriculture and other elements of people’s lives.

1. Divide participants into groups to explore how greater and lower temperatures, as well as unpredictable rainfall, would influence their location.
2. The following points should be addressed:
   - fruit production
   - natural resources and the environment
   - economic and social factors

Each group is required to report back to the plenary.

A discussion around regarding their results must be facilitated.
2 SUBTROPICAL FRUIT PRODUCTION IN RSA

Objectives

1. Understand Climate change and its impact on Agriculture.
2. Understand the Greenhouse Effect.

2.1 OVERVIEW

Subtropical fruit originates from the tropical and subtropical regions of the world. Subtropical fruit crops are characterized by relatively poor winter hardness. The particular climatic requirements of some types of subtropical fruit make their cultivation only possible in certain specific areas of the country. In the absence of effective production practices, trees will not produce fruit suitable for the market.

Fruit and nut production is largely concerned with management of the practices and processes that manipulate the tree to produce high yields of marketable fruit and nuts. Production management, together with the selection of superior varieties and plant improvement, can be seen as an on-going effort to influence the natural tendencies of the tree.

Consumers want the fruit and nuts of their choice to be available at all times. Fruit should look good, be unblemished, well-coloured (superior exterior quality), taste good (high interior quality) and be of the right size. At the same time, the producer wants orchards that will provide high yields over an orchard lifespan, which could exceed half a century. On top of all this, the orchard must be managed in such a way that production practices have the least possible impact on the natural environment.

Commercial production management is about achieving these objectives efficiently and cost effectively.

Subtropical fruit crops are characterized by relatively poor winter hardness. They have a long growing period and require stable conditions during their winter dormant period. Individual crops vary greatly in their frost resistance. Subtropical crops also require various amounts of heat during their growing periods.

The most important subtropical crops in South Africa include citrus fruits, banana, avocado, mango, litchi, papaya, guava, granadilla, pineapple, macadamia and pecan. Minor subtropical crops in SA are coffee, ginger, coconut, cashew and pepper. The particular climatic requirements of some types of subtropical fruit make their cultivation only possible in certain specific areas of the country. In general, subtropical fruit types require warmer conditions and are sensitive to large fluctuations in temperature and to frost. Frost free areas in South Africa are suitable for subtropical crop production although other factors including rainfall and soil also impact suitability of areas. Figure 2 indicates the areas in South Africa that are frost free.
Figure 2  Horticultural Zones in South Africa.  
### Table 1  Description of Horticultural Zones.


<table>
<thead>
<tr>
<th>Zone</th>
<th>Description</th>
<th>Mean monthly minimum temp – coldest month</th>
<th>Frost</th>
<th>Rainfall</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Summer rainfall – suitable for subtropical crop production</td>
<td>5°C to 10°C</td>
<td>Dry frost free winters</td>
<td>The most southern part receives occasional winter rainfall and has cooler conditions (lower temperatures). In some locations, strong winds occur.</td>
</tr>
<tr>
<td>2</td>
<td>Coastal winter rainfall – some areas suitable for selected subtropical crop production</td>
<td>0°C to 10°C</td>
<td>Frost-free - frost occasionally occurs in parts of the zone, but it is extremely light and is short-lived.</td>
<td>Strong winds in areas along the coast</td>
</tr>
<tr>
<td>3</td>
<td>Winter rainfall (Karoo). Certain subtropical crops can be produced here if they receive enough water and are planted in frost-free regions.</td>
<td>-5°C to 5°C</td>
<td>Light frost - northern and coastal regions of Namaqualand frost is absent or very light.</td>
<td>Summer rainfall is experienced in the eastern sections, whilst winter rainfall is seen in the western parts.</td>
</tr>
<tr>
<td>4</td>
<td>Summer rainfall (Karoo/Highveld)</td>
<td>&lt;-5°C to 5°C</td>
<td>Frost in winter is severe</td>
<td>Rainfall occurs primarily in the summer, with dry winters, however rainfall is quite low in the north-western region.</td>
</tr>
<tr>
<td>5</td>
<td>Summer rainfall (Bushveld)</td>
<td>-5°C to 0°C</td>
<td>Frost</td>
<td>The eastern part receives a considerable amount of rainfall, although it becomes drier as one moves north and west.</td>
</tr>
</tbody>
</table>
South Africa's primary subtropical fruit production areas are in Limpopo, Mpumalanga, KwaZulu-Natal, and the Eastern Cape. Fruits cultivated on the Western Cape include granadillas and guavas.

Citrus, avocados, mangoes, bananas, and litchis are significant crops for the country since they have both high growth potential and are in the labor-intensive quadrant.

### 2.2 CLIMATIC REQUIREMENTS FOR SUBTROPICAL CROPS

#### 2.2.1 Citrus

Citrus trees are subtropical in nature and cannot withstand harsh frosts. Citrus cultivation in South Africa is thus limited to places with warm and nearly frost-free winters, when temperatures seldom (once per several years) fall below −2°C and almost never fall below −3°C. If no shelter is given, the average lowest temperature for the coldest month should not drop below 2°C to 3°C.

Moisture is another constraint in citrus production. Because rainfall is frequently unevenly distributed and, in most situations, insufficient, moisture must be supplemented by irrigation to guarantee that moisture stress does not inhibit development and output.

**2.2.1.1 Temperature prior to flowering**

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Flowering should occur nearly entirely in the spring, with these spring blooms producing a substantial fruit yield 7 to 12 months later. This, however, varies with cultivar. In more tropical locations, the blooming pattern is less distinct, and main season yields are often significantly less.

Winters in South Africa are typically cold enough for good in-season crops, particularly Valencia oranges and grapefruit, to set. In warmer climates, however, navel trees generate lower yields and fruit. Cold requirements for navel manufacturing regions typically have a mean temperature of 12 to 13°C. The mean temperature must be below 13°C for the tree to go dormant.
Winters in South Africa are typically cold enough for good in-season crops, particularly Valencia oranges and grapefruit, to set. In warmer climates, however, navel trees generate lower yields and fruit. Cold requirements for navel manufacturing regions typically have a mean temperature of 12 to 13°C. The mean temperature must be below 13°C for the tree to go dormant.

