LEARNER GUIDE

Enterprise Selection, Planning and Establishment

Level 5

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Title:		**Plan a Farm and Select a Site** **Optimise and Integrate Various Farming Systems and Trends within Related Enterprises**					
Applied Title:		**Plan a Citrus Farm and Select a Site** **Optimise and Integrate Various Farming Systems and Trends within Citrus Production Enterprise**					
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Directions

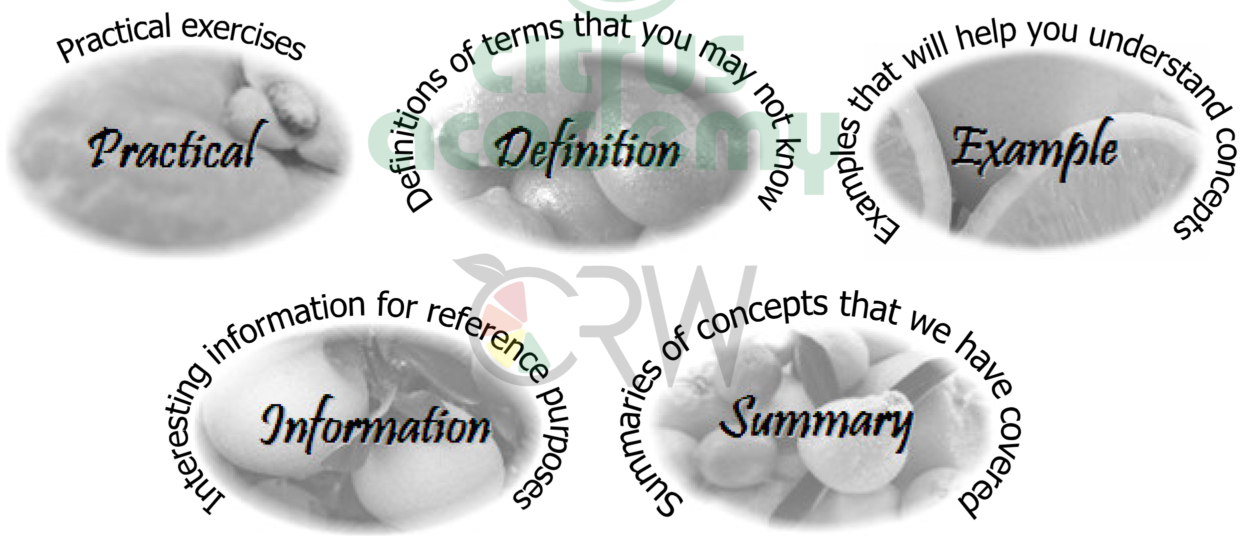
This learning material has been developed to assist the learner wishing to complete this unit standard. The guide contains all necessary learning to ensure that the learner will attain the competencies required by the unit standard.

The learner guide is accompanied by a Learner Assessment Guide. Please ensure that you have access to this guide as well.

The learner guide was designed to be used by a learner during the presentation of a skills program based on the unit standard, and to be kept afterwards by the learner for reference purposes. The learner assessment guide was designed to be completed during and after the presentation of the skills program, and forms part of the assessment process.

Although this learner guide contains all the information required for attaining competency in this unit standard, references to additional resources, both printed and electronic, are provided for further study by the learner.

Information in boxes is indicated by tags that show:



Introduction

1. Purpose

1.1. Unit Standard 116337

Qualifying learners are capable of optimising and integrating various farming systems and trends within related enterprises. In addition, they will be well positioned to extend their learning and practice into other areas of agriculture, specifically integrated crop production and animal production systems.

This training will benefit the profession by equipping learners with adequate skills to have input into the optimisation and integration of farming systems to improve productivity and performance. This unit standard is applicable to all agricultural animals and plant production systems.

They will be able to operate farming practices as businesses and will gain the knowledge and skills to move from a subsistence orientation to an economic orientation in agriculture. Farmers will gain the knowledge and skills to access mainstream agriculture through a business-orientated approach to agriculture.

1.2. Unit Standard 116324

A learner achieving this unit standard will be able to determine the most appropriate and sustainable land-use for different parts of the land, supervise the comprehensive implementation and maintenance of the selected infrastructure and maintain the most appropriate land-use on a farm by continuously assessing the natural resource base.

Competent learners will be fully conversant with agricultural regulations and aspects of conservation, providing the basis for the application of quality practices. Learners will gain an understanding of sustainable agricultural practices as applied in orchard farming. They will be able to participate in, undertake and plan farming practices with knowledge of their environment. This unit standard will instil a culture of maintenance and care for both the environment as well as towards farming infrastructure and operations.

2. Learning Assumed to Be in Place

It is assumed that the learner has successfully completed the unit standards listed below:

2.1. 116337

NQF Level	***Unit Standard Number***	***Unit Standard Description***
NQF4	Literacy and Numeracy	
4	116293	Evaluate, adjust and implement factors influencing agricultural enterprises

2.2. 116324

NQF Level	***Unit Standard Number***	***Unit Standard Description***
NQF4	Literacy and Numeracy	
4	116309	Implement integrated farm layout and site selection

Revision of Level 4

1. Collecting and Presenting Information

- The correct use of data and information is one of the main characteristics of a well run and successful farm.
- Management information would include financial data (budgets and cash flow), administrative data, production data (inputs e.g. labour, materials, machinery and outputs e.g. crop produced), productive use of inputs, human resource data, personnel records, and manning levels for harvesting, packing, etc.
- When collecting data to design a database for a farm, computers are used to correctly structure and store information.
- Tables, graphs and maps are all tools used to convey information.
- Graphs are mainly used to convey the general significance of data, such as general trends, relationships and proportions.
- The major graph types are pie charts, bar or column graphs, line graphs, and area graph.
- A table is a group of rows and columns of data, with a column heading at the top of each column and row headings placed on the left edge of the table.
- A map is a graphic representation of a portion of the earth's surface drawn to scale as seen from above and a presentation of the physical and cultural environment where man finds himself.
- In general maps are divided in two main categories, being topographic and thematic maps.

2. Sustainable Management Practices

- When evaluating whether the available resources are managed sustainably, it must be established whether the climate, soil and available water has been managed in a way that resulted in optimal fruit growth and production.
- Decisions about the production practices employed in a new enterprise or orchard have to be evaluated on an ongoing basis to confirm their correctness and relevance and, if necessary, adjusted where possible.
- Meaningful adjustment of and within resource management has to have a good administration and recordkeeping system as its base.
- It is important to evaluate the combined effect of the production cycles of the cultivars which can be grown in a specific area to establish the cultivar combination which will be best suited for providing the highest profit to the enterprise.
- Production records should not only provide a record of physical production, but also an indication of the quality of the fruit produced historically on a yearly basis.
- To make sure that the right adjustment is made to fertilisation, it is essential that the nutritional status of the soil and tree is evaluated on a regular basis.
- Water analyses allow the farm manager to take the necessary preventative steps to improve water quality if it has the potential to negatively impact on crop production.

- Weather patterns are another factor that must be monitored on an ongoing basis, so that adjustment to management practices can be made if necessary.

3. Land Use

- Agricultural potential concerns only those factors and characteristics that must be taken into account agriculturally, including climate, soil, slope, vegetation and, at times, geographic location and the size of the unit.

- By land suitability or capability is meant the extent to which land provides in the needs of one or more uses under defined management conditions, climate included.

- Land suitability classification means the grouping of land into classes with the same suitability or capacity.

- The main concept used in suitability classification systems is that of limitations, that is characteristics that affect land use unfavourably.

- In the case of the soil suitability classes, soil factors (effective depth, texture, internal drainage, mechanical limitations and other factors) and terrain factors (erosion danger and flooding) are used to describe the classes.

- In the case of the land suitability classes, climatic factors are added to the soil and terrain factors to describe the land classes.

- Several attempts have been made to develop a system by which a productivity index or rating can be provided by means of parametric methods.

- Working groups of the FAO have since 1973 been busy formulating guidelines for land evaluation, especially for use in developing countries.

- Land use planning is the allocation of land for different uses according to criteria that are formulated during the land evaluation process.

- Sustainable farming practices pertain to land clearing and site preparation, soil degradation and conservation, water quality management, cover crops and ground covers, mulching, and orchard floor maintenance.

- Many opportunities exist in horticultural land use for conserving or restoring biodiversity in harmony with farming and rural living.

4. Innovative Land Management

- Soil erosion and land degradation problems are worsened by lack of planning, inadequate runoff control measures on cleared, bared, and cultivated areas, disturbed and eroded watercourses, poor road layout and design, and poor orchard layout.

- The layout of each orchard should be in harmony with the physiographical constraints identified, in particular with the drainage systems and terrain and slope.

- As far as erosion is concerned when it comes to orchard design and layout, it is important to consider tree row gradients, maximum row length, row direction, and adequate control of storm water runoff.

- Diversion banks are required to divert runoff to safe disposal areas where significant catchments exist above the orchard.

- The primary engineering function of a road is to provide a surface giving good foot and wheel traction over a range of weather conditions.
- Continuing road maintenance (grading, drain cleaning) is essential – once every six months in hard setting soils and once every three months in loose soils and areas with a build up of leaf material.
- The planning of a soil management strategy on a farm will be aimed at optimal development and maintenance of the orchards for maximum yield of a high percentage marketable fruit, and should include plant nutrition, irrigation, weed control, and maintenance of the orchard environment.
- The sources of irrigation water on a farm are rain, rivers, boreholes and canals from irrigation schemes.
- Storage can be in farm dams, in which a large supply for future use can be built up, or in small holding dams, in which only an allocation for a specific period is held and which are replenished regularly.
- When developing an orchard or a farm, the total volume of water required by the farm for irrigation must be considered.
- Water supply management implies all the actions to move the irrigation water from the source to the irrigation system in the orchard.
- Irrigation systems can basically be divided into three types, namely flood irrigation, sprinkler systems, and micro-irrigation systems.
- The choice of an irrigation system for a specific case is often difficult, because the various systems each have a wide field of application.
- There are various methods of measuring plant needs which can be used to determine the irrigation schedule.
- The maintenance of an irrigation system is also important because it is designed to last for as long as the crop is cultivated.

5. <u>Infrastructure Maintenance</u>

- Several factors influence the development of infrastructure, such as the enterprise practiced on the farm and the physiographical features of the farm.
- New infrastructure must be developed in accordance with legal and other regulations and requirements.
- New structures must be included in maintenance plans and other recordkeeping systems.
- Maintenance team must be appointed and made responsible for the implementation of maintenance plans and strategies.
- The maintenance team supervisor is responsible for the monitoring and recordkeeping of the maintenance program.
- A systematic and effective fault reporting procedure must be developed and implemented.

6. <u>Stock Management</u>

- The aim of stock control is to minimise the cost of holding stocks while ensuring that there are enough materials for production to continue and meet customer demand.

- As it is difficult to ensure that a business has exactly the correct amount of stock at any one time, the majority of farms will hold buffer stock.
- The decision of how much stock to keep depends on the nature and the size of the business, as well as the effect a stock shortage of a specific item can have on production, quality and supply of the product.
- A stock control system is used to keep track of current stock levels, showing how much stock you have at any one time.
- Any stock control system must be able to track stock levels, indentify when to order stock and keep track of issued stock.
- When a stock shortage occurs, the first reaction should be to secure the required items in the shortest possible time.
- Depending on how critical the stock item is, management may take a decision to increase the buffer stock level for the item after a stock shortage occurred, or to change the re-ordering process in some way to prevent future shortages.

7. <u>Harvesting</u>

- Harvest procedures have to be evaluated on a historical basis as well as during the harvesting season in order to enable management to make the necessary adjustments to ensure a successful outcome.
- A hygiene risk analysis encompassing, amongst others, harvesting procedures, should be carried out prior to, during and after harvesting.
- Workers must be made aware of the possible dangers to their health and safety during the harvesting process, and training around handling and maintenance of picking equipment must be revised during the postharvest assessment.
- Implementation of changes in health and hygiene regulations will depend on the nature of the change and whether it implies training or just informing the involved persons.
- The Occupational Health and Safety Act of 1993 (OHSA) provides for the health and safety of persons at work and when using plant and machinery.
- The act specifies regulations that employees and employers must comply with.
- The quality of fruit must be evaluated on a regular basis to ensure that fruit complies with minimum standards of different markets.
- Shortcomings in quality must be identified and the reason investigated.
- Where necessary production, packing, transport or handling practices must be adjusted to ensure better quality fruit.
- Any adjustments made to practices must be monitored and recorded to ensure their effectiveness.

8. <u>Postharvest Factors</u>

- Careful postharvest treatment is essential to minimise injuries to fruit and therefore preserve shelf-life.
- Attributes including freedom of decay, shelf-life and presentation are determined to a large extent by the effectiveness of the packhouse operation.

- In the packhouse, spot checks must be done to ensure that all equipment is in a good working order and sound condition to prevent injury to fruit.
- A hygiene and food safety risk analysis encompassing farming practices should be carried out prior to the packing season.
- A handy system for performing a risk analysis and for implementing health and safety management is to do a hazard analysis, identify critical control points, establish critical limits, monitor implementation, and measure outcomes.
- A hazard analysis and identification of associated control measures may identify needed modifications to a process or product so that product safety is further assured or improved, and it provides a basis for determining critical control points.
- Critical control points (CCPs) in monitoring the process are then established and are located at any step where hazards can either prevented, eliminated or reduced to acceptable levels.
- The next step is to establish critical limits for each critical control point.
- Monitoring is a planned sequence of observations or measurements to assess whether a CCP is under control and to produce an accurate record for future use in verification.
- Application of health, safety and welfare issues should be a culture on any farm and packhouse handling citrus for local and export markets.

Agrochemicals Agrochemicals are all chemical substances utilised in pre- and postharvest processes to produce horticultural products for fresh consumption. Agrochemicals include substances for soil preparation, fertilisers, and crop protection and postharvest chemicals.
Alien (Exotic) Species Alien species, also referred to as exotic species, are fauna and flora that did not originate from the region or country, but that was brought to that region or country by humans.
Biodiversity Biodiversity means the range of organisms present in a particular ecological community or system, and is measured by the numbers and types of different species.
Bunds Bunds, also called bund walls, are small earthen barriers on agricultural land or dirt roads with slopes ranging from 1 to 6 percent.
Climate Climate is the average weather, usually taken over a 30 year period, for a particular region and time period. Climate is not the same as weather, but is the average pattern of weather for a particular region. Climatic elements include precipitation, temperature, humidity, sunshine, wind velocity, phenomena such as fog, frost, and hail-storms, and other measures of the weather.

Ecosystem An ecosystem is a localised group of interdependent organisms together with the environment that they inhabit and depend on.
Indigenous Species Indigenous species are fauna and flora that originated from and that are typical of a region or country. Certain indigenous species are considered endangered.
Infrastructure Infrastructure refers to services and facilities that support day-to-day economic activity, in this case a citrus production unit.
Invasive Species Around 1% of alien species become problematic to the local ecosystems into which they are introduced. These plants are referred to as invasive species.
Land Capability Land capability classification is a system of grouping land primarily on the basis of their capability to produce common cultivated crops and pasture plants without deteriorating over a long period of time. Land capability classification is subdivided into capability class and capability subclass.
Market The market is a network in which buyers and sellers interact to exchange goods and services for money.
Market Demand Market demand is the total demand or request for a product by all consumers.
Microclimate Microclimate refers to the climate of a small site. It may differ from the climate large of the area due to aspect, tree cover (or the absence of tree cover), or exposure to winds.
Natural Resources Natural resources are the various elements in any given farming environment which will contribute to the production of a quality product on a profitable and sustainable basis, without detrimental effects on the environment.
Soil Fertility Soil fertility refers to the nutrient content of the soil and its resultant ability of the soil to sustain plant growth.
Soil Potential Soil potential refers to the ability of the soil to support plant growth and produce a good quality crop.
Weather Weather is the specific condition of the atmosphere at a particular place and time. It is measured in terms of factors such as wind, temperature, humidity, atmospheric pressure, cloudiness, and precipitation. In most places, weather changes from hour to hour, day to day, and season to season.

Chapter 1

After completing this chapter, the learner will be able to:

Optimise and integrate the natural resources required for the relevant farming systems and enterprises.
Identify and use appropriate technology to determine sustainable farm layout and infrastructure placement.
Research information relevant to the natural resources of a site.

1. Introduction

A citrus farm is a business that has to be planned very carefully for it to succeed. When planning a citrus planting, whether large or small, one has to start with the end in mind, by considering what has to be achieved, or what has to be delivered to the market, to result in a profitable outcome. The starting point should therefore be reliable market intelligence to determine which types of citrus fruit are in the greatest demand.

The different types of citrus cannot all be grown successfully in the same microclimate. The area which is earmarked for future plantings therefore has to be matched with a product or products which is in demand and can be produced successfully in that area. Once the above has been established, the physical aspects of the area identified for the planting have to be examined carefully. Questions such as the following should then be considered:

- What kind of infrastructure do we need to plan for and build on the farm?
- What are the environmental factors that must be taken into account when deciding on farm layout?
- How do we lay out the farm to cause the least possible environmental impact?
- How do we construct the infrastructure that we need?

