

**VALIDATING AND EXTENDING THE FARM SITE
DEVELOPMENT METHOD**

by

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Executive Summary

This report consists out of the final year project that is completed for the BPJ 410 and BPJ 420 modules, in order to successfully complete a degree in industrial engineering.

The focus of this project is on extending a new method known as the *farm site development method* that is developed by focusing on *industrial engineering techniques*. This new method allows farmers / farm managers to expand the critical resources involved in production as well as the farm to a fully saturated state. During the process of circumscription of this method in 2013; certain deficiencies were identified where improvements can be made.

This report focuses on the project approach and the deliverables, as well as an extensive literature study regarding the industrial engineering techniques that is used to extend the *farm site development method* based on the identified deficiencies. These techniques include: (1) demand forecasting techniques, (2) cash flow projections, (3) multi-criteria decision making, and (4) utility criteria that is used to evaluate the farm site development method.

The new and extended farm site development method is evaluated by demonstrating a practical example at a crop growing farm in KwaZulu-Natal. The implementation of this method allows the designers to identify further deficiencies that will improve the farm site development method.

The demonstration includes a number of industrial engineering techniques, such as engineering economics, the forecasting of future cash flow for the farm, calculation of the saturation date and the expected growth in future production. This demonstration does not include the completion of all of the steps of the FSDM, but only the critical steps that are affected by the changes and extensions.

The demonstration of the extended farm site development method identified another important extension point that increases the utility of the method. Not all resources that are used during production are *critical* resources (which are defined as resources that can run out of capacity), but in some cases the business might have a decision to make regarding other resources that influences the business operations. These resources are decision based and the outcome of each decision will influence the future business operating model. The farm site development method is also extended in order to accommodate farms that have such decisions to make.

Finally, a sensitivity analysis tests the assumptions made during the evaluation of resources and evaluates the model in terms of future uncertainties. Further deficiencies in the farm site development method are also identified and recommendations are included which will improve the farm site development method when addressed in future work.

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1. Introduction and Background

1.1 Introducing South African Agriculture

South Africa is a diverse country not only when it comes to the different cultures of the estimated 52 million people living here (Statistics South Africa, 2011), but also when considering agricultural regions with a range of different climates, soil and vegetation types. The agricultural industry plays an important role in South Africa's developing economy and contributes towards the country's gross domestic product (GDP). The agricultural sector also increases food security, social welfare, and job creation. Therefore, farming practices must ensure profitable yields, the well-being of farmers and farm workers as well as the long-term productivity of the land. (Goldblatt, 2009)

The application of agricultural engineering techniques aims to increase the effectiveness of farming operations which will also increase the productivity of the farm that it is applied to. South Africa's total land area is 1 214 470 km² of which 11.9% is arable land. (Trading Economics, 2012). "Arable land is soil that is enriched with nutrients and is ready for the production of crops and plants." (van der Merwe, 2013). It is important that this arable land is utilised for farming activities to ensure that it does not become non-arable or wasteland.

The *farm site development method* (FSDM) is a new method that incorporates facility planning techniques as well as *roadmaps* from the enterprise engineering focus area in order to advance farm facilities in a phased approach towards its saturation-state (van der Merwe, Liebenberg, & de Vries, 2014). The FSDM assists farmers in the long-term planning of their arable land as well as critical resources, utilities, services, and structures in the form of a *facility development plan* (FDP).

This project builds on work that was done by Ronè van der Merwe in 2013. In 2013 the FSDM was developed by combining industrial engineering techniques and by using design research as a research methodology. The FSDM is also evaluated by using a practical demonstration at Waterfall Farm. During this demonstration certain requirements are identified that can be completed in order to extend and enhance the current FSDM. This project focuses on literature regarding the identified deficiencies in order to develop an extended FSDM. After the extended FSDM is developed, it is re-applied at Waterfall Farm for further evaluation.

1.2 Waterfall Farm Background

Waterfall Farm is a start-up operation near the town of Mooi River in KwaZulu-Natal that experiments with a variety of crops such as cabbage, potatoes, and a range of lettuce types. After a devastating hail storm in November 2013 all of the existing crops were destroyed and only cabbage crops were replanted at the end of January 2014. Although only cabbage crops are planted at the moment, the long-term plan of the farm is to continue with the production of the potatoes and the 3 main categories of the lettuce products as well. These categories are: (1) exotic varieties, (2) crisp varieties, and (3) baby leaf varieties.

The agricultural production process as described by van der Merwe (2013) is shown in Figure 1. This is the basic process that is used for all of the products that are grown on the farm.

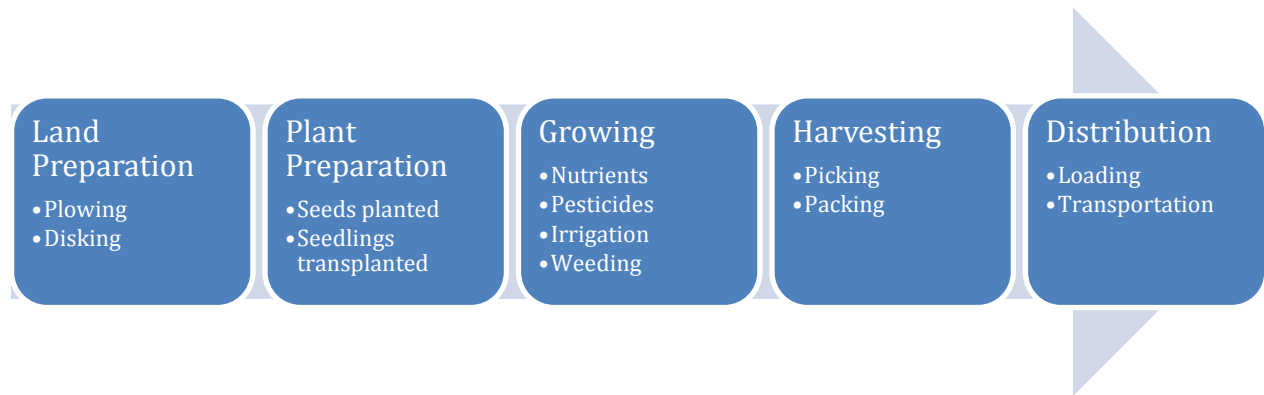


Figure 1: Agricultural Production Process

The growth time of the crops is also dependant on the season of the year. For instance, cabbage and lettuce will take less time to grow in the summer than it does in the winter, where potatoes have a constant growth time throughout the year.

Waterfall Farm supplies the produced crops to one main formal customer, Littlemore Farm. Littlemore Farm requires such a high volume of products that it is not possible for Waterfall Farm to have agreements with other customers, even at saturation-state. Therefore, Waterfall Farm can sell all of the produce that they have available to Littlemore Farm and the demand is not a constraint when implementing the FSDM.

For additional income, Waterfall Farm has the opportunity to deliver the products produced by local farms to their customers. This is a good opportunity for the farm to secure income that will help in expanding the farm to its saturation-state, especially after all crops have been destroyed due to the hail storm and there were no income between November 2013 and January 2014.

2. Project Aim / Rationale

The main deliverable of this project is the *extended FSDM* that will incorporate the additional requirements that were identified during the first design cycle of research. The FSDM steps as described by van der Merwe, Liebenberg & de Vries, (2014) are:

1. Analyze the current-state facility layout,
2. Calculate the saturation-state for the farm (compile a saturation-state facility layout).
3. Determine production requirements and the saturation date.
4. Identify critical resources, utilities, services and structures (RUSS) and design criteria.
5. Identify and evaluate alternatives for RUSS replacement / extension.
6. Compile a series of phase plans, called the facility development plan.
7. Represent the phase plans graphically in support of the facility development plan.
8. Validate the facility development plan.