Navels must consequently approach hibernation in the winter. As the mean temperature for the coldest month increases over 14°C, the odds of growing consistently productive harvests decrease.

2.2.1.2 Effects of climate on fruit quality

The climate has a significant impact on the quality of citrus fruits. The fact that a region will be labeled as a "good navel area" or a "poor grapefruit area" regardless of soil differences or management measures is ample confirmation of the role that climate plays in generating quality fruit. It cannot be overemphasized how important it is for new citrus enterprises to thoroughly evaluate the climatic needs of the various varieties in order to produce only top-quality fruit.

2.2.1.3 Navel orange

Negative climatic conditions have a negative impact on navels. Much of South Africa’s subtropical area is unsuited for its cultivation.

Only in the dead of winter can high-quality navels be created. The average maximum daytime temperature for the three coldest months should be between 22 and 23°C. Areas with colder winters typically have longer winters, resulting in a higher degree of dormancy. This allows for a greater accumulation of reserves to support following consistent blooming and fruit-set. This results in delayed blooming and fruit maturation. This is especially beneficial because the fruit matures during a time of rapidly decreasing temperatures. Fruit color becomes good under these conditions, and the decline in acid content tends to be moderate and under control.

2.2.1.4 Valencia orange

Valencias have a rather long fruit development time, thus the in-season crop usually develops in the middle of winter or early spring. Even in warmer climates, winter temperatures are low enough to assure good colour and a decrease in acid content in the fruit. The fall in acid content is slowed in colder areas by low temperatures, and warmer spring weather is necessary for the acid level to drop sufficiently low prior to harvesting.

Because of these qualities, the Valencia is more tolerant to a wider variety of winter conditions. Valencia has summer environmental needs that are similar to those of the navel, albeit it is more tolerant of warm, humid circumstances that result in lower Total Soluble Solids (TSS) levels in navels.

2.2.1.5 Grapefruit

Grapefruit cultivars have a brief period of fruit development. As a result, grapefruit production thrives in hot, humid climates with short, mild winters.

2.2.1.6 Lemons

Lemon cultivation is well suited to a broader variety of climatic conditions. During February and March, hotter locations yield larger fruits. In hotter climates, the fruit is larger. The primary
crop matures in colder locations from May to July. Fruit size is superior (smaller) than in warm climates. Smaller fruit sizes are desirable, and smaller fruit receives higher export prices. The colder locations produce two or three minor crops in addition to the main crop at different periods of the year.

2.2.2 Avocado

There are three most well-known avocado races, each with its unique set of climatic needs for adjusting to its native habitat.

- **West Indian cultivars** evolved in the humid, tropical lowlands of Central America and are best adapted to hot, humid environments with heavy summer rains. They are, however, highly sensitive to dryness and do not handle frost well (minimum temperature of 1.5°C), as do other avocado cultivars. The ideal temperature for growth is between 25 and 28°C. The humidity level should ideally be more than 60%

- **Mexican varieties** evolved in Mexico’s cold, subtropical highland woods, and mature trees can resist temperatures as low as –4°C. Flowers are readily destroyed by cold and should not be planted in frost-prone locations in August and September. A humidity range of 45% to 60% should suffice. The ideal temperature for growth is 20°C to 24°C

- **Guatemalan cultivars** originated from Guatemala’s tropical highlands and require a mild, tropical climate with no temperature or humidity extremes. The trees can survive light cold down to –2°C, but the blooms are extremely frost sensitive. High temperatures of around 38°C, especially when paired with low humidity, have the potential to trigger blossom and fruit drop. A humidity level of at least 65% is necessary

- The **Fuerte cultivar**, which is the most widely planted in South Africa, is most likely a natural hybrid of Mexican and Guatemalan races, and it has more climate resistance (particularly to cold) than pure Guatemalan varieties

2.2.2.1 Temperature

- The ideal growing temperature for avocado is cool subtropical settings with a mean daily temperature of 20°C to 24°C
- High temperatures, particularly during flowering, are not well tolerated
- Except during flowering and fruit set, light frost may be tolerated (August and September)
- The lowest temperature for survival is –4°C, however avocados are sensitive to frost during blooming
- The Fuerte cultivar is more susceptible
Climate-Smart Agriculture – Training Manual

2.2.2.2 Humidity

High humidity levels are preferable because they reduce the negative impacts of stress conditions (especially high temperature), which are crucial during blooming and fruit set.

South Africa’s mist-belt regions are particularly well suited to this use. Around 14:00, the humidity ought to be higher than 50%.

2.2.2.3 Rainfall

Water stress affects all commercially produced avocado cultivars in South Africa. An annual rainfall exceeding 1000 mm is desired, and it should be evenly distributed, with the only dry months being in June and July. However, the majority of eligible locations in South Africa have a dry spell during flowering, needing additional watering.

2.2.2.4 Wind

Avocados have fragile branches that are readily destroyed by wind. The bulk of flaws that cause fruit to be downgraded are most likely caused by wind damage.

Climate-smart, the ideal places for commercial avocado cultivation are thus the cold, subtropical sections of Mpumalanga and the Northern Province, as well as KwaZulu-Natal, where rainfall is quite high and mist occurs regularly.

2.2.3 Mango

Mango trees can withstand a broad variety of climate conditions. The crop may be grown effectively in a variety of circumstances, including extremely hot and humid temperatures, cold and dry conditions, and extremely hot and arid conditions. The trees can live in marshy circumstances for long periods of time, but they can also survive in places with less than 300 mm of annual rainfall and temperatures as high as 45°C.

2.2.3.1 Temperature

- The average minimum temperature during the winter should preferably be above 5°C.
- When the trees are in full bloom, cold temperatures can cause the fruit to mature to about the size of a golf ball, turn yellow, and then abort. Fruit drop causes a decrease in yield.
• Mango trees thrive in places with extremely high temperatures (45°C). However, when temperatures surpass 46°C, vegetative growth ceases, especially if little humidity is present.
• For optimum growth and production, the average maximum temperature should range between 27 and 36°C.
• Certain cultivars are less resistant of high temperatures and low humidity, resulting in sunburned fruits (Sensation and Keitt). Tolerant cultivars include Neldica, Tommy Atkins, Chené, Kent, Cerise, and Kensington.