As custodians of much of a nation's land, the farming community has many responsibilities, including:

- To provide immediate income from the farming enterprise
- To plan for a long-term income from the farming operation
- To consider the effects of the farming operations on the rest of the society today
- To use the land wisely so that it will still be able to produce for future generations

In the long run, the last responsibility is the most important. From the viewpoint of today's society, the third is most important, while the first and second may be of the greatest importance to the farmer and those dependent on the farming operation for their livelihood. Realistically however, many decisions must necessarily be based on providing immediate income to the farming enterprise. The most obvious reason for operating any business is to make money and to provide income for owner and for the employees of the enterprise.

This means that every decision cannot always serve all the responsibilities of the farmer. The reality is that the farming operation must generate enough income each year to pay operating costs, land lease costs, and machinery and equipment purchases, meet debt payments, cover insurance costs, and maintain farm infrastructure.

While the above costs must be covered each year if the enterprise is to stay in business, the other responsibilities must also be considered in making day-to-day decisions. Extensive investigation and planning therefore has to form the basis of development of any new enterprise and / or planting to ensure that all the responsibilities are considered.

2. Optimising Natural Resources

Optimising natural resources means that resources should be used so that they contribute positively to the outcome of the farming activity. The effect of the climate, soil, water and topography of the farm or land on the required result with the crop has to be considered carefully.

Optimal conditions for one crop or cultivar will not necessarily be the optimal conditions for another. In order to optimise the availability and the effect of natural resources the cultivars and production practices may have to be adapted to the specific circumstances.

If we look for example at the subtropical climate in the Lowveld of Limpopo and Mpumalanga, we find that high quality grapefruit and Valencias that is early in the market can be produced here, but that skin colour development in early varieties of navels and easy-peelers can be a problem with the high night temperatures in autumn and early winter. In summer rainfall areas, we find prolific shoot growth and tree canopy development, but trees are prone to diseases, such as citrus blackspot, which disqualifies it for export to certain markets. In winter rainfall areas on the other hand, high quality easy-peelers, navel and valencia types can be grown for later marketing, but the risk of rainfall in the harvesting period and high potential for development of postharvest decay remains the challenge.

3. Developing a Land Use Plan

Land-use planning is important to mitigate the negative effects of land use and to enhance the efficient use of resources with minimal impact on future generations. Land-use planning is defined as a systematic assessment of land and water potential, alternatives for land use, and the economic and social conditions. Each type of land use has a varying effect on the hydrologic cycle, thereby affecting the people and the natural resources on a landscape. A watershed perspective can be used to scientifically study the effect of land use on water and downstream ecosystems.

Watershed

A watershed is defined as a topographically delineated area drained by a stream system, being the total land area above some point on a stream or river that drains past that point.

A watershed acts as a receiver, collector, and conveyer of precipitation on a landscape. Land uses affect these pathways by altering surface runoff and groundwater infiltration, thereby changing the quantity and quality of water resources.

Natural vegetation, such as forest cover, is usually the most benign of land uses, with higher infiltration and reduced runoff rates. The opposites of forest cover are urbanised areas, where large surface areas are impermeable, and pipes and sewer networks augment natural channels. The impervious surfaces in urban areas reduce infiltration and can reduce the recharge of groundwater. In addition, urban runoff contributes to poor water quality.

Agricultural activities are major forms of land use. Cropping activities involve soil and water manipulation through tillage and irrigation, thereby affecting runoff water and groundwater resources. If improperly used, fertiliser and plant protection chemicals in agricultural operations can affect water resources and ecosystems.

3.1. Land-Use Legislation

When compiling a land use plan, it is important to consider the legislation which may affect the activities to establish a citrus farm or planting. The following are some of the legislation applicable to farm or orchard development, followed by information on the scope of the legislation:

The National Environmental Management Act (NEMA) 107 of 1998

- Duty of care and remediation of environmental damage
- Protection of workers refusing to do environmental hazardous work
- Control of emergency incidents
- Access to environmental information and protection of whistleblowers
- Legal standing to enforce environmental laws
- Private prosecution

The Environment Conservation Act 73 of 1989

- Prohibiting of littering
- Waste management
- Prohibition of undertaking of identified activities

Conservation of Agricultural Resources Act (CARA) 43 of 1983

- Control of weeds and invader plants
- Cultivation of virgin soil
- Utilisation and protection of cultivated land
- Irrigation of land
- Prevention or control of water logging or salination of land
- Utilisation and protection of vleys, marshes, water sponges, water courses and water sources
- Regulation of the flow pattern of runoff water
- Utilisation and protection of vegetation
- Prevention and control of veld fires
- Restoration or reclamation of eroded land or land which is otherwise disturbed or denuded
- Construction, maintenance, alteration or removal of soil conservation works or other structures

Under CARA the State may create schemes, which may provide financial assistance to land users. Subsidies may be established in respect of anything that furthers CARA's objectives, including:

- Construction of soil conservation works

- Reparation of damage caused by flooding or natural disasters to natural agricultural resources or soil conservation works

- Reduction in the number of animals kept on land to restrict detrimental effect of drought on land

- Restoration or reclamation of eroded, disturbed, denuded or damaged land

- Planting and cultivation of particular crops to improve soil fertility or counteract soil erosion

- Combating weeds or invader plants

National Forests Act 30 of 1998

- Natural forests must not be destroyed save in exceptional circumstances where a proposed new land is preferable in terms of its economic, social or environmental benefits

- A minimum area of each woodland type should be conserved

- Forests must be developed and managed in a manner that conserves biological diversity, ecosystems and habitats

National Water Act 36 of 1998

- Prevention and remedying effects of pollution

- Control of emergency incidents
- Water use
- Permissible water use
- Controlled activity
- Offences

The Occupational Health and Safety Act 85 of 1993

- General duties of employers to their employees
- General duties of employers regarding articles and substances for use at work
- Duty to inform
- General duties of employees at work
- Report to inspector regarding certain incidents

3.2. Purpose of Land-Use Plans

Land-use planning can help coordinate various land uses in a watershed, thereby minimising conflicts and sustaining water quantity and quality for future generations. The main objective of this planning process is to allocate land uses to meet the needs of people while safeguarding future resources.

The planning process is iterative (cyclically repetitive) and continuous, and three goals are used to develop a plan, being:

- **Efficiency** in land use is achieved by matching different land use with areas that will yield the greatest benefit at the least cost.

- **Equity** in land use focuses on reducing inequalities in income, food security, and housing.

- **Sustainability** in land use meets the needs of the present while conserving resources for future generations.

Land-use planning aims at achieving a balance among these goals through the use of information on trade-offs, appropriate technology, and consensus-based decision-making. Effective land-use planning often involves local communities, scientific information on land resources, appropriate technologies, and integrated evaluation of resource use.

3.3. Land-Use Planning Actions

Planning well ahead is a prerequisite for establishment of sustainable plantings. Planting material must be ordered at least eighteen months prior to the intended planting date. Contractors are not always readily available in all the areas to do earth moving and soil preparation and getting the right contractor for each operation can be a problem.

Planning a planting is a multi-disciplinary operation which must be coordinated well for ultimate success. The actions set out below are just an indication of what can be involved, as the list of actions will differ from project to project.

3.3.1. Establish Goals and Baselines

The start of the planning process is to set goals and baselines. These are set not only for the planting, but also for the planning process itself, as can be seen from these examples:

- A ten hectare planting of Valencia oranges in two years from date
- Irrigation supply must be linked to present system
- Orchard to be established with minimum damage to indigenous vegetation
- Storm water and irrigation runoff to be channelled to natural water courses
- Draw up preliminary business plan before end of October

These goals and baselines form the foundation for all decisions with regard to land-use, and guide the planning process.

3.3.2. Determine Land Suitability

Now that the goals and baselines are in place, the suitability of the land for the intended land use can be determined.

In the level 4 learning material we discussed in detail the manner in which a land suitability study should be conducted. The first step would be to conduct such a study within a period of six months. Once the suitability analysis is done, a problem analysis should be conducted within three months.

3.3.3. Establish Priorities and Alternatives

Immediately after the problem analysis has been completed, priorities and alternatives can be assessed, taking into account the goals and baselines that were established. Priorities are informed by goals, and alternatives are evaluated and the best options are identified. An action plan is drawn up to achieve the planting target.

3.3.4. Develop a Land-Use Plan

With all this information in hand, a land-use plan can be formulated. This plan must contain all the information about the project goals and gathered during the land suitability study.

Remember that the land-use plan must clearly show how orchard will be laid out utilising the terrain and soil characteristics, how storm water and runoff water will be handled, and how drainage will be used to cut off underground seepage, and must take into consideration indigenous vegetation.

3.3.5. Inventory and Organise Resources

At this point the business plan is finalised and a list of required resources and vendors to support development of project, along with a time schedule, can be drawn up. Consultants will assist with the designs and recommendations for soil preparation, the irrigation system, and so on.

The physical actions of orchard layout and establishment are planned and carried out, while being carefully managed and adjusted when necessary.

3.4. Technology and the Land-Use Plan

New ways of effective land-use planning include information management through the GIS, the use of GPS, computer simulations and spatial-temporal data modelling on present land use, alternative scenarios projections, and the assessment of consequences.

Land-use planning is becoming complex and multidisciplinary as planners face multiple problems that need to be addressed within a single planning framework. Such problems include non-point source pollution, water allocation, urbanisation, ecosystem deterioration, global warming, poverty and unemployment, deforestation, farmland deterioration, and low economic growth.

The GPS, or the Global Positioning System, is a high-tech shortcut to the goal that surveyors and navigators have long sought by slower, less accurate means, namely precise knowledge of one's location. GPS is a system of twenty-four satellites that allows the coordinates of any point on or near Earth's surface to be measured with extremely high precision.

The satellites of the GPS are arranged evenly around the Earth so that at least four are visible at all times from any point on the planet's surface. As one satellite sinks below the horizon at one point, another always rises at another point. A special GPS receiver unit, usually handheld, is used to receive signals broadcast by the GPS satellites and to compute its location from those signals

The coordinates supplied by a GPS receiver must be matched to other data to be meaningful. A GPS receiver relays where something is located, but a human operator must specify what that something is, for example a rainfall measurement or a geographical object.

GIS stands for geographic information systems and is a computer system that can be used for scientific research and for water planning and management. This technology integrates powerful computing capabilities with the unique visual perspective of a good old-fashioned map.

GIS is utilised in as many industries possible to link and compare different kinds of data. For example, information about a river network or watershed can be compiled using GIS. A watershed represents the landscape view of water resources, and the effects of spatial patterns of soils, land use and land cover can be studied.

Combining topography with vegetation and soil type, for example, may help hydrologists understand how water drains from a given landscape, and thus enable them to predict flooding or pollution transport. GIS makes it possible farmers, water resource managers, and many other users to handle the vast quantity of information available from remote sensing, GPS, geology, biology, and other sources.

4. Natural Vegetation

Ten percent of all the known plant species in the world can be found in Southern Africa, even though our land surface is less than 1% of the total. We are responsible for caring for a sizeable proportion of the Earth's plant wealth. South Africa is also the only country to totally contain one of the world's six floral kingdoms – the Cape Floral Kingdom (fynbos). One third of South Africa's plant species occurs in this kingdom.

As primary land users, farmers' responsibility towards conserving this rich diversity is immense – it is land users' duty to document and conserve our biological diversity. But 24,000 different plant species are too many to cope with. We need to simplify the task somewhat so that we can appraise how effectively we are looking after our biological diversity and what we still need to do to conserve it.

4.1. Conservation

Conservation is the wise use of resources so that they will remain available for our and our progeny's use and enjoyment in the future. Conservation embraces any progress and development which increases human betterment, provided that we do not destroy our environment. We thus need to carefully ensure that urbanisation, agriculture and other land-uses do not lead to irreversible losses of our rich diversity.

For any intelligent tinkering, the first and most important step is to note what all the pieces are. When we know what we are working with and how it is put together, we can start figuring out how it works and how much we can use it before it breaks.

A brief summary of our biodiversity resources is provided in table 1.1. Note that these are not evenly distributed throughout the region. The Eastern Cape has the most biomes and vegetation types, the Western Cape has the most plant species, the Limpopo Province has the most mammal, reptile and bird species, and KwaZulu-Natal has the most amphibian species.

Even though it is important that all provinces manage their resources, a national and sub-regional (Southern African) perspective and goals must also be determined. Therefore, if a particular vegetation type occurring in both the Free State and Lesotho is adequately conserved in the latter, then Free State can concentrate its conservation efforts in another of its vegetation types.

Province	Biomes*	Acocks' Veld Types	Number of Species				
			Plant	Mammal	Bird	Amphibian	Reptile
Eastern Cape	7	29	6,164	156	384	51	57
Free State	3	17	2,984	93	334	29	47
Gauteng	2	8	3,303	125	326	25	53
KwaZulu-Natal	4	19	6,141	177	462	68	86
Mpumalanga	3	15	4,782	160	464	48	82
North-West	2	11	3,025	138	384	27	59
Northern Cape	6	18	5,067	139	302	29	53
Limpopo Province	3	14	4,236	239	479	44	89
Western Cape	6	18	8,925	153	305	39	52

Table 1.1: Biodiversity Values for Provinces of South Africa (Source DEA&T, Pretoria)

Biomes

Biomes are major ecological communities, and represent a division of the world's vegetation that generally correspond to a particular climate and are characterised by certain types of plants and animals, for example tropical rain forest or desert.

Conservation of larger natural areas in South Africa is both a national (National Parks) and provincial (Nature Reserves) function. The Rio Convention proposes that we set aside at least 10% of each vegetation type for pristine or near-pristine use. The only pristine uses we have in South Africa are the nature reserves and conservation areas.

It is important to note that many other uses are as good as 'pristine'. For example, game farming and cattle ranching on savannas and grasslands can be sustainable as an agricultural enterprise and still conserve our plant species.

Conservation areas are therefore not the entire picture of conservation in South Africa, but they give us a good window on which vegetation types require urgent action. Only when we know the threats to our biodiversity, can we prioritise protecting it.

The National Environmental Management Act (NEMA), the Environment Conservation Act, and the Conservation of Agricultural Resources Act (CARA) that are discussed in more detail in a previous section, have specific bearing on the conservation on agricultural land. The stipulations of these acts must be taken into account when a new enterprise is planned and developed.

4.2. Identifying Natural Vegetation

Natural vegetation differs between areas – it is important that the natural vegetation of an area that is intended for development is identified when compiling the land-use plan. There are two types of vegetation which one should be aware of in terms of agriculture, being **indigenous** and **alien**, or exotic, vegetation.

4.2.1. Indigenous Vegetation

Indigenous species are fauna and flora that originated from and that are typical of a region or country.

Generally, the indigenous vegetation types in citrus production areas are as follows:

- Western Cape – Fynbos and Renosterveld
- Eastern Cape – Grassland and Savannah
- KwaZulu-Natal – Savannah and Bushveld
- Mpumalanga – Savannah and Bushveld
- Limpopo – Bushveld

All land-users, and especially farmers, have a responsibility of maintaining indigenous flora as far as possible and eradicating invasive plants. The indigenous veld types in the citrus growing areas are just a few of the more than 70 occurring in South Africa, all typical of the specific area where they are found and thriving in the conditions and micro-climate of that area. The ecosystem supporting each of these veld types can easily be disturbed by injudicious actions in the development of a farm which would alter one or more of the basic elements supporting it.

An example is Renosterveld, which is a type of fynbos occurring only on the lowlands of the Western Cape. It is part of the Cape Floral Kingdom, the smallest of the world's six plant kingdoms. Of the total area originally covered by this unique vegetation, less than 4% remains today, virtually all on privately owned land.

Renosterveld is rich in plant species, many of which are endemic and occur nowhere else in the world. In addition, many species are extremely rare and threatened. The conservation of these plant species is a valuable contribution to the greater preservation of biological diversity.

Renosterveld is of international botanical importance and the existence of this veld type and the habitat it provides is dependent on the preservation of sufficient areas thereof. The precarious conservation status of the threatened geometric tortoise, which occurs only is this veld type, is a good example of the close ties animals have with their habitat.

4.2.2. Alien (Exotic) Vegetation

Alien species, also referred to as exotic species, are fauna and flora that did not originate from the region or country, but that was brought to that region or country by humans for their beauty, economic value, or for an ecological purpose.

Only around 1% of alien species become problematic to the local ecosystems into which they are introduced. These plants are referred to as **invasive** species. Invasive plants normally do not have natural enemies in their new environment, and therefore tend to proliferate, competing with indigenous vegetation for resources.

Legislation that pertains to the control of invasive species forms part of the Conservation of Agricultural Resources Act, 1983 (Act No 43 of 1983) (CARA). Regulations 15 and 16 under this Act, which concern problem plants, were amended during March 2001. Whereas CARA previously classified problem plants into two groups – declared weeds and plant invaders – the amended regulations make provision for four groups, being:

- Category 1 declared weeds
- Category 2 plant invaders
- Category 3 plant invaders
- Indicators of bush encroachment

The first three groups are undesirable alien plants and are covered by regulation 15. Bush encroachers are indigenous plants that require sound management to prevent them from becoming problematic and are covered separately by regulation 16.

4.2.2.1. Category 1 Declared Weeds

Category 1 plants are prohibited that will no longer be tolerated, neither in rural nor urban areas, except with the written permission of the executive officer or in an approved bio-control reserve.