The deficiencies that will be addressed in this project are:

- Forecasting / demand planning techniques should be incorporated during the 3rd step (determine production requirements and the saturation date) of the FSDM.
- Cash flow and budget cycles should be considered during the 6th step (compile a series of phase plans, called the facility development plan) of the FSDM.
- Multi-criteria decision making should be considered as an alternative for evaluating the design criteria in the 6th step of the FSDM.
- The final step of the FSDM (validate the facility development plan) should be further extended to incorporate verification. Ensuring that the facility development plan complies with initial requirements / design criteria.

Since the initial development of the FSDM was not developed in accordance with best practices on method design, this study will also incorporate method refinements to increase both utility and ease-of-use.

3. Project Approach, Scope, and Deliverables

The FSDM is extended by applying the five steps of the design cycle, as defined by Vaischnavi and Keuchler (2008):

1. *Awareness of a problem:*
Identifying the need to extend the FSDM to address the several deficiencies identified by van der Merwe, Liebenberg & de Vries in the article: A Farm Site Development Method: Creating a Roadmap Towards Site Saturation.
2. *Suggestion:*
Suggesting the extension of the existing FSDM to address the identified deficiencies; also increase the utility of the FSDM.
3. *Development:*
Developing the extensions of the FSDM, based on design theories, cash flow projection techniques and forecasting techniques.
4. *Evaluation:*
Evaluating the extended FSDM by demonstrating / applying the extended FSDM at Waterfall Farm.
5. *Conclusion:*
Interpreting evaluation results and recommending future work.

In terms of the *evaluation* step (step 4), the FSDM will be applied to Waterfall Farm. Expected deliverables that are produced as a result of the evaluation are given in the following table.

	FSDM Steps	Industrial Engineering Techniques and Tools	Demonstration Deliverable
1	Analyze the current-state facility layout.	Facility layout using appropriate drawing program.	Current-state facility layout.
2	Calculate the saturation-state for the farm (compile a saturation-state facility layout). Determine if additional requirements / constraints should be considered.	Maximum possible production rate.	Saturation-state and saturation-state facility layout.
3	Determine production requirements and the saturation date.	Forecasting techniques.	Saturation date.
4	Identify critical / farmer-prioritised resources, utilities, services and structures (RUSS) and design criteria.	Multi-criteria decision making.	RUSS to evaluate and design criteria.
5	Identify and evaluate alternatives for RUSS replacement / extension.	Multi-criteria decision making.	Restoration dates for RUSS.
6	Compile a series of phase plans, called the facility development plan.	Cash flow and budgeting.	Facility development plan.

	FSDM Steps	Industrial Engineering Techniques and Tools	Demonstration Deliverable
7	Represent the phase plans graphically in support of the facility development plan.	Facility layout of sequential phases using AutoCad.	Graphical representation of facility development plan.
8	Validate the facility development plan.	Verification method.	Finalised facility development plan.

Table 1: Deliverables and Industrial Engineering Techniques per step of the FSDM

In addition, the extended FSDM is evaluated and adapted in terms of utility. The literature study will highlight the utility criteria that will be addressed during design, but also evaluated / validated during the evaluation step of the design cycle (demonstration at Waterfall Farm).

4. Literature Review and Problem Investigation

4.1 Introduction

The purpose of the literature review is to convey theoretical background regarding the industrial engineering techniques and tools (listed in Table 1) that are applied in this project. Section 4.2 provides a detailed explanation of forecasting techniques that can be used to estimate future demand. Section 4.3 discusses the budgets that are required in order to estimate the future cash flows of a business. Section 4.4 is an overview of the utility of the FSDM and section 4.5 describes the analytical hierarchy process used in multi-criteria decision making.

4.2 Forecasting

Forecasting is a planning tool that helps management to deal with the uncertainties in the business environment such as the prediction of future demand of products. According to Chase and Jacobs (2011) forecasts are crucial in every business as it forms the basis for long-term planning and supports significant management decisions. They also divide forecasting techniques into four categories: (1) qualitative techniques, (2) time series analysis, (3) causal relationships, and (4) simulations. Each of these categories has a number of different techniques which will be discussed in this literature review; with the main focus on the time series analysis category.

Time series analysis suggests that for a specific product there is a relationship between the historical demand and the future demand, making this technique time dependant. The time series analysis techniques therefore use the historical demand data in order to predict the future demand. *Causal relationship techniques* also use previous demand data, but assume that the demand is related to an underlying factor in the environment or dependant on another variable (Jacobs & Chase, 2011). In contrast, *qualitative techniques* are subjective and the future demand is predicted based on estimates and the opinions of people. These methods are used when the situation is vague and no historical data is available (Bozarth, 2011).

When choosing the most suitable type of forecast for a business it is important to consider the following factors: time horizon to forecast, data availability, accuracy required, size of forecasting budget, and availability of qualified personnel (Jacobs & Chase, 2011). Another important consideration when applying forecasting in a business is the fact that almost all forecasts will be wrong. Coyle et al. (2009) describes that the ultimate goal of forecasting is to minimize the error between the actual demand and the forecasted demand. This literature study will also include information on the types of forecasting errors that should be taken into account when applying the forecasting techniques in industry.

The purpose of this investigation is to perform a detailed analysis of the different forecasting techniques in order to determine under which circumstances each technique can be used. After the investigation it would be possible to extend the current FSDM and incorporate the applicable forecasting techniques in a way that it is easy to use and that it supports the purpose and structure of the FSDM.

4.2.1 Time Series Analysis

The first step when using forecasting techniques is to plot a graph of the existing demand data on a suitable program (such as Microsoft Excel). The plotted graph will indicate which type of forecasting technique is suitable; as the applicable components of demand will be identified. Chase and Jacobs (2011) describes six components of demand: (1) average demand for the period, (2) a trend, (3) seasonal elements, (4) cyclical elements, (5) random variation, and (6) autocorrelation.

Chase and Jacobs (2011) lists the six main types of time series forecasting techniques as: (1) Linear regression analysis, (2) decomposition of a time series (seasonal and trend effects), (3) weighted moving average, (4) exponential smoothing, and (5) exponential smoothing with trend.

The basic symbols that will be used to explain these techniques are:

- F_t: Forecasted or future demand for period t.
- A_t: Actual demand for period t.
- t: The self-determinable time interval or periods used in the forecast. For example if monthly forecasts are done; t would range between the numbers 1 to 12; where each number represents a particular month in the year.

Linear Regression Analysis

The term regression can be defined as a functional relationship between two or more correlated variables. When the demand for a product follows a linear growth over time, linear regression should be used to forecast the future demand (Jacobs & Chase, 2011).

The historical demand data of a product should be plotted on a graph where the y-axis shows the demand (number of products sold) and the x-axis indicates the change over time. A linear line of best fit is drawn and the formula of a straight line is used to estimate future demand.

The aim of the *least squares method* as described by Chase and Jacobs (2011) is to fit the line to the data by *minimizing the sum of the squares of the vertical distance* between each data point. Microsoft Excel has a very powerful regression tool that will automatically calculate the equation for the line of best fit for a specified data range. This equation, in the form of $Y = a + bx$, can be used to estimate the future demand.

Simple Moving Average

This method is used when the demand of a product is neither growing nor declining rapidly and there are no seasonal characteristics (Jacobs & Chase, 2011). This method simply averages a predetermined number of periods' demand data (A_t) and uses this average as the forecast (F_t) for the next period (Coyle et al., 2009).

The formula that is used as described by Chase and Jacobs (2011) is as follows:

$$F_t = \frac{A_{t-1} + A_{t-2} + \dots + A_{t-n}}{n}$$

where n is the number of periods used. When choosing n it is important to understand that the impact of shorter and longer moving averages on the forecast. By increasing the number of periods a smoother forecast will be given that will be more likely to overlook the trend in demand; where a smaller number of periods will produce more oscillation that will follow the trend more closely.