2.2.3.2 Humidity and rainfall

From October until the fruit is harvested, the average relative humidity for mango cultivation in South Africa should be 55% or less.

The rainfall should ideally not exceed the following:

- September: 50 mm
- October: 85 mm
- November: 110 mm
- December: 140 mm
- January: 140 mm
- February: 140 mm

The relative humidity and rainfall reported here are optimal for the growth of disease-free fruit, but not for maximum output. Irrigation is critical in areas where mangoes are grown due to limited rainfall.

2.2.3.3 Wind

• Scratches on fruit can be caused by wind (even mild gusts). Through these wounds, harmful fungus and bacteria can penetrate the fruit. Fruit bearing marks are not acceptable for commercial purposes
• Winds that are too strong can induce fruit loss, resulting in decreased yields
• Certain cultivars, including as Zill, Haden, and Kent, are more prone to fruit loss than others in windy circumstances
• Damage by wind can be minimised by:
  » Avoiding locations with high winds
  » Creating windbreaks on the upwind side of prevailing winds, such as manmade buildings or fast-growing trees. To prevent producing a funnel effect, mango orchards should be planted so that the rows run diagonally to the prevailing wind direction
  » Pruning non-bearing flower panicles as soon as it is clear that they will not yield fruit, since they leave scratch marks on the fruit when they turn dry and hard

2.2.3.4 Elevation

Mangoes grow successfully at elevations ranging from sea level to 1200 m in the tropical and subtropical areas. At higher elevations, however, production diminishes. Mango production over 600 m altitude is widely regarded to be financially unviable in South Africa.

2.2.3.5 Soil requirements

Mangoes thrive and produce well in a wide range of soil conditions. Mangoes grow successfully under irrigation in soils with an unobstructed depth of more than 1 m. However, if irrigation is carefully planned, there should be no difficulty on soil with a depth of 750 mm, as long as any soil or rocky layers that restrict root development to 750 mm soil depth enable surplus water to drain readily.

A sandy-loam or loam soil (with a clay percentage of 15-25%) is best for mango production under irrigation, but soils with a clay content of up to 50% are also appropriate.
Moisture losses from transpiration and evaporation are so minimal in some places (owing to humidity, temperature, and rainfall conditions) that the soil remains wet throughout the year, preventing tree withering. Mangoes may be cultivated in dry land circumstances if the soil moisture retention ability is such that it can give moisture to the plants during drier seasons. Such soils have a depth of at least 600 mm and a clay concentration of 15 to 30%.

2.2.4 Banana

The world’s largest banana-growing regions are located between the equator and latitudes 20° North and 20° South. The climate in these places is mostly tropical, with relatively modest temperature changes from day to night and from summer to winter. South Africa’s banana-growing zones, on the other hand, are located between 24 and 31 degrees south, with typical subtropical temperatures. The primary distinction between our local subtropical climate and tropical climates is the considerable variation in day and night temperatures, as well as the seasonal temperature extremes encountered in the subtropics throughout both winter and summer.

2.2.4.1 Rainfall

Climate significantly limits banana cultivation in South Africa’s subtropical zones, since optimum circumstances do not exist elsewhere in the nation. Rainfall is insufficient, and distribution is poor, although this may be greatly improved with additional irrigation (see section on irrigation).

2.2.4.2 Temperature

More importantly, in midwinter, air temperatures in banana regions drop every night to between 12 and 5°C, and occasionally much lower. Cold night temperatures induce yellowing and a variety of bunch issues such as November dump, choke throat, and under peel discoloration, all of which affect yield and quality. The daily temperature range approaches optimum only during the three to four summertime months when daily low temperatures are often above 18°C.

During summer heatwaves in the subtropics, peak temperatures on summer afternoons can sometimes reach between 40°C and 45°C. This is almost as bad for banana plants as cold temperatures since it causes wilting, permanent leaf burn lowers leaf area, and reduces photosynthetic efficiency. Heat stress also reduces bunch production and quality during bloom initiation or fruit development.

Choke throat in bananas is a well-known phenomena that occurs from June through
September, when normal leaf development is hampered by cold winter temperatures. The issue is that a bunch attempting to emerge through the top of the pseudostem is thwarted by leaf bases with short internodes that have gotten compressed and crowded at the aperture. This behavior is particularly pronounced in Dwarf Cavendish, whose leaves get rosetted and crowded at the apex of the pseudostem during cold weather. Unless temperatures are really low, it seldom occurs with tall varieties.

The optimum temperature for banana flower initiation is around 22°C. When mean nighttime temperatures fall below 10°C, flower initiation is greatly impacted by the cold, leading in a higher or lesser degree of November dump.

### 2.2.4.3 Other climatic problems

#### 2.2.4.3.1 Hail

Almost every year, a strong hailstorm devastates and destroys certain subtropical banana plantations in South Africa. Hail damage to banana bunches can be mitigated in part by using polyethylene covers, depending on the intensity of the hail and the thickness of the cover. Covers provide some protection during mild hail, and they should be seriously considered for both wind and hail protection this summer.

#### 2.2.4.3.2 Wind

Wind may cause a variety of problems in a banana plantation. Winds of more than 50 km/h create "blowdowns," which are occasionally responsible for catastrophic crop losses. In the subtropics, high seasonal winds (20 km/h to 50 km/h) produce leaf tearing, which can impair production when severe. Winds of 10 km/h to 20 km/h can also degrade fruit quality by increasing leaf and dust abrasion. Finally, hot, dry winds cause water stress and transient wilting, causing physiological damage to the plant.