These plants may no longer be planted or propagated, and all trade in their seeds, cuttings or other propagative material is prohibited. They may not be transported or be allowed to disperse.

4.2.2.2. Category 2 Plant Invaders

Category 2 plants have the proven potential of becoming invasive, but nevertheless have certain beneficial properties that warrant their continued presence in certain circumstances.

CARA makes provision for Category 2 plants to be retained in special areas demarcated for that purpose, but those occurring outside demarcated areas have to be controlled. Category 2 plants may also be retained or cultivated in biological control reserves, where the plants will serve as host plants for the breeding of biological control agents.

The growing of Category 2 plants in a demarcated area qualifies as a water use, and is subject to the requirements of section 21 of the National Water Act, 1998 (Act No. 36 of 1998).

4.2.2.3. Category 3 Plant Invaders

Category 3 plants are undesirable because they have the proven potential of becoming invasive, but most of them are nevertheless popular ornamentals or shade trees that will take a long time to replace. A few of them were placed into this category instead of into category 1 because they do not cause problems in all situations.

In terms of Regulation 15 of CARA, Category 3 plants will not be allowed to occur anywhere except in biological control reserves, unless they were already in existence when these regulations went into effect. The conditions under which these existing plants may be retained are that they do not grow within 30 meters of the 50-year flood line of watercourses or wetlands, that all reasonable steps are taken to keep the plant from spreading, and that the executive officer has the power to impose additional conditions or even prohibit the growing of Category 3 plants in any area where he has reason to believe that these plants will pose a threat to agricultural resources.

4.3. Preventing Damage and Destruction of Natural Vegetation

When a citrus farm is developed it is important to identify all actions which could endanger the natural ecosystem and to develop an action plan with the help of soil conservation specialists or the Department of Agriculture, Forestry and Fisheries. Examples of measures that can be taken are the following:

- Use renosterveld for grazing and conserve it at the same time by leaving sections unploughed, preventing over-grazing, applying correct veld-burning practices, controlling invasive plants, and using fertilisers and poisons correctly.
- Identify sensitive areas and rare plant species on your property which ought to be conserved.
- Identify threats to sensitive veld and take measures to ensure its survival.

- Have threatened areas declared private nature reserves, natural heritage sites or sites of conservation importance. This will increase the conservation status of the land.

- Establish a conservancy with neighbours, allowing the farmer to take care of sensitive land areas without it being legally binding.

- In identifying the areas in which to establish the citrus orchards, ensure that the necessary actions will not endanger the ecosystem.

5. Weather Patterns

There are a variety of internet sources for obtaining information about the past and current weather patterns of a specific area. One such source is www.155.240.219.9/agric/ver1 and another is the South African Weather Bureau, at www.weathersa.co.za. To establish which weather station is the closest to the farm, the exact geographical position of the farm should be known. Accurate positioning of individual points on the earth's surface is made possible by reference to the geometrical system of latitude and longitude.

Latitude parallels are drawn west-east around the earth and numbered by degrees north and south of the equator, which is designated as 0° latitude. Longitude meridians are drawn north-south and numbered by the degrees east and west of the prime meridian, 0° of longitude, which passes through Greenwich in England.

By referring to these coordinates and their sub-divisions of minutes, which is 1/60th of a degree, and seconds, which is 1/60th of a minute, any place on earth can be located to within a few hundred yards. The GPS technology as discussed in this chapter is used for this purpose. For example, Bien Donne Research station in the Western Cape is situated at minus 33.84° latitude and 18.98° longitude and is 119 metres above sea level.

The type of climatic information which is required for enterprise selection and planning for as long a period as possible is the following:

- Average, maximum and minimum temperatures
- Chances of rain with possible precipitation
- Radiation
- Relative humidity
- Wind direction and speed
- Evapotranspiration

All the above are available on an hourly, daily, monthly and yearly basis and the information can be accessed at all times.

Interpretation of long, medium and short term forecasts plays an important role in planning production activities on a citrus farm. The projected effect of global warming on the various citrus production areas may influence the investment decision on where to develop a citrus production unit. Long term forecasts on yearly weather patterns and rainfall as provided by the SA Weather Bureau are normally used for planning and allocation of water for irrigation. Medium term forecasts for one to two weeks are also available from the Weather Bureau as well as from a few private agencies.

6. Optimising Soil Characteristics

Conserving the soil that is used in an agricultural enterprise is central to containing the impact that crop production has on the environment. In the level 2, 3 and 4 learning material for Enterprise Selection, Planning and Establishment the manner in which soil is surveyed, sampled and prepared before planting, and managed, maintained and conserved after planting, is discussed in great detail. In addition, the learning material on Plant Nutrition and Soil Management contain even more detailed information on these aspects. In this section, we will revise shortly the aspects that should be included in soil management.

As part of this planning process soil maps are prepared that indicate soil types, defined by the physical and chemical properties of the soil. The aim of a soil survey is to determine the degree to which a given profile deviates from the requirement, what must be rectified, and how this can be done. The soil survey must be done by experienced soil scientists and the report and soil map include a recommendation on soil preparation for planting. During the survey, the following are noted and recorded for each section of the area:

- Appearance, nature, depth and thickness of layers
- Restricting layers in the upper 100cm
- Stones, gravel, concretions and compaction
- Internal drainage and symptoms of poor drainage
- Lateral movement of clay water and salts
- Parent material
- Root depth
- Structure

Soil samples for chemical analysis are taken in conjunction with the soil survey. From this analysis, physical characteristics such as soil texture and strength are determined, and it can be determined whether any chemical ameliorants should be applied during soil preparation to optimise the soil for tree development and production.

Land preparation techniques are selected with the aim of maintaining the soil structure and avoiding soil erosion. Soil preparation, or profile modification, is an expensive process that can only be justified by an increase in production and the extension of the economic life of an orchard. Chemical and physical profile modification includes elements such as homogeneity, depth, bulk density, air content, pH, phosphorous and cations.

The soil profile must be modified in such a way that a homogenous layer is created. Differences in texture must be removed by mixing, and differences between consecutive layers can be made more acceptable for root penetration through partial mixing. The cultivation depth, for citrus, should be between 60cm and 70cm so that the effective root depth will be at least 50cm after the soil has settled again. The chemical conditions in the profile can also be rectified most effectively during soil preparation.

Following proper soil preparation, it is important that the soil quality be maintained throughout the productive life of the orchard. The quality has to be monitored regularly to ensure that the aim of the grower of a high yielding, quality crop that meets the requirements of the end user is met.

Fertiliser recommendations, made by trained and experienced scientists, are based on leaf analysis, supplemented by soil analysis and orchard information on tree growth, crop size and fruit quality. Fertilisers in citrus production are commonly applied in a range of different forms using a number of methods according to specific management needs. Choosing the correct formulation is important to match the selected application method.

Soil degradation includes physical, chemical and biological deterioration. Examples are loss of organic matter, decline in soil fertility, decline in structural condition, erosion and increasing acidity. These possibilities should be adequately addressed during the early planning stages and the necessary precautionary measures identified. For instance, two soils with identical soil characteristics can occur in completely different topographic landscape positions, e.g. level as opposed to steep. Because the two soils will differ in erodibility, they are not equally suitable for agriculture. A basic set of principles can be used to minimise soil degradation and achieve erosion control in tree crops, being:

- Provide maximum soil surface protection via ground covers or mulch
- Minimise the length of time that soil is left bare
- Rapidly re-vegetate or mulch bare areas
- Control runoff water from flowing over bare ground
- Convey runoff across slope at designed intervals
- Convey water down slope in the grassed or shaped inter-rows

7. Optimising Water Quality

In the level 2, 3 and 4 learner guides that form part of this series we looked at various aspects pertaining to water quality management. In addition, the Citrus Academy learning material on Water Quality and on Irrigation contains exhaustive information on these aspects, and the specific management practices that are employed.

When integrating water quality and irrigation requirements into the overall planning and management of a citrus planting, several matters bear repeating. There are three major critical control points in a water supply system, being:

- Where the water is received on the farm
- Where the water is used
- Where the water leaves the farm

The quality of water at each of these points is usually determined by assessing the physical and chemical water quality factors. Physical water quality factors are determined by the foreign material not dissolved in water, while chemical water quality factors refer to the non-visible qualities of water.

In citrus production large volumes of water are used and water quality requirements are neither extremely specific nor extremely critical to successful production. Quality management focuses on measuring and monitoring water quality.

GlobalGAP also requires controlled and monitored use of irrigation water. Good agricultural practices related to water quality include:

- Scheduled irrigation
- Preventing soil salinisation
- Avoiding excessive leeching
- Storm water control in heavy rainfall areas
- Managing water tables
- Restoring or maintaining wetlands

The water quality management system on a citrus farm has to address the following aspects:

- **Evaluation of the quality of the water received on the farm:**
  Where and when do I take water samples for analysis?
  Which water quality factors are suboptimal?
  Which water quality factors can be improved?
  What precautions are required?

- **Evaluation of the seasonal variation in water quality:**
  To what extent do seasonal fluctuations influence the requirements for the water quality management system?

- **Development of systems to improve the quality where possible:**
  Filtration is required for almost all water. Is a pre-filtration process, such as a settling dam, required to remove excessive suspended solids?

- **Setting up systems to minimise the impact of those water quality factors that cannot be improved economically:**
  How do I deal with a high sodium concentration in the water?
  What is the leaching requirement?
  Do I need to acidify the water used for foliar sprays?

- **Monitoring water quality:**
  Is the filtration adequate?
  Are the systems that have been set up to minimise the impact of water quality factors that cannot be improved having the desired effect?

Is there a recordkeeping system in place to record the analytical data required to monitor the water quality factors over time, including such data as the level of sodium and salts in the soil?

- **Evaluate and monitor the quality of the water leaving the farm:**
  Where do I sample the out-going water?
  How are the results of the analyses recorded?

Summary

Chapter 1

- Extensive investigation and planning has to form the basis of development of any new enterprise and / or planting to ensure that all the responsibilities are considered.
- Optimising natural resources means that resources should be used so that they contribute positively to the outcome of the farming activity.
- Land-use planning is defined as a systematic assessment of land and water potential, alternatives for land use, and the economic and social conditions.
- When compiling a land use plan, it is important to consider the legislation which may affect the activities to establish a citrus farm or planting.
- The planning process is iterative (cyclically repetitive) and continuous, and three goals are used to develop a plan, being efficiency, equity, and sustainability.
- Land-use planning involves establishing goals and baselines, determining land suitability, establishing priorities and alternatives, developing a land-use plan, and the inventory and organisation of resources.
- New ways of effective land-use planning include information management through the GIS, the use of GPS, computer simulations and spatial-temporal data modelling on present land use, alternative scenarios projections, and the assessment of consequences.
- As primary land users, farmers' responsibility towards conserving this rich diversity is immense.
- It is important that the natural vegetation of an area that is intended for development is identified when compiling the land-use plan.
- All land-users, and especially farmers, have a responsibility of maintaining indigenous flora as far as possible and eradicating invasive plants.
- When a citrus farm is developed it is important to identify all actions which could endanger the natural ecosystem and to develop an action plan with the help of soil conservation specialists or the Department of Agriculture, Forestry and Fisheries.
- Interpretation of long, medium and short term weather forecasts plays an important role in planning production activities on a citrus farm.
- Conserving the soil that is used in an agricultural enterprise is central to containing the impact that crop production has on the environment.
- There are three major critical control points in a water supply system, being where the water is received on the farm, where the water is used, and where the water leaves the farm.
- The water quality management system on a citrus farm has to address the evaluation of the quality of the water received on the farm, the evaluation of the seasonal variation in water quality, the development of systems to improve the quality where possible, setting up systems to minimise the impact of those water quality factors that cannot be improved economically, monitoring water quality, and evaluating and monitoring the quality of the water leaving the farm.

Practical

Complete activities 1, 2 and 3 in the **Learner Workbook**.

Chapter 2

After completing this chapter, the learner will be able to:

Implement necessary conservation and natural resource management and harvesting practices.

1. Introduction

When planning a conservation and natural resource management strategy, the overall goal should be to optimise productivity and sustainability of resources, thereby bringing about greater productivity, food security, job creation and better quality of life for all. Natural resource management should bring improvement, optimal utilisation and conservation of our natural resources through the actions of its people, resulting in sustainable agriculture and better quality of life.

It must foster a resource conservation ethic, resulting in a nation motivated and empowered to care for the environment, so that the environment remains productive and can contribute optimally to the socio-economic growth of the country.

2. Soil Conservation Plans

The design and installation of a good drainage system to conserve soil by lessening the effect of erosion requires information on soils, crops, climate and topographical field data. Once the system has been installed, the plan needs to be updated to show the system as built. The drainage plan should be passed on to subsequent landowners.

A drainage plan provides step by step information on how to construct and install a complete land drainage system. The plan includes information on:

- Best possible outlet location (without a topographical survey the best outlet location is not always obvious);
- Location, size, depth, spacing and slope of all open ditches and subsurface drains;
- Location of all pertinent obstructions, such as buildings, trees, fences, gas, oil, water, telephone and transmission lines;
- Upland and surface runoff considerations;
- Backfilling, blinding and outlet requirements; and
- Unusual construction problems

A project plan enables the drainage contractor and designer to lay out the drainage system in the most cost effective way. The plan also allows for evaluation of materials required and anticipated projects costs. Specifications, design standards and work schedules as set out on a plan form the basis of any contractual agreements between the installation contractor and the farmer.

The plan provides a record for future reference and is useful for other development work such as planning crop rotation, land levelling and irrigation.

As a first step existing maps of the problem area should be obtained. Aerial photos are often useful preliminary assessment tool of the problem and can be used to plan a survey strategy. Visual observations of field conditions and location of poorly drained areas should be done when the problem is evident.

The next step is to conduct a soil survey. A soil survey is required to determine:

- The drainage need;
- The type of drainage system (surface or under-drainage);
- The sub-drain spacing and depth requirements;
- Construction methods and materials for special soil conditions; and
- Post-construction management requirements

A soil base map can then be prepared showing land boundaries, roads, creeks and other landscape features. On the map soil boundaries and profile pits should also be shown.

Profile pits should be 0.5 m wide and 1 m deep. The purpose of the pit is to determine hydrologic properties of the soil. A brief description of the profile pit data and soil survey reports should be included with the soil survey base map. The number of pits should be sufficient to make a reliable assessment of all pertinent drainage features.

A topographic survey, showing important elevations and key physical features of the property, used in conjunction with soils and groundwater information enables the designer to layout the drainage plan by identifying the natural drainage plan. Before beginning the survey, locate existing and potential property boundaries. Other factors that must be taken into account in the survey are:

- Topographic surveys should be conducted on a 30 m grid;

- The plan should be drawn with 0.5 m contour lines. On steep slopes, 1m to 2m contours may suffice while 0.25 m contours may be required on level fields.

- Good vertical accuracy is required because of the low grades on agricultural land.

- A permanent bench mark must be established on concrete footings of existing buildings or a new bench mark stake set.

- The topographical survey should include fence lines, ditch bottoms and water levels at regular intervals, culvert inverts and diameters, power poles, farm roads and gates, farm buildings, rock outcroppings, trees and any other pertinent obstacles.

3. <u>Alternative Water Harvesting – Rainwater Harvesting and Micro-Catchment</u>

Rainwater harvesting implies collection and storage of the rainy season precipitation that would have seeped into soil or run off into stream channels. It is an old technique that was probably developed as long ago as 4,500BC.

Extensive rainwater harvesting apparatus existed 4,000 years ago in the Palestine and Greece. In ancient Rome, residences were built with individual cisterns and paved courtyards to capture rainwater to augment water from city's aqueducts. As early as the third millennium BC, farming communities in Baluchistan and Kutch impounded rainwater and used it for irrigation dams.

Although earlier rainwater harvesting systems were designed primarily to meet domestic needs for water, in recent decades scientists in many countries such as Sub-Saharan Africa, the Middle East and Southeast Asia, and especially India, have made efforts to design and develop a wide variety of techniques to collect, store, and use natural precipitation for agricultural purposes.

However, to be successful, the RHA system needs to be integrated with a comprehensive agricultural management system. This means that the management of RHA should be combined with other agricultural technologies and management practices including water and conservation measures, crop management, and soil fertility management.

3.1. Rainwater Harvesting (RHA) Benefits

The efficient harvesting of rainwater can have several benefits to the land user:

- It is a relatively clean and readily available source of water
- The total control and proximity of the water supply
- It is socially acceptable and environmentally responsible
- It promotes self-sufficiency and helps to conserve water
- Rainwater is friendly to landscape plants and gardens
- It reduces storm water runoff and therefore erosion
- It can solve drainage problems
- It uses simple technologies that are easy to maintain
- Potential cost savings especially with rising water costs

In the planning stage, the planner must, along with checking the sequence of priorities, also consider alternative sources of water. These must be compared with water harvesting in cost and in the risk involved. The comparison must take into account the water quality required, operational and maintenance considerations as well as the initial cost. Where alternative water is of better quality, is cheaper to develop, easier to obtain or involves less risk, it should be given priority. An example of this is the development of springs or shallow wells for micro-scale irrigation instead of rainwater harvesting.

The amount of earth or stonework involved in construction directly affects the cost of a scheme or, if it is implemented on a self help basis, indicates how labour intensive its construction will be. A water harvesting scheme will only be sustainable if it fits into the socio-economic context of the area and also fulfils a number of basic technical criteria.