Weighted Moving Average

The main difference between the simple moving average and weighted moving average method is that the simple moving average method assigns an equal weight to the previous data, where the weighted moving average method assigns a different weight towards the data of each previous period (Coyle et al., 2009).

Usually when performing this forecasting technique higher weight is usually given to more recent demand, thus emphasize is placed on more recent demand as the predictor of future demand (Coyle et al., 2009). It is important to note that the weights must add up to 1.

Chase and Jacobs (2011) describes the formula used for the weighted moving average method as follows:

$$F_t = w_1A_{t-1} + w_2A_{t-2} + \dots + w_nA_{t-n}$$

where w_n is the weight associated with period n. Seasonality will affect the weights chosen for each period and higher weights should be given to the periods when the demand is usually higher.

Exponential Smoothing

The three types of data required for this technique are the most recent forecast, the actual demand that occurred for that forecast period, and a smoothing constant alpha (α). This method requires less data than the simple and weighted moving average method because with every new piece of data that is added the oldest observation is dropped (Jacobs & Chase, 2011). The formula used for the exponential smoothing technique is also described as follows:

$$F_t = F_{t-1} + \alpha(A_{t-1} - F_{t-1})$$

where α is the exponential smoothing constant that determines the level of smoothing and the speed of reaction to differences between the forecasted and actual data. The α value must be between 0 and 1 and should be chosen on a trial and error basis by keeping in mind that a smaller α suggests a more stable demand. The simple exponential smoothing method is not suitable for products with a trend demand and in such cases the exponential smoothing with trend method will be more suitable (Coyle et al., 2009).

Exponential Smoothing with Trend

This method is used for products with a linear trend in the demand and is not suitable when seasonal effects are present. There are two methods that can be used when forecasting data with a trend. The first method that is discussed is simpler and uses the demand data of the previous period in order to estimate the demand for the following (future) period; where the second method (also known as Holt's Method) can be used to estimate not only the following period's demand, but the demand of any period in the future. Further explanation of these methods will make it more understandable.

The exponential smoothing with trend technique is an extension of the simple exponential smoothing forecasting technique and includes another constant; the smoothing constant delta (δ) for method 1; or the smoothing constant beta (β) for method 2. These smoothing constant adjusts the forecast for trend and reduces the forecast error (Coyle et al., 2009). The α , β , and δ values should be between 0 and 1 and based on the stability of the demand, as described in the exponential smoothing method.

Method 1:

The 3 formulas that are used for this technique is described by Chase and Jacobs (2011) as follows:

$$\begin{aligned} FIT_t &= F_t + T_t \\ F_t &= FIT_{t-1} + \alpha(A_{t-1} - FIT_{t-1}) \\ T_t &= T_{t-1} + \delta(F_t - FIT_{t-1}) \end{aligned}$$

FIT_t is the *forecast including trend* for period t ; which is calculated by summing the *exponentially smoothed forecast for period t* (F_t) and the *exponentially smoothed trend for period t* (T_t). Chase and Jacobs (2011) also explains that when this forecasting technique is done for the first time, the previous forecasted value (FIT_{t-1}) must be entered manually and based upon an educated guess or by observing previous data.

Method 2 (Holt's Method):

Winston (2004) describes Holt's method by defining a base level (L_t) and a per-period trend (T_t). The base level and trend estimates are calculated by using the following formulas:

$$\begin{aligned} L_t &= \alpha A_t + (1 - \alpha)(L_{t-1} + T_{t-1}) \\ T_t &= \beta(L_t - L_{t-1}) + (1 - \beta)T_{t-1} \end{aligned}$$

The forecast $f_{t,k}$ is the forecast for period x_{t+k} made at the end of period t and is calculated by this formula:

$$f_{t,k} = L_t + kT_t$$

To explain this formula, let t be an integer ranging from 1 to 12 that each represents a different month of the year. Now, let us assume that the forecast of August (month 8) is required at the end of June (month 6). The forecast formula would be written like this:

$$f_{6,2} = L_6 + 2T_6$$

Holt's method allows the forecast to be calculated for *any* future period given the current demand data, where the first method can only calculate the forecast for the *next* time period. Therefore, Holt's method should be used when long term planning and forecasting is required.

When Holt's method is used for the first time, the L_{t-1} and T_{t-1} values should be estimated by using these guidelines:

- T_0 should be set equal to the average period increase during the previous year.
- L_0 should be set equal to the last period's observation.

Decomposition of a Time Series

This section will explain two forecasting techniques. The first technique known as *Winter's method* is used when seasonal and trend effects are present. The second technique can be used when only seasonal effects are present and no trend.

Method 1: Winter's method

Winston (2004) explains the Winter's Method by calculating L_t (the base level), T_t (per-period trend), and s_t the estimate of a seasonal multiplicative factor by using these formulas:

$$L_t = \alpha \frac{x_t}{s_{t-c}} + (1 - \alpha)(L_{t-1} + T_{t-1})$$

$$T_t = \beta(L_t - L_{t-1}) + (1 - \beta)T_{t-1}$$

$$s_t = \gamma \frac{x_t}{L_t} + (1 - \gamma)s_{t-c}$$

c = number of periods in length of the seasonal pattern, for example $c = 4$ for quarterly data, etc.
 α , β , and γ are smoothing constants with values that range between 0 and 1.

At the end of period t , the forecast ($f_{t,k}$) for period $t+k$ is given by:

$$f_{t,k} = (L_t + kT_t)s_{t+k-c}$$

In order to initialize Winter's Method, initial seasonal factors, base, and trend estimates are required. These estimates can be calculated when the sales data of two previous years are available. An example will be used to explain the estimates. If seasonal trends are monthly, therefore $c = 12$, with the previous 2 years' sales data known as "year -1" and "year -2"; the estimates will be:

$$T_0 = \frac{(\text{Average monthly sales year } - 1) - (\text{Average monthly sales year } - 2)}{12}$$

$$L_0 = (\text{Average monthly demand during year } - 1) + 5.5T_0$$

To estimate the seasonal factor for a given month, the *estimate* for that particular month's seasonality for year -1 and year -2 is taken and then averaged. This *estimate* is calculated by dividing the number of sales for the particular month by the average monthly sales of the year.

Method 2: Simple proportion seasonal decomposition

In this method as defined by Chase and Jacobs (2011), the past sales data is used to calculate a seasonal factor (based on the number of periods in a season). The *average sales for each season* are calculated by dividing the total number of sales with the number of seasons (c). The value for the *average sales for each season* will be the same for all of the seasons.

$$\text{Average sales for each season} = \frac{\text{Total sales per year}}{c}$$

The *seasonal factor* can then be calculated by dividing the sales per season with the average sales for each season. This value will be different for every season.

$$\text{Seasonal factor} = \frac{\text{Sales per season}}{\text{Average sales for each season}}$$

This *seasonal factor* is then used to calculate the expected demand for the next period, by multiplying the *average expected demand of the next period* (calculated by dividing the expected demand with c) with the *seasonal factor*.

4.2.2 Forecasting Errors

Seeing that forecasts are only estimates and that the demand for a product is generated through the interaction of a number of factors too complex to describe accurately in a model, there will always be a difference between the actual demand and the forecasted demand for a single period (Jacobs & Chase, 2011). The best forecasting technique to use will thus be the technique that minimizes the error.

The *mean absolute deviation* (MAD) error and the *mean absolute percent error* (MAPE) are the two main types of forecasting errors. These two errors will be explained as discussed by Chase and Jacobs (2011).

Mean Absolute Deviation Error:

In simple terms, MAD is the average error in the forecasts that is determined by using the absolute difference between the actual and forecasted demand. The formula for MAD is:

$$MAD = \frac{\sum_{t=1}^n |A_t - F_t|}{n}$$

Mean Absolute Percent Error:

The MAPE simply takes the MAD and divides it by the average demand. This measurement indicates how much error to expect with a forecast. The formula for MAPE is:

$$MAPE = \frac{MAD}{Average\ demand}$$

4.3 Summary of Forecasting

Table 2 is a summary of the forecasting methods that are discussed in Section 4.2 with the advantages and disadvantages of each method.