#### 2.2.4.3.3 Drought

In South Africa, nearly all bananas are irrigated. However, when the supply of irrigation water is reduced or eliminated due to drought, the plants suffer fast. Heat stress and leaf burn occur more quickly when soil water content is reduced than when soil is well-watered. Drought causes tiny, stunted plants with wilted, yellow leaves, delays in flowering, choking throat even in July, and little bunches with shriveled, blackened fingers.

Because of the diminished growth potential and lower temperatures, the impacts of drought are significantly less severe in the winter.

### 2.2.5 Litchi
Litchis grow best in a subtropical environment with hot summers and cool, frost-free winters. Low winter temperatures are critical for inducing the physiological changes required to induce bloom initiation. Flowers and new shoots can be damaged by temperatures below 0°C. Frost-free parts of South Africa with significant summer rainfall and humidity (particularly the Mpumalanga Lowveld, the Soutpansberg area, and the KwaZulu-Natal coastline area) are therefore best suited. The climate must meet the following requirements for good litchi production:

- During the summer, the average monthly maximum temperature must be less than 32°C but greater than 26°C
- For the three to four winter months, the average monthly minimum temperature must be greater than 6°C but less than 14°C
- From October through fruit maturation, the relative humidity must be greater than 50%

### 2.2.5.1 Water

High summer rainfall supports optimum fruit development and yield in litchi cultivation. From blossoming until the fruit can be picked, which is from August to January, adequate water must be provided. Sufficient soil moisture must be provided throughout the blooming season and for 7 to 8 weeks following flowering since this is the most crucial phase for fruit set and the beginning of cell division in the young fruitlet, particularly in the skin and the early embryo (seed).

Pineapple thrives in a warm, humid area with temperatures ranging from 15°C to 32°C. Daily mean temperatures of 23°C - 24°C are said to be ideal for pineapple acid and sugar levels. High temperatures above 35°C are unfavourable for fruit growth, especially if relative humidity is low. Sun scorching occurs when the fruits are exposed to direct sunlight and temperatures over 32°C.

Pineapples thrive in climates with rainfall ranging from 760 to 1000 mm. However, irrigation is required when yearly precipitation falls below 500 mm or when low rainfall occurs in successive months.

High humidity (daily mean > 75%) prevents sunburn and promotes development in places with limited rainfall. If frost does not occur, pineapples may be cultivated up to a height of 1,100 m above sea level.
2.2.7 Guava

Guavas are fairly versatile and thrive in tropical and subtropical climates. In locations with a distinct winter season, yield and quality tend to rise. They do, however, grow best in places where there is no frost. They can, however, flourish in most regions where the winters are not too harsh, and the young trees should be protected if planted in areas where there is periodic frost. Mature trees, on the other hand, can withstand the rare cold. Cold winds should be kept away from trees.

Guavas may be cultivated up to 1515 m above mean sea level. Drought tolerance is higher in older plants. Guava trees are highly resilient and can grow in a variety of soil types, although they are susceptible to water logging. Deep, loamy soils that are well drained are ideal for guava production.

2.2.8 Papaya

Papayas thrive in hot climates. In South Africa, the ideal temperature range for papayas is between 25°C and 28°C, and output typically peaks between September and November. They can withstand light frost provided they are shielded from cold winds.

Papayas thrive and yield well in a broad range of soil conditions. The best soils are loamy. The root system may penetrate to a depth of 2 m under favourable conditions, although the majority of the roots responsible for nutrient absorption are located in the top 500 mm. Soils must be adequately drained since diseased roots might develop if the soil becomes too moist.
2.2.9 Granadilla

Granadillas enjoy mild temperatures all year. They are susceptible to severe frost (especially the purple granadilla). They should be grown on cool slopes in hot locations, and in cool areas on warm northern slopes. The average maximum monthly temperature should not be higher than 29°C, and the lowest temperature should not be lower than 5°C. Granadillas require high relative humidity and evenly distributed rainfall of at least 1200 mm per year (irrigation can supplement low rainfall).

2.2.10 Macadamia

Macadamias require temperatures ranging from 16 to 25°C. Although the trees may withstand temperatures as low as 3°C, they should not be considered frost resistant.

Most soil types are appropriate for macadamia cultivation, as long as they are well drained and do not have any limiting layers in the top 1 m of the soil. Clay soils with poor drainage are unsuitable.

The altitude above sea level has an impact on nut quality and output. It is commonly known that better crack outs (kernel as a percentage of dry nut in shell weight) are typically attained at lower altitudes due to the nuts developing thinner shells in warmer environments.

Macadamias growing in warmer climates will have thinner shells even at low elevations. The shells of nuts from KwaZulu-North Natal’s Coast are thinner than those from the colder South Coast.

Plantings of macadamias in Mpumalanga and Limpopo extend from 600 to 1200 meters above sea level. However, it is likely that the climatic conditions linked with the elevations,
not the altitude, affect the kernel percentage. Moderate temperatures with considerable humidity appear to be optimal. When the plants are less stressed, less energy is expended on shell formation, resulting in thinner shells. Both heat and cold can cause harm to macadamia plants.

Frost typically kills young trees, while elder trees usually survive. Frost damages blooms, resulting in a reduced fruit (nut) set. Temperatures exceeding 35°C, on the other hand, become too hot and decrease photosynthesis. As a result, tropical and subtropical locations are more suited; nevertheless, there are spots in the highlands that produce macadamia nuts, and microclimate will be more important in these areas.

2.2.11 Pecan

The pecan-nut tree flourishes in subtropical climates. It also thrives in climates with short, cold winters and long, scorching summers.

Low temperatures, including frost, are necessary for effective budding and flower growth from June to August. The tree demands high temperatures for fruit development throughout the summer months (October to April). Trees grow in valleys and beside rivers when the winter temperature is low and frost occurs.

During the summer, the average monthly maximum temperature should be greater than 28°C and lower than 23°C. The average monthly minimum temperature must be higher than 16°C in the summer and lower than 8°C in the winter. The best producing locations include short, cold winters and long, hot summers, with no early or late frost and humidity levels below 55% for the most of the growth season.

Because humidity is high near rivers, valleys, and low-lying regions in the subtropics, only scab-tolerant varieties should be planted. The pecan-nut tree grows best in rich, well-drained soil with a loose to medium texture.