The ground slope is a key limiting factor to water harvesting. Water harvesting is not recommended for areas where slopes are greater than 5% due to uneven distribution of runoff and large quantities of earthwork required which will affect the economical viability of the process.

Soils should have the same attributes of soils that are suitable for irrigation. Soils should be deep, not be saline or sodic and ideally possess inherent fertility. A serious limitation for the application of water harvesting is soils with a sandy texture. If the infiltration rate is higher than the rainfall intensity, no runoff will occur.

3.2. Rainwater Harvesting Techniques

Apart from conventional storage of rainwater in dams and distribution through rivers, canals and pipelines, there are a number of techniques which were developed and in use in relatively low rainfall areas in sub-Saharan Africa, India and other parts of the world.

3.2.1. Negarim Micro-Catchments

Negarim micro-catchments are diamond-shaped basins surrounded by small earth bunds with an infiltration pit in the lowest corner of each. Runoff is collected from within the basin and stored in the infiltration pit.

Micro-catchments are mainly used for growing trees or bushes. This technique is appropriate for small-scale tree planting in any area which has a moisture deficit. Besides harvesting water for the trees, it simultaneously conserves soil. Negarim micro-catchments are neat and precise, and relatively easy to construct.

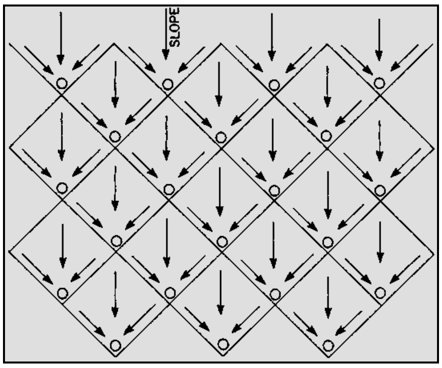


Figure 2.1: Field Layout for Negarim Micro-Catchments

3.2.2. Bunds

Contour bunds for trees are a simplified form of micro-catchments. Construction can be mechanised and the technique is therefore suitable for implementation on a larger scale. As its name indicates, the bunds follow the contour, at close spacing, and by provision of small earth ties the system is divided into individual micro-catchments.

Whether mechanised or not, this system is more economical than Negarim micro-catchment, particularly for large scale implementation on even land since less earth has to be moved. A second advantage of contour bunds is their suitability to the cultivation of crops or fodder between the bunds. As with other forms of micro-catchment water harvesting techniques, the yield of runoff is high, and when designed correctly, there is no loss of runoff out of the system.

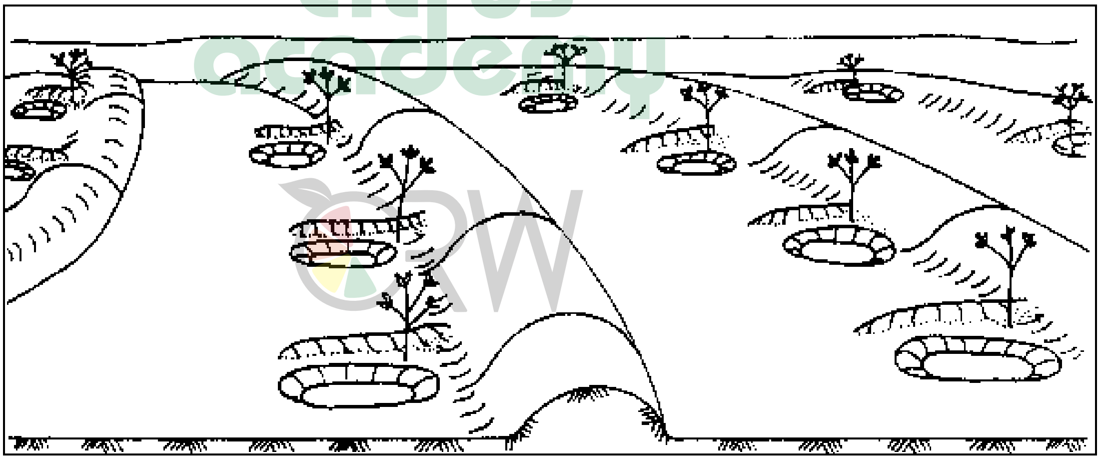


Figure 2.2: Contour Bunds for Trees

Semi-circular bunds are earth embankments in the shape of a semi-circle with the tips of the bunds on the contour. Semi-circular bunds of varying dimensions are used mainly for rangeland rehabilitation or fodder production. This technique is also useful for growing trees and shrubs and, in some cases, has been used for growing crops. Depending on the location, and the chosen catchment cultivated area ratio, it may be a short slope or long slope catchment technique.

Trapezoidal bunds are used to enclose larger areas of up to 1ha and to impound larger quantities of runoff which is harvested from an external or long-slope catchment. The name is derived from the layout of the structure which has the form of a trapezoid. Crops are planted within the enclosed area, and overflow discharges around the tips of the wing-walls.

The general layout, consisting of a base bund connected to wing-walls, is a common traditional technique in parts of Africa. The concept is similar to the semi-circular bund technique. In this case, three sides of a plot are enclosed by bunds while the fourth (upslope) side is left open to allow runoff to enter the field. The simplicity of design and construction and the minimum maintenance required are the main advantages of this technique.

Contour stone bunds are used to slow down and filter runoff, thereby increasing infiltration and capturing sediment. The water and sediment harvested lead directly to improved crop performance. This technique is well suited to small scale application on farmer's fields and, given an adequate supply of stones, can be implemented quickly and cheaply.

Water spreading bunds are often applied in situations where trapezoidal bunds are not suitable, usually where runoff discharges are high and would damage trapezoidal bunds or where the crops to be grown are susceptible to the temporary waterlogging, which is a characteristic of trapezoidal bunds. The major characteristic of water spreading bunds is that, as their name implies, they are intended to spread water, and not to impound it.

Water spreading bunds are usually used to spread floodwater which has either been diverted from a watercourse or has naturally spilled onto the floodplain. The bunds, which are usually made of earth, slow down the flow of floodwater and spread it over the land to be cultivated, thus allowing the water to infiltrate.

3.2.3. Contour Ridges

Contour ridges, sometimes called contour furrows or micro-watersheds, are used for crop production. This is again a micro-catchment technique. Ridges follow the contour at a spacing of usually 1 to 2 metres. Runoff is collected from the uncultivated strip between ridges and stored in a furrow just above the ridges. Crops are planted on both sides of the furrow. The system is simple to construct by hand or by machine and can be even less labour intensive than the conventional tilling of a plot.

The yield of runoff from the very short catchment lengths is extremely efficient and when designed and constructed correctly there should be no loss of runoff out of the system. Another advantage is an even crop growth due to the fact that each plant has approximately the same contributing catchment area.

3.2.4. Permeable Rock Dams

Permeable rock dams are a floodwater farming technique where runoff water is spread in valley bottoms for improved crop production. Developing gullies must be healed at the same time. The structures are typically long, low dam walls across valleys. Permeable rock dams can be considered a form of terraced wadi, though the latter term is normally used for structures within watercourses in more arid areas.

4. Water Runoff Management

A grassed swale is a graded and engineered landscape feature appearing as a linear, shallow, open channel with trapezoidal or parabolic shape. The swale is vegetated with flood tolerant, erosion resistant plants. The design of grassed swales promotes the conveyance of storm water at a slower, controlled rate and acts as a filter medium removing pollutants and allowing storm water infiltration.

When properly designed to accommodate a predetermined storm event volume, a grassed swale results in a significant improvement over the traditional drainage ditch in both slowing and cleaning of water. In swales, storm water is slowed by strategic placement of check-dams that encourage pond to form. These ponds in turn facilitate water quality improvements through infiltration, filtration and sedimentary deposition. Collected storm water is expected to drain away through the soil within several hours or days of collection.

4.1. Placement of Swales

Grassed swales are an appropriate storm water management practice for most regions. Swales are a low cost low maintenance option to remove sediments, nutrients and pollutants. They increase storm water infiltration and add a visually aesthetic component to a site. Establishment of grassed swales is a potential solution wherever storm water needs to be transported from impervious surfaces, slowed down and allowed to infiltrate into soils.

The **volume** of runoff depends on various physical features. Density of vegetation, slope, conditions and composition of the soil as well as the intensity and duration of a given storm event, will all have an effect on runoff. In areas with dense vegetation the soil absorbs rainfall quickly and in most cases entirely. Forested areas typically have less than 10% runoff. The position and number of swales are therefore determined by a combination of all the above factors and can only be determined after a detailed topographic and soil survey in the initial situation analysis.

4.2. Constructing Swales

Before and during the construction of swales certain guidelines and requirements must be followed:

- Accurate grading is essential to the construction of a properly functioning grassed swale.
- Machinery used for excavation and grading should not be driven over the swale site since compaction of soil is likely to occur.
- The swale site should be protected from storm water runoff that will cause erosion and sedimentation during construction.
- Final grading and planting should not occur until the adjoining areas draining into the swale are stabilised.
- Any accumulation of sediments that does occur must be removed during the final stages of grading.
- In dry swales the bottom should be tilled to produce a highly porous surface.
- Installation of erosion control matting or blanketing to stabilize soil during establishment of vegetation is highly recommended.
- In colder climates with short growing seasons of less than five months, the desired level of establishment of vegetation may take two to three growing seasons. Careful employment of erosion control practices must continue for the duration.

4.3. Dry and Wet Swales

The advantages of correctly designed and constructed dry swales are that they:

- Trap and remove sediments and other pollutants and thus improve water quality;
- Reduce peak runoff velocity and promote infiltration;
- Reduce erosion;
- Provide for some groundwater recharge if correctly designed;
- Are favoured for use for treating highway and residential road runoff because of their linear structure;
- Good to use for the replacement of existing drainage ditches; and

- Are less expensive to build and maintain (easy to mow) than a traditional curb and gutter system.

The advantages of the construction of wet swales are that they:

- Can function as linear wetlands;
- Reduce peak flows and runoff velocity and promote infiltration;
- Reduce erosion;
- Are easy to design;
- Can be built in relatively impervious soils or in seasonally saturated soils;
- Trap and remove sediments and other pollutants with increased efficiency and thus improve water quality;
- Create visually appealing and beneficial habitat between uplands and surface waters; and
- Provide the effective pre-treatment of storm water passing through for further processing by additional storm water management practices

4.4. Vegetating Swales

The type of vegetation to cover swales must be carefully selected. The following factors should be taken into account when selecting vegetation:

- Soil conditions;
- **Climate** – plants have to be sufficiently hardy to withstand the most extreme conditions to occur in the local region;
- **Topography** – vegetation must be able to withstand forces created by flowing water; and
- Available sunlight

Selected vegetation must meet the following criteria:

- Have a deep root system or form dense sod to resist scouring;
- Be indigenous to the area;
- Be vigorous growers;
- Have a high stem density to help slow water and facilitate sedimentation; and
- Be tolerant to flooding and be able to survive and continue to grow after the inundation period. Water velocities associated with a two-year design storm should not scour out planted materials, nor should plant leaves be matted down, as this will reduce sediment removal.

4.5. Check Dams

To slow water flow and prohibit erosion of swales, check dams may have to be designed and added to grassy swales. Check dams not only slow water velocity but encourage the forming of ponds of water on the upstream side of each dam, hereby encouraging infiltration of storm water.

The effectiveness of check dams is dependent on these criteria:

- They should be a maximum of 18 inches in height and the height should not exceed half the height of swale bank.
- The spacing will depend on both the longitudinal slope of the swale and height of swale.
- Anchoring of dams is necessary to prevent washout. Each side of the dam needs to extend two or three feet into the swale wall on both sides.
- The downstream side of check dams need to be protected from scour with sufficiently sized rip-rap placed over the geotechnical fabric.
- Check dams should be notched at their top.
- Check dams can be made from wood, concrete, gabions or rip-rap sufficiently sized to withstand the flow of water.

4.6. <u>Other Design Considerations</u>

Additional design considerations for structural components of grassed swales are:

- At the point of inflow into the swale a pre-treatment and sediment collection bay can be designed. The installation of a pre-treatment area contained by a check dam built on a stone base will serve the required function.
- At the end of a dry grassed swale the installation of a check dam can be combined with a pea gravel-filled basin that leads excessive water to the under-drain system. Output from this under-drain must be managed.

<u>Chapter 2</u>

- When planning a conservation and natural resource management strategy, the overall goal should be to optimise productivity and sustainability of resources.
- The design and installation of a good drainage system to conserve soil by lessening the effect of erosion requires information on soils, crops, climate and topographical field data.
- A drainage plan provides step by step information on how to construct and install a complete land drainage system.
- A topographic survey, showing important elevations and key physical features of the property, used in conjunction with soils and groundwater information enables the designer to layout the drainage plan by identifying the natural drainage plan.
- Rainwater harvesting implies collection and storage of the rainy season precipitation that would have seeped into soil or run off into stream channels.
- Rainwater harvesting techniques include Negarim micro-catchments, various types of bunds, contour ridges, and permeable rock dams.
- A grassed swale is a graded and engineered landscape feature appearing as a linear, shallow, open channel with trapezoidal or parabolic shape.
- The design of grassed swales promotes the conveyance of storm water at a slower, controlled rate and acts as a filter medium removing pollutants and allowing storm water infiltration.
- The position and number of swales are determined by a combination of all the above factors and can only be determined after a detailed topographic and soil survey in the initial situation analysis.
- To slow water flow and prohibit erosion of swales, check dams may have to be designed and added to grassy swales.

Practical

Complete activities 4 and 5 in the **Learner Workbook**.

Chapter 3

After completing this chapter, the learner will be able to:

Plan and optimise infrastructural requirements for the relevant enterprise system.

1. Introduction

Infrastructure has a bearing on the practical implementation of all the day-to-day activities on a farm, and is the bare essentials required to operate a commercial farm. Infrastructure must be constructed in such a manner that it is sustainable and a benefit to the farming operation.

Infrastructure can be classified as either external or internal. External infrastructure is mostly the responsibility of other people or bodies beside the farmer, such as Eskom, Telkom, cellular networks, and national and local government. External infrastructure includes electricity supply, communications, access roads and railways to towns, cities and harbours. Internal infrastructure includes structures built, erected or bought on or for the farm to ensure profitable production of high quality crops. Examples are stores and sheds, housing, water storage dams and tanks, roads on the farm, irrigation systems, fencing, vehicles and equipment.

The basis of a decision of whether to plant and develop a citrus farming unit in a specific area will always be the production potential of the farm, with climate, soil and water the most important factors. Infrastructure, although important, will always be a secondary element in the decision-making process.

Although infrastructure will therefore not necessarily be a determining factor in whether to establish a citrus farm, it does play a very important role in the planning process as development off a cost effective infrastructure requires large capital inputs. The medium- and long-term demands in terms of the cost of infrastructure development to produce and handle crops produced by new and replacement plantings, must always be considered carefully. It plays an important role in the cash flow and profits generated by the farm.

Infrastructure supports the production process, and the size of the farm or planned enterprise determines the extent of the infrastructure that is required. A large farm needs a large internal infrastructure to support all the many activities of the production processes. The size may warrant an own packhouse with all the necessary equipment and manpower. A small farm on the other hand needs to make use of more external support, as the extent of its activities may not warrant high expenditure on internal infrastructure.

Parameters used when new or replacement orchards are established on an existing farm includes factors like the utilisation of existing infrastructure, and whether the chosen cultivar will make a contribution to the current cultivar mix.

In level 3 and level 4 the training modules the infrastructural requirements of a new farm is discussed as well as the method used in determining the infrastructural need of a farm or production area. For example, if there is insufficient housing on an existing farm, developing additional housing is a major factor to be considered as it requires substantial capital outlay.

2. Infrastructure Placement

How much of what type of infrastructure we need is the first question that has to be answered when planning for a new farm or the expansion of an existing operation. The next important factor is **where** on the farm this infrastructure should be placed.

In previous chapters and on previous levels we looked at the development of a topographical map of the area that is intended for development. This map forms the basis for many of the planning processes, and also for planning around infrastructure placement.

Good and sufficient housing on a farm is a positive factor. The placement of the houses in relation to the workplace, farm entrance and water courses must be considered carefully with regard to access to water and electricity, transport, security and pollution.

Traffic on a farm normally includes light vehicles for transport and deliveries, heavy vehicles delivering for instance fertiliser or transporting for instance bins with fruit to the packhouse, and farm vehicles traffic like bakkies, tractors and trailers. The safety of movement, types of roads, off-loading and loading areas, and traffic movement on the farm has to be considered. Roads used most often must not run through or adjacent to orchards, because this causes excessive dust on trees and fruit. Entrance to the farm should be controlled to prevent unauthorised entry.

Future needs for expansion of orchards, buildings and other structures must be taken into consideration when developing electricity and water reticulation systems. It must form part of the overall development plan and it is important to include a representative of the body supplying electricity as well as irrigation engineers in the planning phase.

Handling facilities for production and maintenance materials and equipment should be placed strategically and be adequate for its purpose. The location of farm buildings in relation to entrance roads to the farm as well as service roads on the farm has to be planned very carefully.