Forecasting Technique	When to use	Advantages	Disadvantages
Linear regression	Linear trend	Easy to use and simple.	Limited application.
Winter's Method	Both seasonal and trend effects	More than one future period can be forecasted in advance.	
Simple proportion seasonal decomposition	Only seasonal effects	Easy to use.	
Simple Moving Average	Demand not growing, nor declining & no seasonal effects	Easy to use.	Requires large amounts of historical data.
Weighted Moving Average		The effects of past data can be varied unlike the simple moving average. More accurate than simple moving average method.	More inconvenient than <i>exponential smoothing</i> . Requires large amounts of historical data.
Simple Exponential Smoothing		Limited number of data required. Simple and easy to use.	The shortcoming of lagging changes in demand,
Exponential Smoothing with Trend – Method 1	Trend effects without seasonality	Simpler than <i>Holt's Method</i> .	Only the next period can be forecasted.
Exponential Smoothing with Trend – Holt's Method		More than one future period can be forecasted in advance.	More complex than the <i>1st method for exponential smoothing</i> .

Table 2: Summary of forecasting techniques (time series analysis)

For the purpose of the FSDM it is suggested that *Holt's method* is used to do the forecasting on a yearly basis. This technique will incorporate the trend effects of demand and is easy to use. It is important to note that the demand will not always be the driver of the FSDM. In cases where the demand is greater than the saturation capacity of the farm, cash flow rather than demand will be the driver.

4.3 Cash Flow Projections

4.3.1 Introduction to Budgeting

To be able to successfully apply budgeting in the FSDM a basic understanding of the different cost classifications in an organization is essential. The two main categories of costs in a business as described by Seal, Garrison & Noreen (2012) are: (1) product costs, and (2) period costs.

Product costs can be described as all the costs that are involved in acquiring or making a product and are shown in Figure 2.

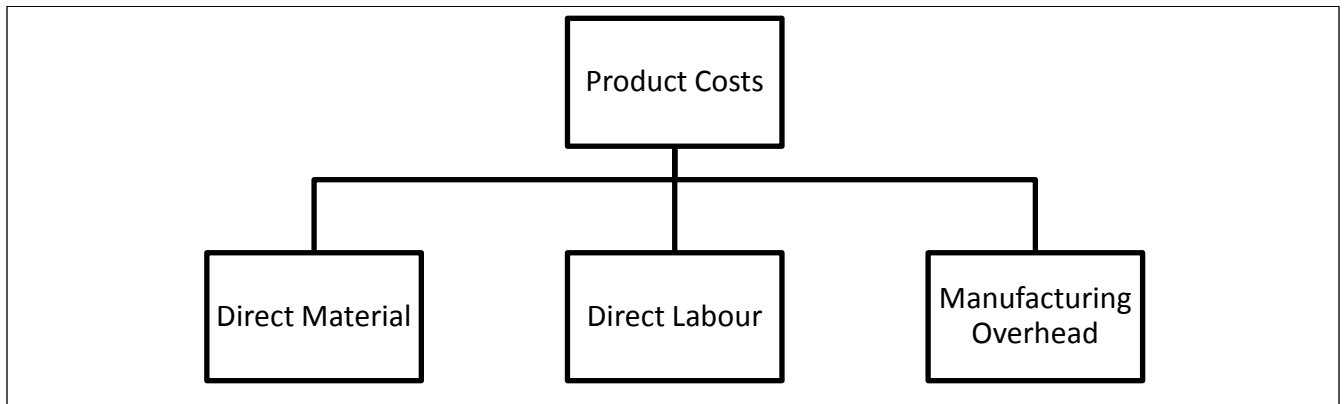


Figure 2: Product Costs of a Business

Direct material is materials that can be physically traced to a product and *direct labour* is the labour costs that can be physically traced to a product. *Manufacturing overhead* are costs associated with manufacturing a product that cannot be traced directly to the product itself, such as indirect materials, indirect labour, utilities, etc.

Period costs are also known as non-manufacturing costs and include: (1) marketing or selling costs, and (2) administrative costs as shown in Figure 3.

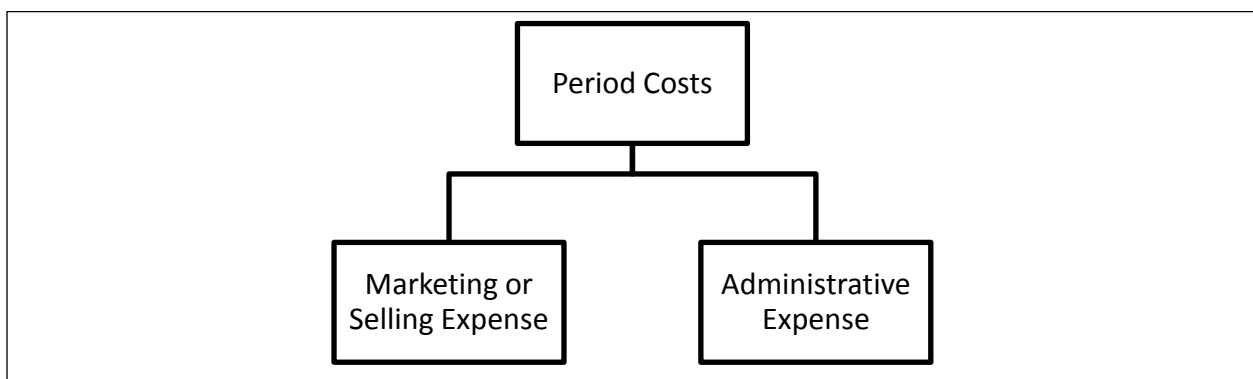


Figure 3: Period Costs of a Business

Furthermore, it is important to differentiate between *variable* and *fixed* costs. Seal, Garrison & Noreen (2012) defines *variable cost* as a cost type that varies in direct proportion to the level of

activity. For example: more materials and water & electricity will be required when more products are produced. *Fixed costs* on the other hand are costs that remain constant regardless of the level of activity, such as rent for equipment or property.

According to Seal, Garrison & Noreen (2012) a budget represents a plan for the future acquisition and use of financial and other resources. The implementation of budgeting techniques in the FSDM will lead to a more practical and useful FDP. When the long-term planning of critical resources, utilities, services, and structures are done, the expected cash flows (including all revenues and expenses) of the business will be considered in order to compile phases of the FDP that are realistic and achievable considering the business’s financial position.

There are a number of different budgets that need to be compiled to ensure successful budgeting. Figure 4 illustrates the different budgets that play a role as well as the relationships between these budgets.