Practical activity 2

1. What subtropical fruit crops can be grown in your area?
2. What are the major limitations and challenges that producers face?
3 MITIGATION & ADAPTATION

Objectives

1. Understand mitigation and adaptation strategies such as orchard management, Conservation agriculture, integrated farming systems, integrated pest management, and water harvesting in subtropical fruit production.

Agricultural producers have always had to deal with changing weather patterns. The weather might be hotter or cooler, wetter or dryer. Farmers have learned to adapt, and despite decreased yields, they are still able to produce and market. Unusual weather patterns are becoming more common and less predictable. Significant weather conditions (e.g., extreme drought, high temperatures, hailstorms) can result in crop failure.

Climate change is causing changes that may have an impact on agriculture productivity. Rainfall is becoming more unpredictable; in some areas, it is decreasing, while in others, it is increasing in frequency and severity. Farmers must now adapt to climatic changes that will affect the way they farm irreversibly, rather than only dealing with short-term weather disasters like droughts, floods, heat waves, and cold spells.

Farmers urgently need to better understand the predicted consequences of climate change in order to become more inventive and produce enough to feed themselves and the ever-growing local, regional, and worldwide populations. Their additional task is to do so in ways that safeguard the environment, particularly soil and water, and reduce agriculture's impact to climate change.

As a counter-measure to the predicted consequences of climate change, it is critical that all agricultural operations contain modifications to reduce these effects on productivity. Biodiversity, in all of its forms, improves resistance to changing environmental circumstances and stressors. The integrated farm system, which employs indigenous and locally adapted species, as well as multi crop systems in which crops and cultivars with tolerance to adverse environmental conditions and stresses (e.g., high temperature, drought, flooding, high salt content in soil, pest and disease resistance) are used to reduce risk.

Conservation agriculture, organic agriculture, and risk-coping production systems that include crop rotations, agroforestry, crop-livestock associations, crop-fish systems, and the use of hedges, vegetative buffer strips, and other farm landscaping measures are among the areas to be investigated.

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Planting trees is one of the most effective and cost-effective means of removing CO₂ from the atmosphere and addressing the climate issue. As trees grow, they absorb and store carbon dioxide emissions that contribute to global warming. According to new study, a global planting program might eliminate two-thirds of all human-caused emissions in the atmosphere today.
Fruit tree production is a medium to long-term investment with few modifications possible after the crop is established. Fruit tree growth periods are typically in the 5–10-year range, with optimum yield occurring several years following planting. As a result, once the crop has been established, the types utilised and cropping regions cannot be readily altered, as this would result in economic losses for farmers.

Targeting existing types in appropriate and acceptable production settings is thus important for every fruit tree grower, both now and in the future. Fruit trees, on the other hand, have the benefit of being more resistant to changes in weather conditions, save at key seasons such as flowering or fruit filling.

Table 2 Comparing current agricultural practices and Climate-Smart Agriculture.

<table>
<thead>
<tr>
<th></th>
<th>Current agricultural practices</th>
<th>Climate-Smart Agriculture</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Land</strong></td>
<td>Expansion of agricultural land by deforesting and turning grasslands to crops.</td>
<td>• Instead than expanding into new regions, intensify usage of current locations</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Instead of deforesting new regions, increase cultivable land area by rehabilitating damaged land</td>
</tr>
<tr>
<td><strong>Natural resources</strong></td>
<td>Make the best use of natural resources - the land, water, forests, and soils needed in industry - while giving little consideration to their long-term sustainability.</td>
<td>Natural resources must be restored, conserved, and used in a sustainable manner.</td>
</tr>
<tr>
<td><strong>Varieties and breeds</strong></td>
<td>Rely on a few crops, as well as a few high-yielding kinds and breeds.</td>
<td>To sustain production, improve yields, and assure stability in the face of climatic change, use a combination of old and new, regionally suited types and breeds.</td>
</tr>
<tr>
<td><strong>Inputs</strong></td>
<td>• Increase the use of fertiliser, insecticides, and herbicides</td>
<td>• Integrated management techniques can be used to control pests and weeds</td>
</tr>
<tr>
<td></td>
<td>• Improve agrochemical efficiency</td>
<td>• Compost, manure, and green manure should all be used</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Rotate crops with legumes to fix nitrogen and decrease the need for synthetic fertilisers</td>
</tr>
<tr>
<td><strong>Energy use</strong></td>
<td>Use farm machinery that typically runs on fossil fuels, such as tractors and diesel pumps.</td>
<td>Use energy-saving technologies such as solar power and biofuels.</td>
</tr>
<tr>
<td><strong>Production and marketing</strong></td>
<td>To increase efficiency, make use of specialised manufacturing and marketing.</td>
<td>Diversify your manufacturing and marketing to increase stability and lower risk.</td>
</tr>
</tbody>
</table>
3.1 ORCHARD MANAGEMENT

3.1.1 Water availability

Drought is now affecting several regions of South Africa, including numerous orchards. Irrigation of subtropical fruit trees is one of the most essential parts of management for a successful yield. Over and under watering are both harmful to the tree and a waste of water and money.

When drought circumstances prevail, the producer strains to produce a crop while also ensuring the life of the trees. Proper irrigation is so critical to the producer.

With this declining production commodity in mind, a few critical techniques are presented. The producer should consider the various options and plan accordingly. However, there is no alternative for water, and the amount of water available will ultimately determine the action.

3.1.1.1 Irrigation depth

The depth of irrigation is governed by the depth of the soil and the depth of the roots. Under typical conditions, the majority of the roots occur to a depth of 600 mm. A farmer should check the root depth of his orchards. Wetting the region below the root zone is a waste of water. It is also reasonable that if 900 mm of soil can be watered instead of 600 mm, the soil water storage would grow by about 50%.

3.1.2 Orchard considerations to take into account

Examine each orchard’s output history. This will show which orchards should be eliminated if required. Different tactics will be used at the start of a drought crisis. Rather than young unproductive trees or extremely old and less productive trees, irrigate trees that have a strong harvest or the potential to generate excellent yields during the early stages of a drought. As the drought worsens, more extreme measures will be required. Older and less productive orchards should not be watered and should be stumped.