3. <u>Environmental Degradation</u>

Planning for the placement of infrastructure should follow the initial process of land evaluation and drawing up a land-use plan. The land-use planning is a systematic assessment of land and water potential, alternatives for land use, and the economic and social conditions. Mitigation of the negative effects of land use and enhancement of the efficient use of resources with minimal impact on the environment should be part of overall planning.

Cropping activities involve soil and water manipulation through tillage and irrigation, thereby affecting runoff water and groundwater resources. If improperly used, fertiliser and plant protection chemicals in agricultural operations can affect water resources and ecosystems. Planning for the placement of infrastructure to protect the environment would include the following:

- The development of orchards with consideration to natural environment and topography, the conservation of indigenous plant growth, and the protection of wildlife;
- The establishment of watershed flow patterns, taking into account the possible negative effects of surface runoff to the immediate environment, the effect on downstream ecosystems, and proper storm water control including erosion control measures;
- The design of irrigation systems and supporting structures must take into consideration cost-effectiveness, pump-house placement with relation to electrical and irrigation reticulation network for efficient use of energy, and the handling of backwash water from filters;
- Important factors in the placement of houses and buildings are the strategic placement with regards to farming activities, runoff from storm water as well as from other activities like gardening, washing and cleaning, the storage of chemicals and control of water from cleaning spray carts, and effluent and garbage disposal;
- With farm roads the most important considerations are storm water control, minimising traffic in and around orchards for dust control, and providing easy access to work areas

4. Regulations and Legislation

There are various regulations and legislation that has bearing on the manner in which both external and internal infrastructure is planned, designed, constructed, and utilised. For instance, housing has to conform to health, safety and GlobalGAP requirements, with regard to water supply, electricity, ablution and runoff. Electricity supply to housing, offices, pump-houses and other structures is also regulated. The quality of the reticulation system, as well as wiring in all existing structures, must conform to local governmental standards and safety regulations in the Occupational Health and Safety Act.

Regulations laid down by the national or local authorities must be observed in any of the various infrastructure fields. The following is some of the relevant legislation that is applicable to infrastructure development and maintenance:

The National Environmental Management Act (NEMA) 107 of 1998

- Duty of care and remediation of environmental damage

The Environment Conservation Act 73 of 1989

- Prohibiting of littering
- Waste management

Conservation of Agricultural Resources Act (CARA) 43 of 1983

- Utilisation and protection of cultivated land
- Irrigation of land
- Utilisation and protection of vleys, marshes, water sponges, water courses and water sources
- Regulation of the flow pattern of runoff water
- Utilisation and protection of vegetation
- Prevention and control of veld fires
- Restoration or reclamation of eroded land or land which is otherwise disturbed or denuded
- Construction, maintenance, alteration or removal of soil conservation works or other structures

The Occupational Health and Safety Act 85 of 1993

- General duties of employers to their employees

Apart from the above, there are a number of regulations which are governed by local authorities and have bearing on activities like erection of buildings, pump houses and the installation of electricity. It is good practice to establish what these regulations are beforehand as it may have a bearing on construction methods and costs.

Chapter 3

- ➢ Infrastructure supports the production process, and the size of the farm or planned enterprise determines the extent of the infrastructure that is required.
- ➢ How much of what type of infrastructure we need is the first question that has to be answered when planning for a new farm or the expansion of an existing operation, and the next important factor is where on the farm this infrastructure should be placed.
- ➢ Planning for the placement of infrastructure should follow the initial process of land evaluation and drawing up a land-use plan.
- ➢ There are various regulations and legislation that has bearing on the manner in which both external and internal infrastructure is planned, designed, constructed, and utilised.

Practical

Complete activities 6 and 7 in the **Learner Workbook**.

Chapter 4

After completing this chapter, the learner will be able to:

Apply the principles of sustainability in terms of the layout and infrastructure placement in an agricultural context.

1. Importance of Sustainability

Sustainable farming meets environmental, economic, and social objectives simultaneously. Environmental sustainability implies agriculture that is nature-based rather than factory-based. Economic sustainability depends on profitable enterprises, sound financial planning, proactive marketing, and risk management. Social sustainability results from making decisions with the quality of life that the farm family and the larger community lead as a value and a goal.

Exploitive agriculture offers great dangers if carried out with only an immediate profit or production motive. The intensive cultivation of land without conservation of soil fertility and soil structure would lead ultimately to vast tracts of unproductive land, erosion and even desert areas. Irrigation without proper drainage would result in soils getting alkaline or saline. Indiscriminate use of pesticides, fungicides and herbicides could cause adverse changes in biological balance as well as an increase of ailments in humans directly exposed or through the toxic residues present in the products. Indiscriminate use of underground water would lead to the rapid exhaustion of this resource.

Ecological soundness therefore is the top priority for agricultural sustainability. The basic principles of sustainable agriculture can be summarised as follows:

- Plant and animal productivity adequate to meet the needs of the markets
- Ecological security and environmental quality
- Economic viability
- Social responsibility and acceptability

The general principles for maintaining ecological soundness of agricultural systems are:

- Strengthening the immune system of the operation through integrated pest management;
- Decreasing toxicity in the system and environment through optimum use of synthetic chemicals;
- Optimising metabolic functioning such as nutrient cycling and organic matter recycling;
- Balancing regulatory systems like nutrient cycles, water balance and energy flows and usage;
- Enhancing conservation and regeneration of soil and water resources and biodiversity; and
- Increasing and sustaining long-term productivity

2. Factors Influencing Sustainability

The given biophysical and socio-economic factors determine the sustainable production on a farm. A farm has its own natural resources and other human, economic, technological and knowledge resources which may vary on a short- or long-term basis and affect sustainability to varying degrees.

When analysing the sustainability of a farm, the production goals and strategies of the farm, the biophysical factors and the socio-economic constraints should be taken into account. The farm production goals and strategies are driven by the basic resources available for development and the operational funds. Included will be the physical facilities, technology, human and financial resources.

The biophysical attributes of a farm are controlled by the prevailing geographic, physical, chemical and biological attributes that determine the climate, topography, native biota, soil type and water availability.

These determine such factors as soil quality and productivity characteristics, the plant and insect gene pool, surface and ground water as well as soil.

The human-imposed socio-economic environment within which the farm operates has a number of control factors, categorised as PEST factors:

- **Political** – Agricultural and non-agricultural policies and priorities of the government, imports, exports, the free market, etc.

- **Economic –** Price of inputs and outputs, subsidies on inputs, procurement, pricing, credit, exchange rates, etc.

- **Sociological –** Regional preferences, population, labour constraints, skills and awareness of the farmer, value systems, etc.

- **Technological –** Level of available technology and support services such as timely availability of inputs, infrastructure and markets.

The farm interacts with this system through purchase of inputs and sale of outputs and is facilitated or constrained according to the PEST environment.

Describing the prevailing biophysical and socio-economic environments as favourable and unfavourable, four combinations are possible in determining sustainability, being:

- Favourable socio-economic and biophysical factors
- Supportive biophysical and adverse socio-economic factors
- Adverse biophysical and supportive socio-economic factors
- Adverse socio-economic and biophysical factors

2.1. Favourable Socio-Economic and Biophysical Factors

Soils are fertile and resilient, containing high levels of organic matter have good structure and rainfall is generally adequate and well distributed. Easy availability of inputs, enabling services, infrastructure, markets and favourable economic policies such as subsidies, support prices and export incentives provide a socio-economic environment conducive to sustainable farming operations.

This is the ideal situation for carrying out sustainable agricultural production. Such win-win situations with respect to ecological, or biophysical, and socio-economical factors exist for farmers in the fertile and temperate regions the country.

2.2. Supportive Biophysical and Adverse Socio-Economic Factors

Typical examples can be found in many parts of South Asia where traditional farms in fertile areas have good soils and water endowment and well-adapted crop varieties, but are not profitable. Small, non-viable production unit size, coupled with the lack of positive socio-economic factors that allow for profitable prices, leads to unprofitable farming.

2.3. Supportive Socio-Economic and Adverse Biophysical Factors

Examples of such production systems can be found in fragile, ecologically stressed areas such as mountain slopes, forest-cleared lands, and shallow soils with low fertility and poor structure.

These systems may be temporarily economically viable through production of high value cash crops for export, or profitable products for a niche market. Farmers often exploit such opportunities for short term gains without concern for ecologically sustainability, especially if the lands are not under permanent ownership but are leased out.

2.4. Adverse Socio-Economic and Biophysical Factors

This is the worst situation for any form off productive agriculture, let alone sustainable farming. Such desperate conditions exist in many areas of sub-Saharan Africa with hostile ecological conditions, including low fertility soils and a harsh tropical climate with either very high or low humidity.

Added to this are adverse socio-economic conditions, high population growth, poverty, adverse policies and political volatility. The result is chronic low productivity, uneconomic returns, and resource degradation. This results in mining of nutrients, loss of organic matter, severe erosion and topsoil loss. Consequently, the rate of productivity growth has been slowing continuously and food production has not been able to keep pace with the demand.

3. Managing Sustainability

Agro-ecosystems are natural ecological systems manipulated by humans to produce agricultural outputs to satisfy human needs. Every managed agricultural system interacts with, rather than merely existing alongside, the ecological system. There exists a continuous feedback loop such that human intervention creates a response in the natural system, which in turn generates a response from humans.

Economic and ecological systems co-evolve in this way, with reciprocal stimuli between human and natural systems. If this underlying relationship is ignored when making farm decisions on the basis of economic efficiency, there is likely to be damage to the ecological system and negative feedback to the agricultural system.

Models of farm-level decision making sometimes ignore this connection between the natural and managed systems. The interaction is seen as being in one direction only, with farm management influencing the environment, but not vice versa.

The exclusion of the environment's effect on farm productivity is at least partially related to management decisions that are not environmentally sound. For example, waste flows from the farm into the surrounding environment, but is assumed to have no negative effect on farm productivity, and therefore no cost for the farmer. The productive value of natural resources is assumed to be static. For example, added inputs like fertiliser are assumed to be required to increase the marginal product of natural inputs like soil, but yield improvements from gains in nutrient cycling efficiency due to organic matter are ignored.

The payback period for practices that protect the natural system is sometimes considered too long to have relevance in the farmer's planning period. For example, the effects of soil conservation in terms of nutrient management and soil health are not valued. Environmental quality is of vital and immediate importance to farm productivity, and farmers' management decisions directly influence this factor.

Biophysical factors that affect farm productivity are based on the three functions performed by the environment, namely:

- Supplying resources as inputs to production activities
- Assimilating waste by-products of production activities

Soil and water are examples of resources as inputs to the production process. Their quality can be degraded and their availability depleted by use. Quality and availability of these inputs affects the efficiency of other inputs, such as chemical fertiliser. If the total use level is greater than the renewal rate, a renewable resource can be exhausted. Reduction in quantity or quality of such resources forces changes in the farmer’s management strategy.

Water can take in and dilute nutrient runoff, but at some point with continued disposal, water quality is degraded. A decline in quality of the medium (soil, water, air) in exchange for by-product removal may be acceptable to the farmer, but with severe degradation, the assimilation efficiency declines and the capacity is exhausted. As this occurs, the production choices open to the farmer become restricted.

A farmer's objective in production in a given year is usually the maximisation of profit. Extended over a longer period, the farmer aims to maximise profits over the lifespan of a citrus orchard. The calculation of profit normally takes into account price of output, yield, input use and cost of inputs, but ignores biophysical factors and the sustainability of the income stream. When on-farm costs and returns related to biophysical factors are not included in the calculation of profit, decisions are made without full accounting for their effects.

Managing production within the parameters of the given sets of biophysical and socio-economic circumstances is the most important factor in determining the long-term sustainability of any farming enterprise.

Summary

Chapter 4

- Sustainable farming meets environmental, economic, and social objectives simultaneously.
- The basic principles of sustainable agriculture can be summarised as plant and animal productivity adequate to meet the needs of the markets, ecological security and environmental quality, economic viability, and social responsibility and acceptability.
- The given biophysical and socio-economic factors determine the sustainable production on a farm.
- The biophysical attributes of a farm are controlled by the prevailing geographic, physical, chemical and biological attributes that determine the climate, topography, native biota, soil type and water availability.
- The human-imposed socio-economic environment within which the farm operates has a number of control factors, being political, economic, sociological and technological (PEST) factors.
- Describing the prevailing biophysical and socio-economic environments as favourable and unfavourable, four combinations are possible in determining sustainability.
- Managing production within the parameters of the given sets of biophysical and socio-economic circumstances is the most important factor in determining the long-term sustainability of any farming enterprise.

Practical

Complete activity 8 in the **Learner Workbook**.

Chapter 5

After completing this chapter, the learner will be able to:

Optimise and maintain stock required for the relevant enterprises.
Identify relevant service providers who can render specific services.

1. Stock Requirements

In many cases, the production stock required for specific operations are quite simple to determine. When a new orchard is established, for instance, the plant material that is required can be calculated by simply multiplying the number of trees per hectare with the size of the orchard. This information is available on the orchard plan.

Similarly, the tools and equipment, irrigation equipment, soil preparation chemicals and equipment, and other requirements can be determined from the orchard plan and is usually calculated when the planning for the establishment of the orchard is done.

Determining the stock requirements for ongoing production is not as simple. The stock requirements depend greatly on the production practices and the production volumes. The ability to accurately predict stock usage and determining stock requirements is often only perfected over time and with experience, but having effective systems in place greatly enhances the process.

The various production reports and programs are handy tools in determining the requirements for a wide variety of production items. These reports include the pest and disease control, fertilisation, plant manipulation, and weed control programmes, the maintenance plan, and the production report.

2. Stock Considerations

2.1. Stock Type Requirements

The types and quantities of stock items required depend on the production practices and size of the farm. Tools and equipment that is required on citrus farms include:

- Maintenance tools and equipment
- Gauges, metres and other measuring equipment
- Harvesting tools and equipment
- Plant manipulation tools and equipment
- Irrigation tools and equipment

Maintenance items include spare parts, lubricants, and other items that are required to repair and maintain vehicles, equipment, machinery and infrastructure. The maintenance items that will be required in a specific period can be calculated from the maintenance plans that are put in place.

The number of spare parts that are required for the irrigation system, for instance, depends on the age and general condition of the system. Extraordinary requirements, such as when a decision has been taken to replace all the emitters in specific orchards, must be communicated in time to ensure that the items are ordered and available.

The fuel that is required depends on the production practises, the size of the production unit and the number of vehicles in use on the farm. The consumption of fuel varies between different times of the year, depending on the activities on the farm, and this must be taken into account when the requirements are calculated.

The required types and quantities of other consumables depend mostly on the production practices and the number of employees on the farm. Protective clothing, for instance, is ordered according to the number of workers on the farm, and must be sufficient to ensure that workers have the opportunity to wash and clean their clothing regularly. Special protective gear is also required for operations such as spraying and this must be taken into account.

Stock management is simplified if standardisation is applied wherever possible. If the same type of irrigation equipment is used in all orchards, stock control and supply is much easier. The same principle applies for instance to vehicles, tractors, trailer wheels and tyres.

2.2. Stock Quality Requirements

Pesticides, fertilisers and other agrochemicals must adhere to specific quality standards. Poor quality agrochemical stock can lead to product and income losses. The quality required of any stock item should be managed as follows:

- Establish effect of various qualities of stocks for cost effectiveness prior to ordering
- Specify the stock item correctly at placement of the order
- Verify ability of the service provider to supply the required quality
- Verify quality of product be against specification on delivery
- Ensure that items or materials are applied or used as indicated, in case of future claims

2.3. Stock Control Systems

Systems for keeping track of stock requirements, ordering stock on time, controlling the issue of stock items, and monitoring current stock levels must be in place on all farms, and requires careful planning before the production unit is established.

While in production stock items, such as agrochemicals, maintenance items, fuel and consumables are managed with the help of a stock control system. Machinery and equipment are recorded in an asset ledger.

Stock control systems assist in monitoring the levels of the stock items on hand. Stock control systems can be computerised or manual. Computerised systems are generally more accurate and easier to maintain. There are a variety of software packages available to assist with stock control.

2.4. Stock Levels

While certain items, such as fertiliser and most plant protection chemicals, are ordered only when they are required and in the quantities that are required, other items, such as maintenance items, fuel and consumables, are kept on hand at all times. The decision on how much of these items to keep on hand takes a lot of consideration. Deciding on stock levels is about balancing two equally important factors, being cash flow and shortages.

The stock on hand at any given point costs money to buy, using funds that could have been earning interest or put to other uses. Stock items that do not have a direct impact on production – items that will not affect production if not readily available – should not be kept on hand.

Production should however never at any time be compromised or halted due to a critical stock item not being available. Compromising the quality or safety of fruit is never worth the money that could have been saved in not keeping stock items on hand.

Another factor that must be taken into account is the availability of the stock items. If the items are purchased from a local supplier who can be depended on to deliver the items in a short time, it is not necessary to keep it on hand. If however it is highly specialised items that can only be ordered from suppliers that are not local with a long delivery time, at least some of the items should be kept on hand.

The following steps are useful in managing stock levels:

- Determining critical stock levels
- Identifying suppliers
- Authorising ordering

2.4.1. Critical Stock Levels

The first critical stock level is the minimum stock level, meaning the level below which the stock item should never fall. For example, one can decide that there should never be less than 200l of diesel available on the farm. The minimum stock level helps to determine the re-order level.