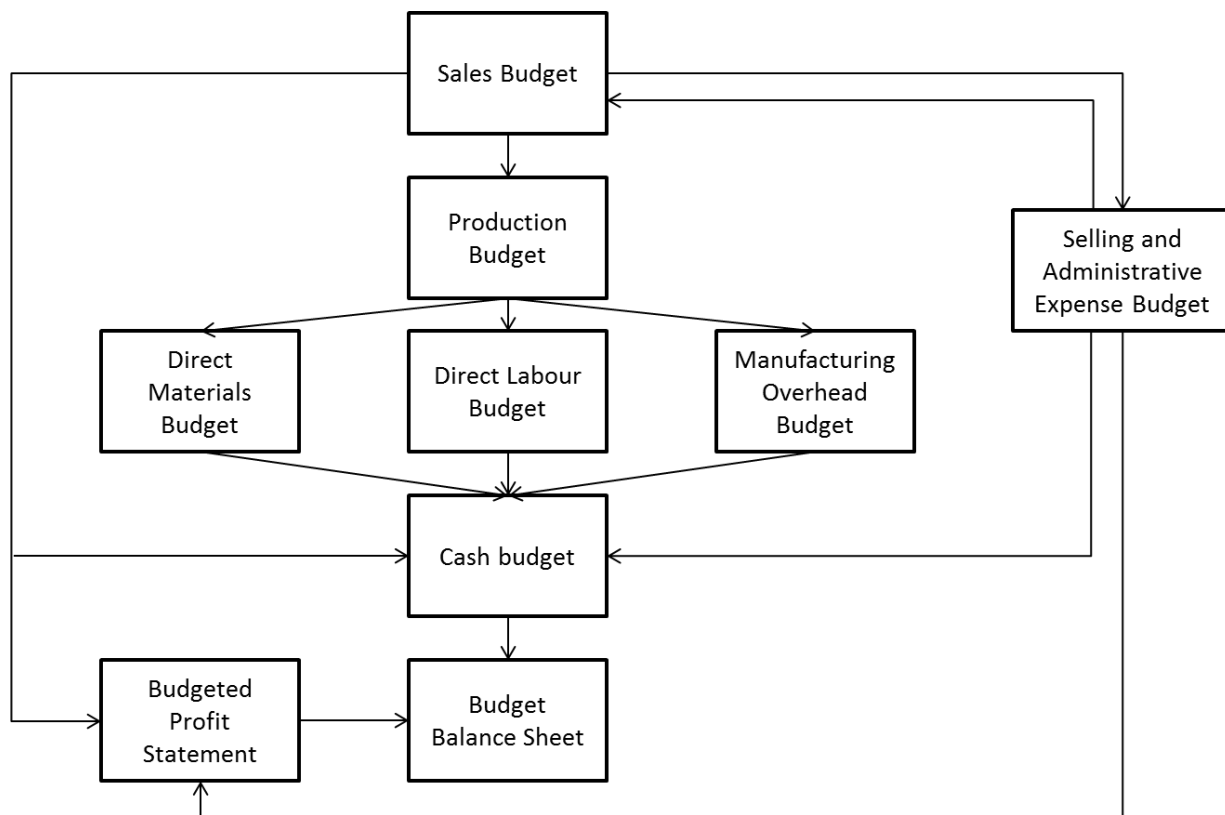


Figure 4: Master Budget Inter-relationships (Seal, Garrison & Noreen, Exhibit 11.2, p441)

The budgets that are shown in Figure 4 will be discussed in detail in section 4.3.2 to 4.3.5.

4.3.2 The Sales and Production Budgets

According to Seal, Garrison and Noreen (2012), an accurate *sales budget* plays a key role in the entire budgeting process. All other budgets used in an organization are based on the outcomes of the sales budget. A lot of inputs are required to set up the sales budget. The main component or input is the amount of stock/produce that should be available at the determined timeframe to be sold. This component, the amount of stock that should be available, will be forecasted using historical data and the forecasting methods that are discussed in section 4.2 of this report. In short, the *sales budget* is the money forecasted that will be available due to the forecasted amount of produce being sold at a predetermined price.

Figure 5 is adapted from Seal, Garrison & Noreen (2012) and shows the outline of the sales budget.

Business Name				
Sales Budget				
for the period of _____				
	Year			
	2014	2015	2016	2017
Forecasted sales amount (units)				
Selling price per unit -R				
Total Sales - R				
Schedule of expected cash collections				
	2014	2015	2016	2017
Debtors beginning balance	xxx			
Sales for 2014				
Sales for 2015				
Sales for 2016	Amount of sales for 2014 collected in 2014		Amount of sales for 2014 collected in 2015	
Sales for 2017				
Total cash collections - R				

Figure 5: Outline of a Sales Budget

After the sales budget is set up, a *production budget* is needed to determine the amount of produce that will have to be delivered to fulfill the forecasted amount of sales. The outline of the production budget as adapted from Seal, Garrison & Noreen (2012) is shown in Figure 6.

The *required amount of production* is calculated by using the forecasted sales and adding the losses that are usually encountered in production as well as the desired ending stock. The desired ending stock amount will depend on management and is usually the safety stock levels of a product.

It is also important to note that the desired ending stock of a product for a certain year will equal the beginning inventory of the subsequent year.

Business Name				
Production Budget				
for the period _____				
(in units)				
	Year			
	2014	2015	2016	2017
Forecasted sales				
Add: Additional production due to losses				
Add: Desired ending stock of product				
Equals: Total needs				
Less: Beginning inventory				
Equals: Required production				

Figure 6: Outline of a Production Budget

After the production budget has been compiled it will be possible to determine whether there is sufficient critical resources, utilities, services, and structures at a certain point in time. If the amount of critical RUSS that are necessary for the *required production* exceeds the amount of critical RUSS that are available, additional critical RUSS must be acquired.

The direct material, direct labour and manufacturing overhead budgets can be compiled after the production budget and is explained in the next section.

4.3.3 The Direct Material, Direct Labour, and Manufacturing Overhead Budgets

Direct Materials Budget

The *direct materials budget* details the raw material that must be purchased to fulfill the production budget and to provide adequate stock. The direct materials budget uses the *required production* that was calculated in the *production budget* as an input. The *required production* in units is multiplied with the *raw materials needed per unit* in order to determine the production needs. The amount of raw materials that must be purchased are then calculated by considering the desired stock levels of raw material and the stock on hand. Figure 7 shows the outline of a direct materials budget as adapted from Seal, Garrison & Noreen (2012). The beginning stock of raw material for a certain year is equal to the desired stock of raw materials of the preceding year.

Business Name				
Direct Materials Budget				
for the period of _____				
	Year			
	2014	2015	2016	2017
Required production (units)				
x Raw materials needed per unit				
Equals: Production needs				
Add: Desired stock of raw materials				
Equals: Total needs				
Less: Beginning stock of raw materials				
Equals: Raw materials to be purchased				
Cost of raw material to be purchased				

Schedule of expected cash disbursements for materials				
	Year			
	2014	2015	2016	2017
Creditors, beginning balance				
Purchases for 2014				
Purchases for 2015				
Purchases for 2016				
Purchases for 2017				
Total cash disbursements				

The amount of 2014's purchases that will be paid in 2014.
The amount of 2014's purchases that will be paid in 2015.

Figure 7: Outline of a Direct Materials Budget

Direct Labour Budget

As with the direct materials budget, the direct labour budget is used to determine whether the business has sufficient labour time available to meet production needs. To do this the direct labour budget needs the direct labour time that is used per unit of production. The *required production units* that were calculated in the production budget is multiplied by the *direct labour time per unit* to calculate the number of direct labour hours needed in production. Figure 8 illustrates the outline of a direct labour budget, as adapted from Seal, Garrison & Noreen (2012).

Business Name				
Direct Labour Budget				
for the period of _____				
	Year			
	2014	2015	2016	2017
Units to be produced				
x Direct labour time per unit				
Equals: Total hours of direct labour time needed				
x Direct labour cost per hour				
Equals: Total direct labour cost				

Figure 8: Outline of a Direct Labour Budget

Manufacturing Overhead Budget

As discussed in section 4.3.1 the manufacturing overhead costs cannot be traced directly to each product. These costs are necessary in order to produce the product, but it cannot be “seen” in the finished product itself. Typical costs include water and electricity, rent of production equipment, indirect labour (such as routine checks on production equipment), indirect material (materials that are used in order to produce the product but are difficult or impossible to trace to a product), etc. Seal, Garrison & Noreen (2012).

By considering the nature and difficulty of tracing these costs, there is only one way these costs can be allocated; and that is by using an *allocation base*. An allocation base is a measure such as direct labour-hours or machine hours that is used to assign overhead costs to products and services.