Water consumption can be reduced by lowering or turning off all sprinklers on trees that are old, sick, or damaged. Another alternative is to shut off the water supply to the boundary trees, which are more stressed as a result of the wind. These trees are excellent pollinators and can be regarded for high functioning types. They can then be irrigated at a low volume to preserve blooming but not fruit set.

Mulching around trees reduces evaporation, improves moisture retention, and helps to manage weeds. Younger trees, in particular, should be mulched to ensure their survival.

Pruning, thinning, and stumping procedures should only be considered in extreme drought situations when the amount of water and other options, such as lengthening the irrigation schedule, are insufficient to bring orchards through. Trees that are more than a decade old should be trimmed or thinned back. Heavy trimming will minimize canopy area, resulting in less water loss and use. However, due to the deep root systems of some fruits, such as avocado, thinning 50% of the trees would only lower water demands by 25-30%.

Stumping should be used only as a last option. This will halt production of the trees for roughly three years. For this reason, entire portions might be evaluated. The advantage of this approach is that it enables for the trees to be top-worked to new and better-adapted cultivars. After three years, when the trees that were initially
If water becomes a key issue after all other variables have been considered, tree phenology should be closely studied to predict essential watering periods. Yield reductions will occur well before the tree starts to wilt. Most subtropical fruit trees require irrigation from early blooming till after fruit set. Irrigation should be done especially the day before bad weather, such as strong winds, is predicted during this time period. Furthermore, if the bloom is light, it implies minimal yields and should be considered stumping the trees.

Government assistance has aided farmers in surviving protracted droughts and, to some extent, has safeguarded the productive capacity of the country's agricultural sectors. However, due to climate change, South Africa as a country must reconsider how it planned for and responds to drought in the future. South Africa must better plan for droughts in order to mitigate their effects. Even if the present drought ends, others will follow. Investing in more drought-resistant practices, for example, decreases the demand for drought relief today and in the future. Moving the emphasis from drought alleviation to drought management and preparedness will ultimately be more successful in the long run.
3.1.3 Cultivar selection

Using more appropriate and/or robust varieties/cultivars will be one of the adaptation methods to reduce the impact of climate change. Adoption of new kinds, an often mentioned alternative for climate change adaptation, happens considerably more slowly in perennial fruit crops than in annual crops. Perennial agriculture’s extended time horizon poses unique problems in a changing environment. During the lifetime of an orchard, previously favorable areas may become unfavourable.

By choosing the best varieties for the current climate, one runs the risk of selecting a variety which will not suit future climates. Thus, while adjustments such as planting new cultivars and relocating to different regions may decrease long-term consequences, short-term losses may occur. Farmers will require crop varieties that are more resistant to stressors like heat, as well as photo and thermal-insensitive cultivars, in this context.

Considering that tree species differ in their capacity to adapt to climatic circumstances and their sensitivity to risks, fruit crop selection and breeding will take climate forecasts into account, with hybridization and clonal selection offering the possibility to respond to environmental changes. Because future precipitation may be more irregular, cultivar and species selection criteria will need to focus more on water efficiency, drought tolerance, and disease and pest resistance.

Fruit breeders, researchers, and other users can improve yields in the context of climate change by using genetic diversity acquired from diverse agro-climatic situations and conserved ex situ and on farm.

3.1.4 Diversifying crops

By introducing new varieties of crops and cultivating new species, we can improve plant productivity, quality, health, and nutritional value, as well as improve crop resistance to diseases, pests, and environmental stress. This might involve introducing new crops or cropping systems into agricultural production while taking into consideration various returns from value-added products and market prospects.

3.2 CONSERVATION AGRICULTURE

Conservation agriculture is an integrated agricultural strategy that attempts to use soil, water, biological resources, and natural processes more efficiently through improved soil, water, and plant nutrient management. The essential concepts include guaranteeing the recycling and regeneration of soil nutrients and organic matter, as well as making the most use of rainfall by retaining and better using biomass, moisture, and nutrients. One important component is preserving a permanent soil cover, which requires zero or little tillage. Conservation agriculture, low or zero tillage, and the preservation of permanent soil cover can enhance soil organic matter and mitigate the effects of flooding, erosion, drought, heavy rain, and winds.
While heavy soil tillage lowers soil organic matter by aerobic mineralization, moderate tillage and the maintenance of a permanent soil cover (through crops, crop residues, or cover crops, as well as the use of diverse crop rotations) increases soil organic matter. A no- or low-tilled soil preserves soil structure for fauna and associated macrospores (earthworms, termites, and root channels) to act as drainage routes for excess water. Surface mulching protects soil from high temperatures and evaporation losses, and it can lower crop water requirements by up to 30%.

Soil erosion and water loss through runoff are entirely or significantly reduced as a consequence of vegetation and residues covering the soil, crop production is more stable and less vulnerable to weather fluctuations, and better yields may be produced. Not only does employing these methods increase and, more importantly, stabilize output, but it also lowers production costs. Conservation agriculture helps to save the environment while both increasing and sustaining agricultural production. The application of conservation agriculture and minimal or zero tillage, as well as the preservation of permanent soil cover, can enhance soil organic matter and mitigate the effects of flooding, erosion, drought, heavy rain, and winds.

3.3 INTEGRATED FARMING SYSTEMS

Integrated farming balances food production, profitability, safety, animal welfare, social responsibility and environmental care. Integrated farming aims to strengthen agricultural production’s beneficial affects while minimizing its negative effects. The main drawback of single crop production companies is that they are susceptible to a high level of risk and uncertainty due to the farmers’ seasonal, irregular, and uncertain revenue.

Meeting farmers' requirements in order for them to implement an integrated farm system necessitates a new rethinking of agricultural education, research, and extension. An integrated farm is a living system with dynamic interactions between its many components. The integrated farm aspires to be a closed system, capable of operating eternally with minimal outside inputs and little or no waste, and is fueled by what industrial farming deems waste, particularly manure.