The re-order level determines the point at which an item must be re-ordered. It takes into account the delivery time for that specific item and the rate at which the item is used. For example, if you know that diesel is used on average at 100l per day, and that it will take three days for the supplier to deliver, the minimum re-order level should be set at 500l. When the diesel reaches 500l, there is sufficient time to order the item and not fall below the minimum stock level.

The other stock level that can be set is the maximum stock level, meaning the maximum number of items that should be available at any given time. Setting this level helps in cash flow management, and gives the stock controller some idea of how many items should be ordered. The maximum levels for some stock items are set by simple storage limitations – if you have one 5,000l diesel tank on the farm, 5,000l is your maximum stock level for diesel. For other stock items a maximum level may not be applicable.

These critical levels should be determined beforehand for all stock items. The stock management system should be able to keep record of the critical level and produce re-order and comparative reports.

2.4.2. Stock Suppliers

Suppliers for all stock items should be identified in good time, including alternative suppliers that can be used if the regular supplier is not able to deliver. When purchasing an item of the first time, it is good practice to contact a few suppliers to determine who are able to reliably deliver the best quality item at the best price. Suppliers who are well established is often more reliable, but if they have a secure market, they may not offer the best prices. Keep the contact details of suppliers at hand.

2.4.3. Authorised Personnel

Identify the persons who are authorised to order stock items and ensure that at least one of them is available at all times. Make sure that the suppliers are aware of who have been authorised, and that all authorised personnel have access to all the information required, including the contact details of preferred and alternative suppliers.

2.5. Storage of Stock

The following are guidelines for the storage of stock items:

- The store must be secure and dry
- Quality of the stock should be maintained
- The stock should be easily accessible and well identified for control purposes
- All plant protection products should be stored as prescribed by good agricultural practices
- Stock should be dated and utilised on a first-in-first-out basis
- Stock that deteriorates in quality over time should be identified and checked before use
- Redundant stock must be identified, and sold or destroyed on a regular basis

3. Selecting and Evaluating Suppliers and Service Providers

A good supplier is one who can meet all the customer's expectations, with respect to stock range, quality, delivery time and dependability. Potential suppliers for the various stock items needed on a citrus farm should have the following qualities:

- Competitive and value added capabilities
- Proven track record and references
- Good financial standing
- Leading edge technological capabilities
- Quality processes, e.g. ISO 9000 accreditation
- E-commerce for product purchases and payments
- Understanding the client's business
- Compliance with OSHA safety standards for products and services
- Third-party certification
- Compliant with client's Code of Business Conduct and supplier terms and conditions

For a large job, for instance the installation of a new irrigation system, interview three or four firms. Request specific details on previous work they have done, get references and check them. In turn, the firm or contractor should interview you to define the scope of what is required.

Ask serious contenders for a written proposal. In the proposal, look firstly for a clear mission statement. There should be a statement of purpose, and the scope of the study should be clearly defined, for example, analysis plus recommendations, implementation and so on.

Secondly, look at the structure set out in the proposal. Sizeable tasks should be broken into stages or interim deliverables, and the proposal should include a work programme for each stage. Once the work begins, the contractor will move on to the next stage when you have signed off on the preceding one. Progress should be reviewed regularly with the contractor to forestall hitches or surprises.

The last very important aspect of a proposal is the fees. The fees on large supply or construction jobs are usually time-based. Each stage should be assigned a minimum and maximum estimated fee, to protect you against overrides caused by delays or inadequate time estimates. Make sure that the proposal stipulates that the supplier should notify you of problems in advance, so that you have enough time to modify the job to stay within budget.

When selecting suppliers and service providers it is of course not possible to foresee whether they will sustain the service levels and standards and it is therefore important that they are evaluated regularly. Keeping in mind the expectations of the customer, the following list contains seven key characteristics of a good supplier against which they can be evaluated:

- ***Timely Delivery*** – A good supplier keeps up to timely delivery of goods and supplies. Delayed supply can cause losses to the customer. This also opens up avenues for other secondary systems like buffer inventories to keep the chain going, in addition to increasing overall costs.

- ***Constant Frequency of Delivery*** – If a supplier can supply goods at constant and small frequencies, the cost advantage is supplemented. If a product or part is found to be defective, the time spent in replacing it is minimal, as opposed to having to replace a whole carton or shipment of that item, since the delivery is frequent and the supply chain is actively functioning. This is not only cost effective but is also a time and space saver.

- ***Reasonable Prices*** – Farming is a margins business, driven by volume. Cost saving on input items without compromising in quality is critical in improving the farm's profitability.

- ***Minimal Paperwork*** – From placing of an order to delivering the stock can involve a ton of paperwork. A good supplier will find ways of reducing the amount of paperwork involved.

- ***Quick Response Time*** – The world of business is changeable and the gap between demand and supply can be hard to predict. A good supplier will always be prepared to deal with such contingencies. The ability to supply frequently and in smaller quantities is the key.

- ***Quality Control*** – The inspection of goods is a time consuming activity for both supplier and buyer. However, quality assurance can reduce the time spent on inspecting goods.

- ***Transport Damage*** – Transportation and delivery can involve a lot of wear and tear. A good supplier is someone who recognises these limitations and takes proactive steps to help reduce or avoid the damage involved.

Accurate records of all the relevant details of suppliers, service providers and any person or organisation being of service to the farm, is a necessity. These records should not only include contact details, but also the type of service, when it was provided as well as cost and efficiency. A database containing the above information assists tremendously in the management decision making process and is used to evaluate supplier performance.

Summary

<u>Chapter 5</u>

- The various production reports and programs are handy tools in determining the requirements for a wide variety of production items.
- The types and quantities of stock items required depend on the production practices and size of the farm.
- Stock management is simplified if standardisation is applied wherever possible.
- Pesticides, fertilisers and other agrochemicals must adhere to specific quality standards.
- Systems for keeping track of stock requirements, ordering stock on time, controlling the issue of stock items, and monitoring current stock levels must be in place on all farms, and requires careful planning before the production unit is established.
- While certain items are ordered only when they are required and in the quantities that are required, other items are kept on hand at all times and the decision on how much of these items to keep on hand takes a lot of consideration.
- The following steps are useful in managing stock levels determining critical stock levels, identifying suppliers, and authorising ordering.
- Stock must be stored in a secure, dry area with access control and according to good agricultural practices, where applicable.
- A good supplier is one who can meet all the customer's expectations, with respect to stock range, quality, delivery time and dependability.
- For a large job, proposals should be submitted, indicating the purpose and scope of the project, the structure in terms of deliverables and the fees and costs.
- Suppliers and service providers should be evaluated regularly, on timely delivery, constant frequency of delivery, reasonable price, minimal paperwork, quick response time, quality control, and transport damage.
- Accurate records of all the relevant details of suppliers, service providers and any person or organisation being of service to the farm, is a necessity.

Practical

Complete activities 9 and 10 in the **Learner Workbook**.

Chapter 6

After completing this chapter, the learner will be able to:

Innovate and plan production systems within relevant enterprises.

1. Citrus Production Systems

Citrus production systems are driven by the production cycle, which is a year-round process, closely related to the annual growth cycle of the citrus tree. It is designed to provide the tree with what it requires to optimally support the current growth stage.

In the learning material for previous levels, we used the table below to illustrate how the growth cycle of the tree determines when certain production processes are undertaken.

Month	***Cell Processes***	***Fruit and Flower Development***	***Production Processes***					
			Fertilisation	**Pest and Disease Control**	**Irrigation**	**Pruning**	**Harvesting**	**Packing**
July	Flower Initiation	Flowering						
August	Cell Division							
September								
October		Fruit Set						
November								
December	Cell Enlargement							
January		Fruit Growth and Maturation						
February								
March								
April								
May								
June								

Table 5.1 – Approximate Citrus Production Cycle

These processes and practices all contribute to the success of the production system. The six major production processes on a citrus farm can be seen as:

- Fertilisation
- Plant protection
- Irrigation
- Pruning
- Harvesting
- Postharvest handling

Each of these processes can also be seen as a production system in itself, with specific inputs and specific expected outcomes or outputs and timing. In the table below are examples of the inputs and outputs or outcomes for each production system.

Production System	***Inputs***	***Outcomes / Output***	***Approximate Timing (Valencia)****
Fertilisation	• Soil and leaf analysis reports • Fertilisation programme • Agrochemicals • Machinery and equipment • Labour	• Trees with access to sufficient nutrient resources to produce high yield • Good quality fruit • Controlled environmental impact	August-October
Plant Protection	• Scouting reports • Plant protection programme • Agrochemicals • Machinery and equipment • Labour	• Low pest populations and disease prevalence • Effective weed control • Good fruit quality and volumes • Controlled environmental impact	September-March
Irrigation	• Records of soil water level and irrigation working parameters • Climatic records and weather forecast • Irrigation schedule • Machinery and equipment • Labour	• Trees with sufficient moisture resources • Good fruit quality and volumes • Controlled environmental impact	All year round, varying
Pruning	• Production records • Tree size and form guidelines • Agrochemicals • Machinery and equipment • Labour	• Trees with good framework development, light interception, no low branches, no deadwood, good fruit / vegetation balance and fruit set • Good fruit quality and volumes	September
Harvesting	• Maturity indexing • Yield and fruit size estimates • Historical records • Harvesting plan • Machinery and equipment • Labour	• Harvested fruit delivered to packhouse • Maintained fruit quality and safety	July-August
Postharvest Handling	• Harvested fruit • Market requirements • Packing standards and requirements, packing instructions • Packing material • Machinery and equipment • Labour	• Fruit packed as per market requirements and specifications • Maintained fruit quality and safety	July-September

Table 5.2 – Citrus Production Systems

* Note that the timing is based on the production cycle of a valencia orange tree and that particularly harvesting and postharvest processes will change for other cultivars. Varieties of citrus are harvested from as early March to as late as October.

The integration of these production systems forms the basis of production management. Once the manager has a clear understanding of the inputs and expected outputs or outcomes of each process, or system, he is able to integrate planning for machinery and equipment usage and maintenance, human resource management, environmental management, stock management, and so on.

Understanding each of these systems and the requirements for their smooth operation is also essential to enterprise development, because it impacts on decisions about what to plant, and on planning for resource requirements, where resources include human, natural, mechanical, and stock resources.

But production systems are not set in stone. Even though careful planning at the outset contributes to the long term sustainability and profitability of the enterprise, it is the ongoing management and monitoring of the systems that ensures success and that furthermore gives rise to new and innovative approaches to production.

2. Production System Innovation

Innovation in citrus production is ongoing – no one farms citrus today in the same way as their grandfathers did it. But such innovations would be impossible without sound research. Citrus Research International (CRI) is the research arm of the Southern African citrus industry. The research priorities of the CRI are informed by the citrus growers who fund their activities. At present, research mainly focuses on four programmes, being:

- Disease management
- Integrated pest management
- Crop yield and fruit quality management
- Cultivar development and evaluation

The outcomes and findings of this research is continuously communicated to growers through the internet, email, the CRI Net, Cutting Edge publications, research briefs in industry publications, and study group meetings. It is essential for all citrus growers and managers to be part of this communication network, and to stay up to date with the latest findings.

Technological advancement is another factor that plays a major role in innovation. There has been considerable advancement in the technologies used in farming over the last few years, not only on the farm, but also in the packhouse and even in facets such as administrative management.

One example of production innovation is fertigation, where new development and research has enabled the application of fertilisers, and in some cases even plant protection products, through the irrigation system. This system has brought about improved efficiencies in that production system, along with higher yields and improved product quality. Another example is product innovation, such as the development of new biological control agents for pests.

It is essential for farm managers to understand their own production systems very well, so that they are able to assess the viability of innovation in each aspect of their farming operation, and above all to remain up to date and informed about the latest developments and research findings in every facet of citrus production.

3. Observation Reports

The decision of what and where to plant to achieve a balanced fruit flow and acceptable profitability is based on a set of pre-planting information and assumptions.

These have to be evaluated after every season to establish whether the orchard performance and contribution of each cultivar to fruit flow is satisfactory and has resulted in the required profitability. If not, an adjustment to production practices, additional plantings or even removal of an orchard has to be considered. It is therefore important to observe and record all factors that influence the outcome. There are many factors that are interrelated and that affect the general management and smooth operation of a citrus farm and has to be considered in such an evaluation, including:

- Cultivar performance (volume, timing of production and its effect on picking and packing)
- Equipment (handling, transport and other cultural practices)
- Human resources (management, supervision and labour requirements)
- Production (volume, quality and production practices)
- Cost implications

It is important to develop a formal recordkeeping system that is kept up to date and can be interrogated at any time.

A good example of observation reports is scouting records. The main function of scouts is to monitor the pest and disease prevalence in the orchards so that timely interventions can be made. But scouts are also able to report on a wide variety of other orchard conditions, such as on growth phenomena for example blossom dates and fruit drop, the water stress condition of the trees, and on the extent of hail or other physical damage to fruit.

Details of these observations are normally recorded on scouting records, and can easily be enhanced by creating more awareness amongst the scouting personnel. This inspections information can assist in the following three ways:

- Inter-seasonal decision making based on comparisons of results between seasons
- Intra-seasonal decision making based on fruit set, growth, and pest and natural enemy trends
- Immediate decision making based on intervention thresholds

Orchard maps facilitate the organisation of inspection systems, the interpretation of inspection data, and the subsequent execution of control operations. The maps can be used to record various aspects of orchard operations, the position of inspection sites or routes, and fluctuations in pest or disease presence. Copies of the maps can be utilised to show the development of a particular pest or growth phenomena in a specific area.

The results of each inspection round should be recorded for permanent reference. Over time, regular inspection and the related written records will provide a good basis for fine tuning treatment thresholds for pests and other production, harvesting and crop projection requirements and become central to the monitoring of the process.

4. Production Records

The volume, size and quality of fruit at harvest are determined by a large number of factors. A system of recording all these factors must exist on every citrus farm. Recordkeeping is a way of monitoring external and internal factors, as well as procedures which can influence the outcome of the production process.

There are various types of data which has to be collected to provide information to management on a citrus farm. Records are used to monitor processes and determine their effectiveness. Records that must be kept are:

- ***Production*** - Inputs (labour, materials, machinery), outputs (crop produced), productive use
- ***Human resources*** - Personnel records, manning levels for harvesting, packing, etc.

The ultimate aim is to ensure efficient and sound management to ensure profitability and sustainability.

An efficient information and recordkeeping system will therefore assist management to monitor the cost of input processes, materials and other resources, and to improve profitability through correct production and packing decisions and judicious marketing.

The correct use of data and information is one of the main characteristics of a well-run and successful farm. The flow of data and information must be assessed and monitored throughout and evaluated to see whether it meets the requirements of management.

It is important that all employees are aware of the importance of recording all necessary actions and observations during the production process, as well as why the information is necessary. This means that every individual that is required to collect and forward data to the next level for processing, must be well trained, provided with the necessary equipment, and monitored.

Examples of actions and observations that must be recorded include the following:

- ***Blossom dates of all cultivars –*** Blossom dates vary from year to year and influences the development of the fruit up to the time of harvest. Comparing the date of full blossom with those of previous years is an indication of the picking date relative to the previous years and can be utilised in planning the harvesting and picking process. Spray recommendations quite often also refer to days after full bloom.

- ***Weather data –*** Weather data includes information on rainfall, daily maximum and minimum temperatures, humidity and evaporation. Analysis of trends in weather data are used to determine fruit growth patterns, which indicate the fruit size spectrum at harvest. This information is used in crop prediction and plays an important role in marketing, as the markets vary in their fruit size preferences, as well as planning production practices such as spraying and harvesting.

- ***Irrigation scheduling*** – The irrigation manager prescribes the irrigation scheduling, but the actual implementation of the planned irrigation schedule must be recorded accurately to ensure that scheduling was complied with. Irrigation reports must include details of problems that may have been encountered with the irrigation system.

- ***Fertiliser applications*** – This information is utilised in combination with production statistics to formulate the fertiliser recommendations for each year. It must also be available for inspection for qualification under the GlobalGAP system. All instructions to employees indicating time of application and quantities must be given in writing and the actual application per orchard must be recorded as one of the requirements for traceability.

- ***Plant protection product application*** - All details of the pest and disease control program must be recorded for GlobalGAP qualification. This should include verification that the person recommending the program is qualified, all instructions to employees, safety precautions, and training records.

- ***Fruit yield, size and quality*** – The yield and fruit size and quality achieved in each orchard must be recorded every year. This information assists with planning before the start of the picking season every subsequent year, while comparative analyses of the data allows one to identify production trends and to address problems.

A recordkeeping system should be designed in such a way that the information conforms to Good Agricultural Practices (GAP) norms. GAP certification and registration has become a requirement for exporting fruit to most countries. In order to be certified and registered farmers should be able to demonstrate their commitment to:

- Maintaining consumer confidence in food quality and safety
- Minimising the detrimental impact of farming practices on the environment
- Reducing the use of chemical crop protection products
- Improving the efficiency of natural resource use
- Ensuring a responsible attitude towards worker health and safety

A good recordkeeping system should help the farmer to prove his commitment to these aspects, and must also be such that it is possible to trace back fruit received on the market to its origins, meaning to where it was produced in the orchard. All the production processes and actions employed in the production of the fruit must also be traceable and open to scrutiny.

As an example, we will look at the application of plant protection products and how their applications can be monitored and managed with the help of a good recordkeeping system.