The manufacturing overhead budget requires inputs such as the *variable overhead rate* which can be determined by using a previous period’s variable overhead cost information. This rate will be calculated by *dividing the total variable overhead cost for a period by the level of activity for the period*. The level of activity will be either the amount of direct labour-hours or direct materials that were used in that period, depending on whether the business is workforce or material driven.

The *total hours of direct-labour hours needed* that is calculated in the *direct labour budget* is used as an input in the *manufacturing overhead budget* as the *budgeted direct labour hours*. Future depreciation on equipment and vehicles is accounted for in the *manufacturing overhead budget* as shown in Figure 9.

Business Name				
Manufacturing Overhead Budget				
for the period of _____				
	Year			
	2014	2015	2016	2017
Budgeted direct labour-hours				
x Variable overhead rate				
Equals: Variable manufacturing overhead				
Plus: Fixed manufacturing overhead				
Equals: Total manufacturing overhead				
Less: Depreciation				
Equals: Cash disbursements for manufacturing overhead				

Figure 9: Outline of a Manufacturing Overhead Budget

After the direct material, direct labour and manufacturing overhead budget is compiled, the *selling and administrative expense budget* as explained in section 4.3.4 should be compiled.

4.3.4 Selling and Administrative Expense Budget

The selling and administrative expenses of a business form a part of the *period costs* as discussed in section 4.3.1. This budget will include all of the fixed and variable non-manufacturing costs of the business including salaries of administrative personnel, advertising, depreciation of equipment or vehicles not used in manufacturing, etc. The *variable selling and administrative expense per unit* should be estimated.

Figure 10 shows a detailed outline of a typical selling and administrative expense budget.

<i>Business Name</i>				
Selling & Administrative Expense Budget				
for the period of _____				
	Year			
	2014	2015	2016	2017
Budgeted sales				
x Variable selling and admin expense per unit				
Equals: Variable Expense				
Add: Fixed selling and admin expenses:				
Advertising				
Executive salaries				
Insurance				
Property taxes				
Depreciation				
Total				
Total selling and admin expenses				
Less: Depreciation				
Equals: Cash disbursements for selling and administrative expenses				

Figure 10: Outline of a Selling & Administrative Expense Budget

The next budget to compile is the cash budget, which is discussed in section 4.3.5.

4.3.5 Cash Budget

The important budget that will be used to determine the funds that would be available to spend on the development of future expansion is the Cash Budget. As shown in Figure 4 in section 4.3.1, the cash budget's figures are dependent on a lot of preceding budget plans.

The cash budget is where management decides when and on what they want to spend their money that is available after all the responsibilities have been taken care of. The responsibilities include the increase in variable expenses due to the increase in the demand of produce. The cash budget in turn has a reverse effect on the production budget due to the funds declared available for the expansion of the facilities and equipment regarding the production of the forecasted amount of produce. If not enough funds are available to expand the facilities to meet the production demand, the sales budget is then affected due to the sales forecast demand that will not be met. Management can decide to apply for a loan in the event that not enough funds are available to allocate to the production budget for the necessary expansions if the loss will be too great if demand requirements are not met. Adjustments regarding the loan will have to be made in the cash budget.

<i>Business Name</i>				
Cash Budget				
for the period of _____				
	Year			
	2014	2015	2016	2017
Cash balance, beginning				
Add: Receipts				
Collections from customers				
<i>Equals: Total cash available before</i>				
<i>current financing</i>				
Less: Disbursements				
Direct Materials				
Direct Labour				
Manufacturing Overhead				
Selling and Admin				
Equipmnet Purchases				
Dividends				
Total disbursements				
<i>Equals: Cash excess / deficiency available</i>				
Add: Financing				
Borrowings (at beginning)				
Repayments (at ending)				
Interest				
Total financing				
<i>Equals: Cash balance, ending</i>				

Figure 11: Outline of a Cash Budget

Figure 11 shows a detailed outline of a typical cash budget. This budget requires inputs from all of the budgets discussed in section 4.3.2 to 4.3.4. The *collections from customer* balance are found in the sales budget and the *direct materials, direct labour, manufacturing overhead, and selling and administrative* balances are the total expenses calculated at each specific budget.

4.4 Utility

Since the FSDM was classified as a method, method engineering literature as well as the associated evaluation criteria in terms of utility is relevant. Offerman et al. (2010) released an article describing the methods that can be used to increase the utility of a method design artifact. In this article the eight components of a design theory are identified and a number of evaluation criteria are given for each component. The evaluation criteria for each component are derived from 4 main criteria groups: (1) validity / credibility, (2) objectivity / conformability, (3) generalisability, and (4) transferability.

Validity / credibility can be explained as the truth of the utility statement of the FSDM. After applying the extended FSDM, will the claimed utility be yielded?

Objectivity / conformability can be interpreted as the degree to which others are able to confirm the utility statement. In other words, the degree to which an objective user will be able to confirm the utility statement when he / she applies the FSDM.

Generalisability can be defined that the utility statement holds true for all possible instances in the scope. For example; when the FSDM is applied in a different context.

Transferability assumes that the utility statement would hold true to a certain degree when it is applied in an out-of-scope situation.

The 8 components of a method design theory as described by Offerman et al. (2010) are: (1) purpose and scope, (2) constructs, (3) principles of form and function, (4) artifact mutability, (5) testable propositions, (6) justificatory knowledge, (7) principles of implementation, and (8) expository instantiation.

The table on the following page is adapted from Offerman et al. (2010) and describes the evaluation criteria for each of the 8 components of a method design theory. Additional notes have been added by the original designer of the FSDM and the current FSDM practitioner to evaluate whether the current FSDM complies with the given criteria. The highlighted areas of the current FSDM should be adapted and changed where necessary in order to ensure that the extended FSDM is developed according to best practices of method engineering.

Component	Evaluation Criteria	Is it covered in the current FSDM according to an FSDM practitioner?	Notes from the original designers
Purpose and Scope	Given a problem, is the purpose described in a way to tell if the method solves the problem?	Yes, the purpose is explained extensively enough in section 3 (Rationale) of the FSDM.	Yes
	Is the product of the method clear?	Yes – the FSDM as method with the FDP and SSFP as main deliverables.	Yes
	Given a problem context, is the scope described in a way to tell if the context falls within the scope?	No	No. Section 5 describes the FSDM. A “Scope, Purpose, Context and Roles” section is required (as part of section 5) to stipulate that the FSDM is intended to be applied to any farm site, irrespective of the kind of products that are produced by the farm. Yet the FSDM has only been validated on two kinds of farms.
	Are all the relevant dimensions specified within the scope?	Agree with original designer. As the scope defines the “population” of cases, in which applying the method is supposed to achieve the claimed utility – the variables that will impact the FSDM need to be specified up-front in the scope.	No. The dimensions (variables) are specified within the body of the method, but not defined up-front. Within the “Scope, Purpose, Context and Roles” section a summary of variables should be given, with a short definition of the variables. That would enable the use of the method, i.e. reviewing the variables prior to using the FSDM.
	Are the covered lifecycle roles, phases, and activities specified?	The activities are specified, but additional information on stakeholder roles is required.	No. The introductory paragraph summarizes the method activities, but the roles are not made explicit. The summary of activities should be moved to the section “Scope, Purpose, Context and Roles”, which should also include a summary of the stakeholder roles within the FSDM.