As a result, the integrated farming system is a low input system that seeks to optimise the management and use of internal (on-farm) production inputs such as manure, compost, cover crops, and management practices while minimizing the use of off-farm resources such as chemical fertilisers, herbicides, and pesticides wherever and whenever feasible and practicable to lower production costs. This has the potential to enhance both short-term and long-term profitability. In the long run, the agricultural system is thus more economically, socially, and environmentally sustainable.

This does not mean no input is made, for example that soil nutrients are not being maintained or that weeds are not controlled. It just means most inputs can be made from on-farm resources and few have to be purchased from outside. kept up by putting more focus on cultural practices, Integrated Pest Management (IPM), and the use of on-farm resources and management.

Thus, integrated farming is a common-sense (whole-system management) strategy that integrates ecological care of a diversified and
healthy environment with agricultural economic demands to assure a continuous supply of nutritious and readily available food. It is not prescriptive because it is a dynamic concept: it must be adaptable in order to be applicable on any farm, and it must be open to change and technology improvements.

### 3.3.1 Intercropping

One of the most difficult issues for farmers today is increasing production per hectare in a sustainable manner. Intercropping is essentially a multiple cropping practice in which two or more crops are grown on the same land. The fundamental objective of intercropping is to maximize the potential yield of a certain field by maximizing the potential of the resources available at a given moment.

Intercropping is the cultivation of two or more crops in the same field at the same time throughout the growing season. It is the implementation of ecological concepts like variety, crop interaction, and other natural regulatory systems in practice.

The improvement in production per unit of land is one of the most important reasons to cultivate two or more crops together. Intercropping offers several benefits linked to the complementary use of natural resources by the component crops, which results in higher and more consistent yields, improved nutrient recycling in the soil, better control of weeds, pests, and diseases, and enhanced biodiversity.
3.3.1.1 Advantages of intercropping

- Increased crop yields per unit area
- Improved soil fertility by leguminous intercrops (nitrogen fixing)
- Reduced soil erosion
- Lowered soil surface evaporation
- Reduced weed infestation
- Intercropping trees with plants can also help repel pests since many herbs have insect repellent qualities

3.3.1.2 Disadvantages of intercropping

Intercropping is not always appropriate for a mechanized agricultural system because it is:

- Time consuming: It necessitates greater attention and, as a result, more intense, skilled management
- Planting, weeding, and harvesting efficiency is lowered, which may increase labor expenses in these activities
- Good planning is essential, and this involves careful cultivar selection, correct spacing, and so forth

3.3.2 Mulching

Mulching is the process of covering the soil with a layer of material. In the summer, it keeps the roots cold, and in the winter, it keeps them warm. Leave agricultural leftovers on the land rather than removing it.

Mulch significantly lowers the amount of weeds while also retaining soil moisture. Any old plant material can be used, with the exception of weeds that have already set seed, which will result in an increase in weed population. To ensure that the soil is thoroughly covered, mulch is placed around the trees and in the vegetable row. The mulch enhances the soil structure and fertility as it decomposes. To provide a continual soil cover, more mulch should be spread when the previous mulch breaks down.

3.3.2.1 Types of mulch

- **Organic residue** – grass clippings, leaves, hay, straw, comfrey, shredded bark, entire bark nuggets, sawdust, shells, woodchips, shredded newspaper, cardboard, wool, and cow dung are all examples of organic waste.
- **Green mulch** – also called living mulch. Green weeds or other plants used to cover bare soil and supply nutrients (fertiliser) to important crops.
- **Wood chips** are a by-product of tree pruning and are used to dispose of bulky trash.
- **Leaves** – the leaves of deciduous trees that shed their foliage in the fall. They are frequently chopped or shredded before application since they are dry and fly around in the wind.
- **Straw** – is made from the discarded stems of harvested grain harvests.
- **Grass clippings** - originate from mowed lawns and are occasionally collected and utilised as mulch elsewhere.
- **Compost** – this should be fully composted material to avoid possible phytotoxicity problems, and weed seed must have been eliminated, otherwise the mulch will actually produce a weed cover.
3.3.2.2 Advantages of mulching

- Mulching increases soil nutrient and water retention
- Encourages beneficial soil microbial activity
- Suppresses weed growth
- Mulching helps to minimize evaporation
- Mulching also aids in the retention of moisture, the prevention of soil erosion, the control of weeds, and the addition of nutrients to the soil

3.3.2.3 Disadvantages of mulching

- Heavy mulching over a long period of time may result in soil buildup over the crown area of plants
- Mulching can create a safe haven for cutworms and other pest insects
- The high cost of some materials can be an impediment to large-scale mulching
- Nitrogen deficiency can arise when sawdust and woodchips are used as mulch

3.4 INTEGRATED PEST MANAGEMENT

Climate change is having an impact on the biology, distribution, and outbreak of pests (insects, diseases, and weeds), as well as the possibility for new pests across all land uses and landscapes. Climate change and global warming will have a massive effect on the geographical distribution and population dynamics of insect pests, insect-host plant interactions, the activity and abundance of natural enemies, and the efficiency of crop protection technologies. Insect pests that are now restricted to tropical and subtropical regions may migrate to temperate regions when their host plants' production areas alter.

As a result of global warming and climate change, the relative efficacy of pest management approaches such as host-plant resistance, natural enemies, bio-pesticides, and synthetic insecticides is expected to vary. Pests currently account for up to 40% of the world's food supply; consequently, minimizing pest effect is critical to ensuring food security, cutting inputs, and lowering greenhouse gas emissions. Although certain climate change impacts may be helpful, research shows that pest issues will become more unpredictable and amplitude would rise (Gregory et al., 2009). Forecasting the impacts of climate change on pests is, however, difficult due to the complex interplay of increasing atmospheric CO₂ concentrations, shifting climatic regimes, and increased frequency or intensity of extreme weather events (Heeb et al, 2019).

IPM is a modern, sustainable strategy that supports the use of natural pest management mechanisms in order to cultivate healthy crops with the least amount of disruption to agroecosystems and hazards to human health and the environment.