Products used for plant protection has to be considered carefully and their application must be well managed to ensure that the end result is cost effective and residues on fruit fall within the legal limits set by various markets. At the outset, it must be ascertained that all products applied for plant and fruit protection, are used according to specifications. The registration requirements for plant protection products on Southern African export citrus in terms of the SA Act 36 of 1947 must be adhered to at all times. The purpose of the restrictions is to ensure compliance with residue tolerances in the countries to which South African citrus is exported.

Fruit is not allowed to be harvested before the end of the withholding period of the specific chemicals used. Due to the multiple fruit set pattern of lemons, plant protection products may only be used as specified during the first spring blossoming and fruit set period. Special caution should be exercised to ensure that pesticides applied to protect later sets do not result in unacceptable residues in fruit remaining on the trees from earlier sets.

The compliance to all these regulations can only be shown with the help of a good recordkeeping system.

5. Optimising Production According Market Specifications

The requirements of the market influence the decisions on what to produce and the production practices that are employed. Production practices are mostly impacted in terms of market requirements that relates to food safety and quality.

A prime example in this sense is maximum residue levels (MRL), meaning the residue of a given chemical that is allowed to be in the fruit when it is exported. MRLs are legislated by the Department of Agriculture, Forestry and Fisheries, who issues a list of MRLs for all plant protection products that are used in crop production. If it is found that a consignment of fruit exceeds the MRL for a plant protection product, the consignment will be rejected for export and action can be taken against the grower.

Production practices, and in this case specifically the application of plant protection products, are influenced by this market requirement in that the spray program will be planned in such a manner that no plant protection product is applied too near the harvest time.

The market information that is gathered in order to decide what to produce and to assist with production planning include the following:

- Market preferences
- Expected income per unit in various markets
- The cost chain to various markets
- Price fluctuation over the production season
- Quality requirements of the various markets (fruit size, internal and external quality)
- Production trends in the local as well as overseas production areas

The various export markets each have their own set of preferences for fruit type. The Japanese market has for instance a specific preference for grapefruit and soft citrus outside their own production season. The American market prefers navel oranges and soft citrus. The European market will absorb a good quality fruit in more or less any fruit type, except white grapefruit which has a small niche market in Italy. The Scandinavian markets prefer fruit of a larger size spectrum than the Russian market, whereas the complete size spectrum can be marketed in the rest of Europe. Fruit marketed in the Middle, Far East and Japan must be relatively blemish-free and have good colour. Waste fruit is heavily discounted in these markets.

Growers can get access to this information by studying trade publications and historical market information. It is however most of the time easier to rely on market and export agents for this information. Knowledge of these preferences by the chosen market agent is imperative for success.

Summary

Chapter 6

- Citrus production systems are driven by the production cycle, which is a year-round process, closely related to the annual growth cycle of the citrus tree.
- The six major production processes on a citrus farm can be seen as fertilisation, plant protection, irrigation, pruning, harvesting, and postharvest handling.
- Each of these processes can also be seen as a production system in itself, with specific inputs and specific expected outcomes or outputs and timing.
- Even though careful planning at the outset contributes to the long term sustainability and profitability of the enterprise, it is the ongoing management and monitoring of the systems that ensures success and that furthermore gives rise to new and innovative approaches to production.
- Citrus Research International (CRI) is the research arm of the Southern African citrus industry.
- At present, research mainly focuses on four programmes, being disease management, integrated pest management, crop yield and fruit quality management, and cultivar development and evaluation.
- There has been considerable advancement in the technologies used in farming over the last few years, not only on the farm, but also in the packhouse and even in facets such as administrative management.
- It is essential for farm managers to understand their own production systems very well, so that they are able to assess the viability of innovation in each aspect of their farming operation, and above all to remain up to date and informed about the latest developments and research findings in every facet of citrus production.
- There are many factors that are interrelated and that affect the general management and smooth operation of a citrus farm and has to be considered in such an evaluation.
- It is important to develop a formal recordkeeping system that is kept up to date and can be interrogated at any time.
- There are various types of data which has to be collected to provide information to management on a citrus farm.
- A recordkeeping system should be designed in such a way that the information conforms to Good Agricultural Practices (GAP) norms.
- The requirements of the market influence the decisions on what to produce and the production practices that are employed.

Practical

Complete activity 11 and 12 in the **Learner Workbook**.

Chapter 7

After completing this chapter, the learner will be able to:

Plan and maintain harvest system within the relevant farming systems and enterprises.

1. Introduction

The planning of a harvest system is based on the types of citrus to be harvested and the crop size. Maintaining the system largely depends on a well-managed monitoring system, and on good supervision and communication throughout the harvesting season.

The principles of a successful harvest are:

- Forecast, plan and budget
- Do not harvest before the crop has reached the required minimum standards
- Train managers, supervisors and workers
- Maintain optimum fruit safety and quality during the harvest
- Monitor all picking actions
- Monitor transport of fruit to packhouse
- Maintain health and safety of workers during the harvest
- Manage costs, equipment and staff to maximise profit
- Give feedback and implement corrective actions where necessary

2. Harvest Planning

2.1. Crop Estimates

An accurate crop estimate is the basis for calculating equipment and personnel needs to harvest each cultivar within it's the normal picking period cultivar. Apart from crop volume, the estimate must also indicate projected size spread per cultivar and the estimated time of maturity.

There is no standard method for estimating the crop that can provide for seasonal variation due to climatic and other factors. However, it is possible to achieve reasonable accuracy by basing estimates on the following information:

- Accurate tree and area census data that indicate the number of trees and hectares, tree-age and tree-spacing per orchard;

- Historical count distribution, export percentage, and total yield in carton equivalents per orchard; and

- Seasonal variations, based on orchard observations and exchanges of information with other growers in the area.

The first estimate must be made available to management and submitted to the packhouse in January. It is used for both preparation of budgets, marketing planning, and the preliminary calculation of packing material requirements.

Fruit size predictions are based on measuring the diameters of 100 fruit per tree on 10 index trees per orchard at weekly intervals. A growth curve is then established and correlated with data from previous seasons and actual fruit size distribution at packing.

These calculations can be verified by conducting a strip estimate three to four weeks ahead of the estimated harvest date. All the fruit of at least one tree per orchard are picked and processed through the packhouse to determine yield, pack-out percentage, and fruit size distribution. This information is then interpreted and extrapolated to estimate the total export crop.

2.2. Harvesting Practices

Before the rest of the planning and preparation can be done, a number of decisions have to be taken with regard to how the harvest will be executed. These decisions are in many cases taken simply on the basis of how the fruit was harvested in the past. If it is however the first time that the fruit will be harvested, all the available options must be carefully considered.

The picking process, which takes place over a relatively short period, is of critical importance and should be carried out as effectively as possible to avoid losses due to injuries, waste and poor handling.

Harvesting citrus in South Africa is done by either clipping or snap picking and during harvest planning a decision has to be made about which harvesting method to use.

Picking by using clippers is the only method allowed for picking export fruit and is generally recommended. Using clippers ensures that the fruit are picked one by one and therefore handled with care, and that the buttons remain in place, thus extending the shelf-life of the fruit. Clipping though is slower and can lead to lower productivity. Poor monitoring of the process may result in long stems and clipper injuries.

Snap picking is when fruit is picked off the tree by hand without using clippers, by simply twisting and snapping the stem. This method is faster than snap picking and is used to strip orchards of fruit destined for processing after the export fruit has been picked.

The further decision that may have to be taken is whether selective picking will be done. In some cases, for instance with poor colour development, it makes sense to first selectively pick well coloured export fruit, using clippers and carefully handling the fruit. Well-trained workers select fruit in the orchard that comply with the external quality and size requirements for export fruit, leaving the fruit that obviously do not comply with these requirements on the trees. After the export fruit has been picked, a second team is sent in to strip the trees of the remaining fruit using snap picking, which is then sent straight to the processing plant.

Although selective picking seems less productive, it has the advantage that the harvesting of factory fruit is speeded up and receiving costs at the packhouse is reduced, because it is not overloaded with fruit that obviously does not comply with export standards. It however complicates management of the harvesting process and the danger exist that fruit of export quality can be sent directly for processing if workers are not well-trained and supervised.

2.3. Human Resources

The number of harvest workers and supervisors required for the harvest is calculated on the basis of the crop estimate, taking into account the period in which the harvesting must be completed for each cultivar.

Planning the picking process for soft citrus is more complex due to cultivar types, climate, optimum maturity periods and labour distribution. The following picking planning methodology has been developed for the Western Cape, but can be used as the basis for planning in other production areas.

In the table below, the picking hours per day for the Western Cape and the Lowveld area is shown to demonstrate the difference between areas. It is also shown for various times during the picking season, to show the seasonal variances. This information is used to determine the estimated number of picking hours available to harvest the crop within the normal picking period for each cultivar, and for the entire production unit.

Month	***Picking Time (Hours per Day)***	
	Western Cape	**Lowveld**
March	7	6
April	6	7
May to July	5	8
August and September	6	8

Table 7.1: Comparison of Available Picking Hours – Western Cape and Lowveld

In the table below, the average expected yield, in tonnes per hectare, and the average picking rate, in kilogram per picker per hour, for the various cultivars are shown. The man-hours required per hectare are calculated by dividing the yield in kilogram per hectare by the average picking rate.

Cultivar	***Yield (t/ha)***	***Picking Rate (kg/hour)***	***Man-Hours per Hectare***
Navels	40	170	235
Valencias	50	170	294
Lemons	55	85	647
Oroval / Marisol	45	80	563
Other Clementines	45	60	750
Satsumas	50	60-80	833

Table 7.2: Average Yield and Picking Rate per Cultivar

The number of pickers per hectare is then calculated by dividing the man hours needed for picking by the available picking hours, as in the table below.

Cultivar	***Picking Time***	***Effective Picking Days***	***Available Picking Hours***	***Man-Hours per ha***	***Pickers Required per ha***
Miho Wase	Mar / April (3 weeks)	10	7h x 5d + 6h x 5d = 65	833	12.8
Marisol	April (2 weeks)	7	6h x 7d = 42	563	13.4
Oroval	May (2 weeks)	7	5h x 7d = 35	563	16.1
Other Clementines	May / June (5 weeks)	15	5h x 15d = 75	750	10
Navels	May / June (6 weeks)	20	5h x 20d = 100	235	7.4
Valencias	Aug / Sept (7 weeks)	25	6h x 25d = 150	294	2
Lemons	April / June (8 weeks)	30	5h x 30d = 150	647	2.6

Table 7.3: Calculating Pickers Needed

The number of supervisors and quality monitors depends on the number of pickers required. The ideal number of pickers per picking team is twenty, with one supervisor per team. The ratio of pickers to supervisors will decrease with an increase of susceptibility of the fruit to injury.

Additional temporary workers are taken on for the harvest period, with permanent workers usually acting as supervisors. Temporary workers are sourced from the surrounding community and must be trained well in advance of the start of harvesting. Training of supervisors should start at least three weeks and pickers at least two weeks before harvest.

As part of the training process, all temporary and permanent workers must be made aware of the need for maintaining the quality and safety of the crop throughout the harvesting process, and of the regulations with regard to worker health and safety.

It is also useful to allow temporary workers, especially those that will be involved in the picking process for the first time, to familiarise themselves with the layout of the farm before the harvest starts. It is essential that all workers must be aware of the location of ablution facilities, and that enough facilities must be available to accommodate the additional workers.

2.4. Harvesting Tools and Equipment

The first decision that must be taken is whether to use bins or trailers to collect the fruit in the orchard. The decision is mostly based on the volume of fruit that has to be harvested. An exact crop estimate is not required, but factors such as tree age and the expected average yield per hectare are taken into account. The availability of equipment also plays an important role. Bins can be rented from a number of suppliers or from the packhouse, while picking trailers require a capital investment. The availability of tractors must also be taken into account, as well as the need for flatbed trailers to transport bins.

The distance to the packhouse and the state of the roads on the farm and to the packhouse is another important factor, as is the facilities at the packhouse for receiving fruit in bins or trailers. Some packhouses may only have the facilities to receive fruit in picking trailers or to tip bins. Other equipment that is required for the harvest is determined as follows:

- ***Clippers*** – 1 per picker
- ***Picking bag*** – 1 per picker
- ***Gloves*** (where required) – 1 per picker
- ***Ladders*** (where required) – 1 per 3 pickers
- ***Bins / trailers*** – dependent on transport option, fruit volume transported per day
- ***Tractors*** – dependent on transport option, fruit volume transported per day

Tools and equipment must be checked, cleaned and, where necessary, serviced before the harvest starts. Picking bags must be clean and whole and, where picking is monitored per bag, of the same internal size. Ladders must be well maintained and strong enough to withstand daily handling and the weight of individual pickers. Clippers must be in a condition to enable the picker to clip the fruit without injury to the fruit and without leaving a long stem on the fruit.

Picking trailers and bins must be checked carefully to ensure that the fruit will not be injured when placed inside. They must also be checked for loose parts and trailers must preferably be serviced beforehand. Protective clothing must be issued to all workers. As a rule, workers are issued with overalls and gumboots and with gloves where necessary. The clothing should at all times be clean, neat and in good condition.

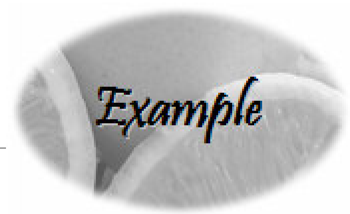
3. Monitoring Harvesting

The practices and procedures surrounding harvesting a citrus crop must be managed well and monitored on an ongoing basis. This includes managing the process with consideration of the affect of weather conditions before and during harvesting and of picking and handling practices on the ultimate quality of the fruit delivered to the market.

Practices that should be carefully monitored and managed include the following:

- Weather conditions (rain, high humidity)
- Orchard sanitation
- Fruit maturity (internal and external)
- Staff training (harvest practices, health and hygiene)
- Picking process
- Equipment condition and handling
- Orchard culling of fruit clearly not fir for export
- Transport to packhouse (road conditions, tyre pressure of vehicles and trailers, speeding)

The management and monitoring process must be open to inspection. Only through efficient monitoring and recordkeeping can product quality be assured and maintained. Below is an example of a daily inspection form that is used during the harvest.



Daily Inspection Form

Harvesting – Daily Inspection			
Variety:		**Date:**	
Orchard:			
Aspect		**Remarks**	
1. Pickers fingernails			
2. Ladders (condition and handling)			
3. Clippers (type and condition)			
4. Picking bags (sand, leaves, etc.)			
5. General handling (emptying of picking bags, handling of bulk bins, etc.)			
6. Picking injuries (as indicated by indigo carmine test)			
7. Long stems			
8. Supervision (frequency, picking rate)			
9. Condition of picking trailers / bins			
10. Picking hours			
11. Orchard condition (water stress, moisture, rain, growth flushes)			
12. Fruit colour			
13. Condition of roads			
14. Tyre pressure (trailers)			
15. Transport speed			
16. Orchard sanitation			
17. Deadwood in orchard			

A cull analysis on an individual orchard basis at the packhouse is done to record the internal and external quality of the fruit, and provides immediate feedback to the picking teams. It also forms part of the harvest and is used for future planning, and to facilitate traceability.

4. Health and Hygiene

A hygiene risk analysis encompassing, amongst others, harvesting procedures, should be carried out prior to, during and after harvesting. All identified actions should be communicated to all persons involved in the harvesting process through training, and must be strictly enforced by supervisors and management. All such actions must be documented and monitored throughout.

The legislation that governs the worker health and safety during harvesting is the Occupational Health and Safety Act (OHSA) of 1993. According to OHSA employers have a duty towards employees to provide and maintain a working environment that is safe and without risk to the health of the employees.

Employees also have a responsibility under the OHSA to not take unnecessary risks and to report any areas of concern. Reaction of employees to their responsibility will to a large extent depend on the relationship with their supervisor. It is therefore important that supervisors and managers are well trained in building and maintaining good working relationships.

Health and hygiene regulations are amended regularly and it is challenging for individual farmers to keep abreast of developments in this field. It is important to have access to a human resources practitioner who monitors the field continuously and give feedback to the farming enterprise of any changes. It is important to discuss the matter with such person at least on a yearly basis. Implementation of changes will depend on the nature of the change and whether it implies training or just informing the involved persons.

5. Quality Management

Exports markets have very high external and internal quality standards. Fruit must comply with very specific requirements with regard to colour, size, shape, and must be almost blemish-free. In addition, the internal quality standards are regulated not only with regard to the safety of the product, but also with regard to the juice percentage, and the sugar and acid levels, which determine the taste.

Most markets also insists that records be kept of all actions, pre- and postharvest, so that the origin of fruit offered for sale on the market can be traced back to the orchard in which it was produced.

The requirements for the local fresh fruit markets are not as strict, and fruit of a lower external quality can be sold on these markets. There are no requirements for the external quality of fruit that is sent for processing.

It is however very important to remember that all fruit, whether destined for export, local markets, or processing, is destined for human consumption. All fruit therefore has to be sound, with no decay or internal insect infestation, such as from fruit fly or false codling moth, must not be split or granulated, and must not have possible contaminants or colorants on the external surface of the fruit which could affect the internal quality.

Records that must be kept include records of all maturity indexing testing where fruit quality is measured before harvesting. Maturity indexing records can be used as proof that fruit was within the set internal and external quality parameters before harvested.