Component	Evaluation Criteria	Is it covered in the current FSDM according to an FSDM practitioner?	Notes from the original designers
Constructs	<p>Are terms and concepts presented to:</p> <ol style="list-style-type: none"> 1. describe the method? 2. describe the resulting structure? 3. describe the application context? 4. describe the purpose and scope? 5. create testable propositions? 	Agree with original designer.	<ol style="list-style-type: none"> 1. Yes, the method is described in abstract terms, i.e. variables. 2. Resulting structure imply that key artifacts are produced, i.e. the SSFL and FDP. It may be difficult to represent the abstract components of a saturation-state facility layout (not a real example), but would be required. In addition, an abstract representation of the FDP should describe the structure of the FDP. 3. No, but if the “Scope, Purpose, Context and Roles” is updated as requested, the application context should be fine. 4. No, but if the “Scope, Purpose, Context and Roles” is updated as requested, the purpose and scope should be fine. 5. No, not sure which propositions would be created.
	Are the concepts introduced comprehensively in one location and derived systematically?	Yes.	Yes, the method was deduced from an extensive description (documented in a project report), but reduced to a sequential and systematic method articulated in an article.
Principles of form and function	Is the method described extensively enough to be useful and transferable?	Will only be able to tell after demonstration at another farm.	No. Transferability will only be verified once the FSDM has been executed within a different farming environment, i.e. livestock farming.
	For each possible role is it clear which activities have to be done in what order?	<p>In the extended FSDM the variable activities should be specified in a logical and understandable manner.</p> <p>Agree with original designer that the responsibility of each step</p>	Will ensure that the order of activities is clear when the extension points are added. No, the roles are dispersed throughout the method. It seems as if the FSDM practitioner has a primary role. The role of the farm owner is not clear. I would suggest that you also indicate as part of the new section “Scope, Purpose, Context and

Component	Evaluation Criteria	Is it covered in the current FSDM according to an FSDM practitioner?	Notes from the original designers
		should be made clear.	Roles” the responsibility allocation against each method step.
Artefact mutability	Is the method described extensively enough to understand the functioning of each component?	Yes.	No. Additional abstraction is required for the two key artifacts that are produced.
	Are conditions for change described?	Not currently, but it should be included in the extended FSDM.	No. The conditions for change would be the “extension points” that will be added when a second validation is performed on a livestock farm.
	Does it become clear, which parts change and what they change into?	This should be done after the extension points have been added.	No. The conditions for change would be the “extension points” that will be added when a second validation is performed on a livestock farm.
	Are method tailoring mechanisms defined?		No. The conditions for change would be the “extension points” that will be added when a second validation is performed on a livestock farm. Additional tailoring mechanisms may also be required.
Testable propositions	Are testable propositions concerning the method utility given?	Agree with original designer.	Not completely. My interpretation of this criterion is that the FSDM need to stipulate value-in-use of the method. When the FSDM is used, what would be the value achieved by the practitioner? How would he/she know that they achieved the intended value? For example: “The practitioner would have created an optimized and feasible FDP to define facility expansion in phases accordance with production growth and other constraints (including cash flow constraints of the farm owner/funder)”.

Component	Evaluation Criteria	Is it covered in the current FSDM according to an FSDM practitioner?	Notes from the original designers
			The FSDM will be extended to make the utility explicit, also extending Step 8 of the current method to include verification against initial requirements.
	Are the propositions sufficiently well operationalised to allow testing by other scientists?	Cannot be validated yet.	This will only be validated when other practitioners apply the method.
Justificatory knowledge	Are theories presented: 1. for key method features not covered by testable propositions? 2. to support the testable propositions? 3. regarding the method product? 4. regarding the method setting?	Agree with original designer.	1. No. Once adapted according to additional FSDM requirements, this criterion needs to be re-visited. 2. Yes. The testable value propositions are based on existing theories regarding the <i>engineering design process</i> , as well as the concept of a <i>roadmap</i> . 3. Yes. The construction components of the facility layout artifacts are based on the constructs defined by Tomkins et al. (2010)
Principles of implementation	Is the tailoring / assembly advice comprehensive with regard to the combinatorial possibility?	Yes.	No. The conditions for tailoring need to be extended. "Extension points" need to be added when a second validation is performed on a livestock farm.
	Does the advice for introducing the method cover different settings within the scope, or is at least clear for which it applies?	Agree with original designer.	No. Additional advice for different settings (crop producing farm vs. live stock farm) need to be added, and will become evident when the FSDM is also validated on a livestock farm.
Expository instantiation	Does the example cover a case within the scope and is it covering the main concepts of the method?	Yes the current example is extensive enough to cover the main concepts of the FSDM. After extension points have been added the example should be expanded in order to	Yes.

Component	Evaluation Criteria	Is it covered in the current FSDM according to an FSDM practitioner?	Notes from the original designers
		ensure that it covers the extended case.	
	Is the example specific enough to be illustrative but not too idiosyncratic to be incomprehensible?	Up until this stage the example is sufficient. Deficiencies will be highlighted when the extended method is applied for demonstration at a farm.	Yes, however, this could only objectively be assessed if a new practitioner applies the method, highlighting possible deficiencies.

Table 3: Utility Evaluation Criteria with Additional Notes

4.5 Analytical Hierarchy Process (Multi-Criteria Decision Making)

The Analytical Hierarchy Process (AHP) was developed by Thomas Saaty (1980). This method is used when two or more solutions to a certain problem are presented when all of the solutions are capable of adhering to the requirements of the problem at hand. The method aids in the process of determining which of the solutions present will provide the best overall solution to the problem by comparing similar and important aspects of each solution (Saaty, 1980).

There are many other multi-criteria decision making techniques, but AHP is chosen for the purpose of the FSDM, because it is useful when comparing alternatives with specific identified design criteria in a simple approach. It is straightforward to use and calculates the best alternative based on weights and inputs that is determined / given by the farmer. The AHP process should however not be used in cases where there are not a number of different design criteria present, and it thus depends on the specific situation and application to determine whether the AHP process will add real value.

The aspects of the presented options that contribute to the solutions are called attributes. The attributes are then compared against each other regarding the importance of the role each attribute plays in solving the problem. This factor is usually a scale from one to nine. One being the two attributes regarded as equally important in solving the problem and nine as the attribute in question being absolutely more important than the comparing attribute. These judgments are made by more than one unbiased persons to ensure fair and positive outcomes. A general rule of thumb is that an average of 7 attributes in total should be used in the decision making process. The AHP method uses a Consistency Ratio to ensure that the judgments made regarding the importance of the attributes are indeed consistent, thus verifying the validity of the criteria to be used.

Each main option is then rated according to all of these attributes on a scale of one to ten as to determine at what level the option's current attribute contributes to the solution of the main problem. Finally, the options' attributes' values are then multiplied by the factors of importance determined for each attribute and added up to calculate which option has the highest contributing value for the problem at hand.

It is recommended that the AHP model is incorporated into the extended FSDM, for cases where other design criteria is essential when evaluating different alternatives.

4.6 Literature Review Summary

Section 4 presented a detailed literature study regarding all of the industrial engineering tools and techniques that will be used in this project. After the in-depth analysis it is possible to include these tools and techniques in the FSDM in a manner that supports the structure and contribute towards the goal of the FSDM.

Section 5 describes the extended FSDM based on the techniques discussed in the literature study.

5. Extended Farm Site Development Method

A key finding during the literature review and analysis of Waterfall Farm was that the FSDM is not always constrained by the demand of products. As is, the FSDM relies on future production requirements (demand) to determine the phases in which the facility will be expanded and developed. In cases where the saturation-state of a business / facility is greater than the demand of the products, the cash flow will constrain the development. If this is the case, it will not be necessary to forecast the production requirements, but the resources and facility will rather be expanded according to the cash that is available.

Section 4.3 in the literature review contains a detailed discussion on a method that can be used to forecast future cash flows of a business. For the purpose of the FSDM, the cash flow section will not be done with that level of detail. Cash-to-cash cycles and the basic costs associated in production will be considered in the FSDM whilst doing the cash flow of the business. These costs will include the expenses used in production (labour, material cost etc.) and the income generated when selling the products at the end of the cash cycle.

The rate at which income is generated by the business will influence the saturation date of the farm. If more money is used for expansion at the end of each cycle, the farm will reach the saturation-state earlier. This influences the FSDM steps as it can be seen that the forecasting of the cash flow is done in step 3 (determine production requirements and the saturation date).