Key pillars of IPM include:
- Pest identification
- Monitoring and assessing existing and potential pest threats
- Gaining detailed knowledge of pest threats and the various management options available to them
- Preventing the establishment of these pests
- Implementing interventions against any pests that emerge
- Evaluating the effectiveness of pest threat management to improve it where necessary
Monitoring is the first and most important step in implementing effective integrated pest control. It should be implemented systematically on an ongoing basis, down to the same number of representative plant samples within specified blocks, so that data collected for generations of crops can be compared to determine whether an integrated pest management strategy is effective or needs to be improved.

### 3.5 WATER HARVESTING

Water harvesting is classified into three types: rainfall harvesting, floodwater harvesting, and groundwater harvesting. When deciding on the best water collecting technology, a lot of things must be considered. These are summed up as follows:

- Rainfall
- Land use and vegetation cover
- Topography and terrain profile
- Soil type and depth
- Hydrology and water resources
- Socio-economic and infrastructure conditions

Rainwater harvesting is the gathering and storage of rainwater from roofs, land surface catchments, or rock catchments utilizing basic techniques as well as more complicated ones such as contemporary storage tanks. It employs a variety of ways to concentrate, collect, and store rainfall and surface runoff for various applications by connecting a runoff generating region with a distinct runoff receiving area. Because it allows for local food production, particularly at the family level, this approach is highly successful in increasing food security.

Water harvesting may be categorised into two types: in-field harvesting and ex-field harvesting. In-field harvesting, which includes rooftop harvesting, water collection, and micro-catchments, is the most relevant as a solution to homesteads' lack of access to water in rural communities.
Rooftop harvesting – is often used as a method of getting reasonably clean water that may be used for drinking and other domestic purposes. The ‘catchment’ area is the homestead’s roof, and it uses gutters and pipelines to direct water into tanks.

Water collection – effectively prevents net runoff from a given area by storing rainwater and extending the period for infiltration. This method of water retention employs a variety of strategies, including ridges, terraces, borders, and mist harvesting.

Micro-catchment – there are numerous benefits to utilizing this system, including the fact that it is easy and affordable to build, has a high runoff efficiency, frequently avoids or lowers erosion by decreasing runoff, and can be used on virtually any slope as well as flat surfaces (Rutherford, 2003).

Another notable example of a mitigation adaptation synergy is agroforestry, which is one of Africa’s most visible land-use systems across landscapes and agro-ecological zones. The significance of agroforestry stems from the fact that it increases land productivity by providing a favourable microclimate, permanent cover, improved soil structure and organic carbon content, greater infiltration, and higher fertility, therefore decreasing the demand for mineral fertilisers. Agroforestry is advantageous because it affects all three pillars of CSA: adaptation, mitigation, and productivity. Planting trees provides assets and revenue from carbon, as well as wood energy and increased soil fertility, while ecosystem services and tree products may give livelihood advantages to people, particularly during drought years. The majority of these advantages have immediate implications for local adaptation while also contributing to global efforts to reduce atmospheric greenhouse gas concentrations.

Many indigenous fruits are well recognized and highly valued throughout Southern Africa, especially by rural people that rely on these trees for food security. Indigenous crops can improve food security, boost global competitiveness, and diversify the agricultural sector. Indigenous plant species have the benefit of being better suited to local conditions and so have a greater chance of combating land degradation, promoting a sustainable agro-system, and maintaining natural plant heritage.

Identifying and promoting alternative crops and cropping systems, such as agroforestry or the domestication of indigenous fruit trees, is therefore an essential approach for adapting to climate change, particularly for resource-poor rural households and emerging farmers. Native fruit tree crops offer numerous benefits over alien varieties. They are better adapted to the marginal and degraded soils that are frequent in communal areas, have higher drought tolerance,
reduced input and maintenance requirements, the fruit is extremely nutritious, and they are resistant to several pests and diseases that are widespread in foreign crops. Domestication of indigenous fruit trees in South Africa, on the other hand, has been rather sluggish, possibly due to a lack of suitable knowledge on tree species best suited to certain areas.

Indigenous fruits provide great prospects for alternative and specialised products to augment or replace traditional agricultural products and crops. Indigenous fruits may be used to make a variety of value-added products such as jam, juice, and dried goods.

Indigenous trees can also be planted as living fences, creating a natural barrier as they develop. Certain indigenous fruit trees are well adapted to this and yield fruit that may be used to make a variety of goods. These indigenous trees are well suited to local circumstances and grow well, if slowly, in dryland settings. Planting these trees beside an existing fence can give extra protection, and as the fencing ages and deteriorates, the trees will provide enough protection. Windbreaks can also be provided by these trees.

**Figure 5** Dovyalis caffra (kei-apple/ umQokolo) planted as a living fence.

**Practical Activity 3**

1. What if any of the mitigating factors are being implemented by farmers in your area?
2. Do you believe that crops grown in your area will provide new problems to farmers, and if so, what do you believe these issues will be?
3. Is there a possibility of developing new crops in your region as a result of climate change - what crops and why?
4. What suggestions would you give to your farmers to help them adapt to climate change?
4 CONCLUSION

**CSA** is founded on three concepts: flexibility of agricultural practices, support for agricultural systems that maintain the integrity of the land while boosting output for food security, and reduction of greenhouse gas emissions.

Because of **climate change**, crops that have been traditionally planted in one area may no longer be able to grow there, but crops that were previously impossible to grow could now be viable due to changes in the climate. Furthermore, ecological services that support crop development (e.g., pollination, soil biodiversity) may be impacted. For these reasons, crop production must be addressed at the agricultural system level.

If the appropriate technological, institutional, socioeconomic, and regulatory infrastructure is in place, crop management methods and approaches have great potential to adapt to and contribute to climate change **mitigation**.

While agriculture contributes considerably to climate change, it also presents options for adaptation and mitigation. CSA is not a single agricultural method or technique that can be used globally. It is a procedure that includes site-specific assessments to determine the best agricultural production technology and methods.
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