Summary

Chapter 7

- The principles of a successful harvest are forecast, plan and budget, do not harvest before the crop has reached the required minimum standards, train managers, supervisors and workers, maintain optimum fruit safety and quality during the harvest, monitor all picking actions, monitor transport of fruit to packhouse, maintain health and safety of workers during the harvest, manage costs, equipment and staff to maximise profit, and give feedback and implement corrective actions where necessary.
- An accurate crop estimate is the basis for calculating equipment and personnel needs to harvest each cultivar within it's the normal picking period cultivar.
- Harvesting citrus in South Africa is done by either clipping or snap picking and during harvest planning a decision has to be made about which harvesting method to use.
- The number of harvest workers and supervisors required for the harvest is calculated on the basis of the crop estimate, taking into account the period in which the harvesting must be completed for each cultivar.
- As part of the training process, all temporary and permanent workers must be made aware of the need for maintaining the quality and safety of the crop throughout the harvesting process, and of the regulations with regard to worker health and safety.
- Tools and equipment must be checked, cleaned and, where necessary, serviced before the harvest starts.
- The practices and procedures surrounding harvesting a citrus crop must be managed well and monitored on an ongoing basis.
- A hygiene risk analysis encompassing, amongst others, harvesting procedures, should be carried out prior to, during and after harvesting.
- It is very important to remember that all fruit, whether destined for export, local markets, or processing, is destined for human consumption.

Practical

Complete activity 13 and 14 in the **Learner Workbook**.

Chapter 8

After completing this chapter, the learner will be able to:

Plan and maintain postharvest systems within the relevant farming enterprise.

1. Introduction

The postharvest system includes all the processes and actions that fruit is subjected to after it is harvested.

Of the citrus fruit produced in Southern Africa, around 61% is exported, 30% is processed and the remaining 9% is sold as fresh fruit on the local market. The postharvest system for particular citrus fruit ultimately depends on which market segment it is meant for, but most citrus tend to enter the postharvest system at the packhouse. In most cases fruit is sorted and channelled to the appropriate market segment at the packhouse.

The export segment remains the most important of the three market segments for Southern African citrus growers. Although only 61% of citrus is exported, this generates around 90% of the income for the industry. In this chapter we will therefore focus on the postharvest system for export citrus.

2. Postharvest Systems

The table below shows the links in the value chain for Southern African export citrus, together with the 2009 industry average percentage that each link contributes to the final cost of export fruit.

Value Chain Link	***Average Cost Contribution (2009)***
Production and Picking	11.5%
Packing	13%
Transport	1.5%
Harbour Handling	3.5%
Shipping	18.5%
Receiving and Transport	13%
Sales	30%
Other Costs (Commissions, Levies and Fees)	9%
Total	**100%**

Table 8.1: Citrus Value Chain with Average Cost Contribution

From this table we can see that at the point when citrus has been harvested and delivered to the packhouse, the grower has only spent around 11.5% of the money that he will eventually spend on his export fruit before he can expect any return.

The importance of postharvest systems in citrus production cannot be underestimated. It is very easy to fall into the trap of not paying due attention to this system, because growers are confronted much more immediately and for longer periods of the year with the production of their fruit. But it is the postharvest system that constitutes nine tenths of the cost chain for export fruit. This is where the most money is spent, and where the most money can therefore be lost.

In order to plan and manage the postharvest system, it is important to first of all understand the links that make up this part of the value chain, as follows:

- Packing
- Transport
- Harbour handling
- Shipping
- Receiving and transport
- Sales

2.1. Packing

Before deregulation, most packhouses were cooperative, meaning that all the farmers in a region packed their fruit at a communally-owned packhouse. Since deregulation, many farmers that have the necessary critical mass have built their own packhouses in an attempt to control a greater part of the value chain. In Southern Africa we now have packhouses packing 50,000 or less cartons right up to huge communal or company owned packhouses that pack up to 8 million cartons.

When citrus fruit reaches the packhouse, it is in some cases de-greened, washed, treated, waxed, sorted, graded, sometimes wrapped and labelled, and then packed into cartons, which are stacked on pallets and inspected to make sure it is fit for export. In some cases, fruit will be pre-cooled at the packhouse before being transported. The cost that is added in this process can be quite a lot, and depends on the type of citrus you have and the market for which it is meant.

2.2. Transport

The next link in our chain is moving the fruit from the packhouse to the port from where it is shipped to an overseas market. Pallets can be loaded onto flatbed, tautliner or refrigerated trucks, depending on the cultivar and the market. Refrigerated trucks are used to transport fruit that has been pre-cooled at the packhouse.

The fruit can also be packed into containers at the packhouse, with the packed container then shipped on a truck. Another option that is gaining popularity in South Africa is transporting containers or loose pallets by rail.

The distance that the fruit has to travel to the port depends on where you are in the country and where the port is from where your fruit will be shipped. The distance and method of transport determines how much it will cost you.

The choice of transporter is usually up to the packhouse management, but it is important that the grower is aware of who transports his fruit, as it is he who carries the cost and will carry the losses if anything should go wrong.

2.3. Harbour Handling

Before the fruit is loaded onto a ship, it may have to be stored at the harbour terminal for a period of time, where it is either cooled in pre-cooled facilities, or kept in holding rooms that maintain the temperature of the fruit if is has already been pre-cooled.

The exporter normally selects the pre-cooling facility and makes the necessary bookings, based on information supplied by the packhouse. Again, it is critical that the grower is aware of who takes these decisions, the costs involved and any possibly pitfalls. If the pre-cooling and handling facilities are not up to scratch, the quality of the grower's fruit can be affected negatively. The grower also carries these costs and delays and inefficiencies will end up costing the grower money.

2.4. Shipping

The fruit is now loaded onto ships, either in containers, or as loose pallets. On the ship fruit must be kept at the temperature to which it has been pre-cooled, and is sometimes also exposed to cold a sterilisation treatment, depending on the market it is going to.

2.5. Receiving and Transport

When the fruit arrives in the overseas market, it is again handled in the harbour, sometimes stored, and transported to the point where it is sold to the consumer.

2.6. Sales

The fruit is now eventually sold to the consumer. The retailer adds on his profit margin, which is normally around 30% of the final costs, and the consumer buys the product.

The export agent or his logistics agent is also normally responsible for negotiating rates with shipping companies, managing the shipping and receiving process, and negotiating with the buyer or supermarket in the overseas market. The grower must however stay informed about all of these matters – it is his money that pays for all these services.

3. Regulations, Legislation and Market Requirements

3.1. Export Fruit Quality

The standards and requirements for export citrus, as stipulated in Government Notice no. 1983 of 23rd August 1991, require that consignments of citrus fruit destined for export must conform to certain quality, packaging, chemical treatment and phytosanitary requirements. Growers are normally informed of the details of these export standards and requirements by their export agents. It is important that every person involved in the production, harvesting and postharvest handling of citrus fruit are familiar with these regulations.

Having catered for different market sectors by means of different quality standards, it is important to ensure consistent compliance with those standards within each grade. Inspection of the final product is one way of doing this. It is the function of the Perishable Product Export Control Board to ensure that export citrus complies with the minimum standards set in the regulations. Fruit is inspected either inland at the various packhouses or at harbours prior to export.

Remember that inspections confirm compliance with standards, but cannot produce quality. Quality can only be produced by applying quality management throughout the production process in the orchard through to the packhouse.

3.2. Health and Safety

The Occupational Health and Safety Act of 1993 (OHSA) regulates the working environment to ensure the health and safety of persons at work and when using plant and machinery. It also provides for protection of persons other than those at work against hazards to health and safety arising out of activities of persons at work.

According to the OHSA, employers have the basic duty towards employees to provide and maintain a working environment that is safe and without risk to the health of the employees. A hygiene risk analysis encompassing, amongst others, harvesting procedures, should be carried out prior to harvesting and postharvest handling.

All identified actions should be communicated to all persons involved in the fruit handling process through training, and must be strictly enforced by supervisors and management. All such actions must be documented and monitored throughout.

3.3. Market Requirements

Apart from the requirements set out in export regulations, the various markets and importing companies have their own requirements with regard to internal and external quality as well as packaging. Most importers also require compliance with good agricultural practices as set out in GlobalGAP and other accreditation systems.

All exporters should therefore be fully aware of the specific requirements of the market they are consigning their fruit to, as non-conformance on arrival at the market will lead to fruit being discounted and a subsequent loss of income.

4. Postharvest 0uality Management

A quality management system to ensure top quality fruit in the market for maximum proceeds should include all the elements in the production and postharvest handling processes which will ensure the required quality fruit.

No planning process can be successful if it is not based on:

- Previous management experience
- A good information system, including production records
- Results of postharvest measures the previous season
- Results of the cull factor analysis of the previous season
- Packhouse reports of previous season
- Market feedback on fruit quality

It is important to bear in mind that once the fruit is harvested, its quality can no longer be improved – it can only be maintained or diminish. All actions from this point on should be carefully controlled through good management and controlled supervision and monitoring systems.

4.1. Monitoring of Harvesting

Harvesting must be monitored regularly, on an hourly and daily basis, with signed records to confirm compliance with the aspects listed in the harvesting checklist.

Apart from monitoring in the orchard, a cull analysis should be done on the fruit on arrival at the packhouse and the results communicated to all involved on a continuous basis for corrective measures to ensure a high quality harvesting process.

Careful harvesting and transport to the packhouse is essential to minimise injuries and preserve shelf-life. It also prevents the rupturing of oil glands in the rind, which causes oleocellosis and rind pitting. The picked fruit must be inspected by checkers at the bins and trailers during the picking process for long stems, injuries, plugging and that the picking bags are properly filled and do not contain rotten fruit as the picking bags are emptied.

4.2. Cull Factor Analysis

A cull factor analysis on fruit arriving at the packhouse provides information on the extent and nature of external quality defects, the presence of phytosanitary pests, and the decay potential arising from mechanical and insect damage to the fruit.

A random sample of fifty fruit per two to four tons is collected from the trailers or bulk bins as they are received. The fruit are sorted into categories and the percentages recorded. Fruit are normally sorted into these categories:

- Harvest defects (injuries, long stems, plugged fruit, button-less fruit)
- Decay factors (decay, false codling moth, fruit fly, damage, oleocellosis, creasing)
- Blemish factors (wind, thrips, scale, sunburn, bollworm)

Information on harvest defects should be fed back regularly to the picking teams. It may also be valuable in predicting decay potential and developing a decay control strategy. It further provides an early warning for the packhouse to adjust more rapidly to quality defects and forms a basis for planning the next season's production and crop protection program.

4.3. Traceability

The fruit arriving at the packhouse, and at any subsequent stage, should be traceable back to the particular orchard, picking team and date of harvest. Each trailer or bulk bin of fruit should be accompanied by a card or document on which indicating at least the name of the grower, the orchard reference, the variety, the receiving date, and the supervisor's signature.

To facilitate traceability, the time and date the fruit is received at the packhouse must be recorded on the abovementioned document. It must be filed or processed by date order to enable fruit to be traced back from any stage after packing to the day on which the fruit was packed and the orchards from which the fruit was harvested. The ability to trace fruit back to where it originated is a critical component of any quality management system.

5. Maintaining Postharvest Practices

Value is added to the crop in the packhouse by washing, treating, sorting and packing the fruit, resulting in a quality product that meets the requirements of the markets. Attributes including freedom from decay, long shelf-life and presentation are determined to a large extent by the effectiveness of the packhouse operation. For management purposes the packhouse can be divided into six operational areas, being:

- Receiving
- Washing
- Grading and labelling
- Sizing, packing and marking
- Carton erection
- Palletisation and despatch

An important requirement for effective operation in all the above areas is that the responsibility, authority and interrelation of the personnel who manage, perform and verify the quality of work in each of these areas must be clearly defined. Management must also identify and provide adequate resources and assign trained personnel for management, performance of work and verification activities including self-audits. Adding value to the crop goes hand in hand with a well managed and trained workforce from top management down to the workers at the lowest level.

An adequate recordkeeping system monitoring treatments and practices must be in place to ensure the effectiveness of processes.

It is important to identify all aspects which impacted negatively on the packhouse operation and fruit quality after each season. At this discussion, a critical assessment should be made of the packhouse, including design criteria, maintenance, organisation and management, packhouse sanitation, and purchasing and quality of all materials.

Any structural changes or alterations to the machinery and other supporting equipment must be planned well ahead and done as soon as possible after completion of the previous season. The whole packhouse should be inspected, serviced and equipment overhauled where necessary to ensure that downtime will be kept to a minimum during the ensuing season.

Worn belts, conveyors, brushes, and so on, must be replaced before commencement of the packing season. Management must ensure that as far as can be foreseen, the equipment will not injure or contaminate the fruit and that grading, sizing, labelling and packing equipment is in good working order.

It is also necessary to ensure good monitoring of all equipment during the packing season. In-season checks should be part of the operational directives and done and recorded on a daily and weekly basis.

6. Postharvest Health and Hygiene

The Occupational Health and Safety Act of 1993 (OHSA) provides for the health and safety of persons at work and when using plant and machinery. It also provides for protection of persons other than those at work against hazards to health and safety arising out of activities of persons at work.

The legislation on health and hygiene, as well as requirements for registration for GlobalGAP and other systems, clearly states the conditions for employees and non-employees in a working environment. A well-documented risk analysis covering the complete process from production to despatch should form the basis of determining actions and facilities to ensure a healthy work environment.

Audits of all the processes identified under the quality management system should be carried out on a regular basis and preferably by staff who are independent of the operation or process being audited, or an external agency. The results of the audits and corrective actions taken should be recorded and subject to ongoing management assessment or review of the effectiveness of the system.

Apart from the legal requirements, registration for GlobalGAP also requires a number of specific actions with regard to postharvest handling of produce:

- Although only categorised at a minor level for compliance, a hygiene risk analysis should be performed for the produce handling process. It should be well-documented and cover the complete process up to the point of despatch to the market.
- Training and instruction of workers with regard to the relevant aspects of produce handling hygiene must be recorded with signed acknowledgement by the workers of receiving the training and instructions.
- The implementation of the actions identified in the risk analysis should be visible, documented and monitored on a regular basis.
- Water used for washing the final product should be potable and declared safe for use by the competent authorities.
- Re-circulated water should be filtered and pH, concentration and exposure levels to disinfectants regularly monitored. Water analysis should be carried out by an accredited laboratory.
- All postharvest treatments must be applied as prescribed by trained employees and be thoroughly documented.
- All products used to treat the fruit must be officially registered, permitted by the appropriate governmental organisation, and allowed under the regulations of the country of destination.

All actions and activities emanating from the regular audits should become part of a permanent management culture of training, monitoring and assessing in the organisation. It should also be included in the agendas of the safety committee meetings for noting and action. If that is not the case and a lot of actions were for instance identified for GlobalGAP registration, but not followed up thereafter, old habits and practices will quickly again become the norm.

Examples of good practices and the effects of non-compliance are:

- Training and instruction must be documented. If this is not documented nobody will know who has received training or what instructions have been given.
- Employees must acknowledge training and their understanding of their instructions in writing. It is important to be sure that they comprehend the detail of the job they are required to do.
- Workstations and the environment must be assessed to determine their effect on sight, hearing and fatigue. The quality of work and employee's health can suffer if these aspects are not addressed.

- Regular audits must be conducted by independent staff or an external body of all processes. Regular staff members sometimes do not see mistakes or deviations from procedures.

- Audit results and corrective measures must be recorded. It is important in the process of ensuring that actions were actually taken and determining recurring problems.

Chapter 8

- The postharvest system includes all the processes and actions that fruit is subjected to after it is harvested.
- At the point when citrus has been harvested and delivered to the packhouse, the grower has only spent around 11.5% (2009 industry average) of the money that he will eventually spend on his export fruit before he can expect any return.
- In order to plan and manage the postharvest system, it is important to first of all understand the links that make up this part of the value chain, being packing, transport, harbour handling, shipping, receiving and transport, and sales.
- The standards and requirements for export citrus require that consignments of citrus fruit destined for export must conform to certain quality, packaging, chemical treatment and phytosanitary requirements.
- The Occupational Health and Safety Act of 1993 (OHSA) regulates the working environment to ensure the health and safety of persons at work and when using plant and machinery.
- Apart from the requirements set out in export regulations, the various markets and importing companies have their own requirements with regard to internal and external quality as well as packaging.
- A quality management system to ensure top quality fruit in the market for maximum proceeds should include all the elements in the production and postharvest handling processes which will ensure the required quality fruit.
- Harvesting must be monitored regularly, on an hourly and daily basis, with signed records to confirm compliance with the aspects listed in the harvesting checklist.
- A cull factor analysis on fruit arriving at the packhouse provides information on the extent and nature of external quality defects, the presence of phytosanitary pests, and the decay potential arising from mechanical and insect damage to the fruit.
- The fruit arriving at the packhouse, and at any subsequent stage, should be traceable back to the particular orchard, picking team and date of harvest.
- Value is added to the crop in the packhouse by washing, treating, sorting and packing the fruit, resulting in a quality product that meets the requirements of the markets.
- The legislation on health and hygiene, as well as requirements for registration for GlobalGAP and other systems, clearly states the conditions for employees and non-employees in a working environment.

Complete activity 15 and 16 in the **Learner Workbook**.

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