In cases where the saturation-state of the farm is not greater than the customer demand, the FSDM steps will be followed normally by incorporating the Holt's Method for forecasting in step 3 (determine production requirements and the saturation date). The future production requirements are used to determine when the critical RUSS is out of capacity.

Furthermore, when the choice of critical RUSS is made and evaluated, the Analytical Hierarchy Process must be used as explained in Section 4.5. The design criteria for different critical RUSS will be determined in step 4 (identify critical RUSS and design criteria) and must be evaluated by using the Analytical Hierarchy Process in step 5 of the FSDM (identify and evaluate alternatives for RUSS replacement / extension).

The FSDM was also evaluated for *utility* in Section 4.4 and certain deficiencies were highlighted together with a set of evaluation criteria to ensure the usefulness of the method. These deficiencies are used in order to describe the FSDM in a way that is clearer so that the user will fully understand the deliverables and steps of the FSDM. The "Scope, inputs and Requirements" section of the FSDM is shown in Table 4.

Scope of Method	
Financial :	Cash Flow Calculations
	Engineering Economics
Operational Requirements:	Fixed Assets
	Equipment
Production Requirements:	Product Type
Market Conditions:	Demand as Constraint
	Cash Flow as Constraint
Pre-conditions and Input Data	
Crop Producing	Livestock
Which crops are produced	Animals
Production expenses (R/ha):	What animals to farm with
Operating expense	LU for each animal kind (LU/ha/Year)
Fertiliser cost	Production potential of each animal (Offspring per year)
Input cost	Breeding technique
Waste / cut rate (%)	Additional cost (Excl feed)
Planting density	Auction price (When Selling)
Arable area of farm	Auction price (When Buying)
Yield	Price growth
Growth times of crops	Farm
Inflation rates	Yield section size
% Split in production	Yield section production capacity (LU and kg)
Product selling price	Cost of land/feed
% of profit to use in expansion	Other
	Miscellaneous Expenses
If the <i>demand</i> is a constraint for expansion of the farm, historical sales data is required for forecasting.	
Requirements from Farmer and Constraints	
This includes any constraints related to the farm expansion, production growth, facilities, assets, and equipment.	
Typical Users	
Farm owner	
Farm manager	

Table 4: Scope, Inputs and Requirements for Farm Site Development Method

The extended FSDM is shown in Table 5 with the new and farm specific extensions. The extension for the livestock farm is as described by Hanekom (2014) who implemented the FSDM at a livestock farm in order to further extend the FSDM for another environment.

Main Step	Preconditions	Extensions for FSDM	Input Data		Farm Specific Extensions	
			Livestock Farm	Crop Producing Farm	Livestock Farm	Crop Producing Farm
Step 1			Feed yield potential; section sizes.		1. Calculate the feed yield potential (LU) of the farm using the input parameters.	
Step 2			Yield potential of intensive crop.	1. Arable area 2. Waste 3. Planting density	1. Identify all areas suitable for intensive feed production. 2. Determine production capacity of the areas using the input parameters 3. Calculate the amount of LU of each kind of animal at saturation state using a LP.	
						1. Calculate maximum capacity of farm. 2. Calculate maximum possible production rate. 3. Express maximum possible production rate in standardised units.
		Determine if additional requirements and constraints should be considered (from owner). If there are, first execute step 4 and step 5 before returning to step 3.				

Main Step	Preconditions	Extensions for FSDM	Input Data		Farm Specific Extensions	
			Livestock Farm	Crop Producing Farm	Livestock Farm	Crop Producing Farm
Step 3		<p>Not necessary to calculate saturation date.</p> <p>Determine production requirements by using cash flow.</p>		<p>1. Expenses.</p> <p>2. Incomes.</p> <p>3. Growth periods.</p> <p>4. Yield</p> <p>5. Inflation</p> <p>6. Production split</p> <p>7. % profit to use in expansion</p>		
	Demand is constraint / demand is less than farm saturation state.	Calculate production requirements by using Holt's forecasting method. Use the future demand to limit the expansion while doing cash flow.	Historical sales data.			
Step 4	Additional requirements / constraints from farmer.	Identify requirements / constraints from the owner (farmer-prioritised RUSS) with applicable design criteria.				
Step 5	Additional requirements / constraints from farmer.	Identify and evaluate alternatives for farmer-prioritised RUSS and then return to step 3.				
Step 6					Phase plans include the growth of livestock herds as these needs to be included in cash flow planning.	

Main Step	Preconditions	Extensions for FSDM	Input Data		Farm Specific Extensions	
			Livestock Farm	Crop Producing Farm	Livestock Farm	Crop Producing Farm
Step 7					Phase plans need to be indicated in the form of a table that group together logical dates of extension to ease in cash flow planning.	
Step 8		Redo the FSDM annually or when input data change.				

Table 5: Extended Farm Site Development method

The FSDM as described by van der Merwe, Liebenberg & de Vries (2014) with the new extension points are discussed in detail below.

Step 1: Analyse the current-state facility layout

A site visit should be conducted to confirm and supplement existing layout plans, photos, GPS coordinates and land surveys. If available, existing plans should be used to draw the current-state facility plan using an appropriate drawing program, such as AutoCAD. If no existing layout plans are available, GPS coordinates should be used to map the current-state facility layout, indicating all buildings and site features to scale.

Step 2: Calculate the saturation-state for the farm

The objective of the future/saturation state calculation is to estimate the *maximum possible production rate* of the farm, given the available arable land on the farm. The *maximum possible production rate* could be calculated in three steps:

1. Calculate the maximum capacity of the farm.
2. Calculate the maximum possible production rate.
3. Express the maximum possible production rate as standardised units.
4. Draw the saturation-state facility layout.

After completion of this step it is necessary to determine whether there are additional requirements and constraints from the farm owner. These requirements / constraints may include any relevant decisions that the business needs to make which will influence the future business operations and cash flow. If there are any requirements / constraints, step 4 and step 5 should first be executed (for farmer-prioritised RUSS) before returning to do step 3.

Step 3: Determine production requirements by forecasting /calculating future cash flow

This step requires all expenses and incomes related to production as well as other incomes and expenses that are acquired by the business. Microsoft Excel should be used to calculate the future cash flow of the business by considering all of the relevant costs as well as the production waste and other factors such as inflation and future production requirements. The cash flow should also incorporate the farmer-prioritised RUSS as identified and evaluated in step 4 and step 5.

In cases where the demand is a constraint for the expansion of the farm, production requirements should be forecasted for each product type by using Holt's forecasting method (as discussed in Section 4.2.1). A graphical representation could be used to represent *expected production requirements/demand* expressed in standardised units (y axis) per calendar units (x axis). These future production requirements should then be used to constrain the expansion of the farm when doing the cash flow.

In cases where the demand is *not* a constraint for the farm expansion, the farm owner must provide a percentage of the profit that will be used to expand the facilities. This *percentage* is then used to calculate the expansion of the farm while doing the cash flow.

Step 4: Identify critical and farmer-prioritised resources, utilities, services and structures (RUSS) and design criteria

The farm owner should be consulted to determine specific farmer-prioritised resources, utilities, services and/or structures (RUSS) and applicable design criteria. These farmer-prioritised RUSS includes any resources, utilities, services and/or structures that affect the business operations and are *not* capacity related (for example the choice between planting *seedlings* or *seeds* or if the business should invest in hail shields). After the identification of farmer-prioritised RUSS and specific design criteria, step 5 should first be executed (for farmer-prioritised RUSS) and then step 3.

Critical RUSS and design criteria should only be identified after step 3 is completed. The specific farming industry should be considered when determining the most important critical RUSS required for the FDP, as well as appropriate design criteria (e.g. financial and technical criteria) for evaluating alternatives pertaining to the RUSS. It is important to note that *critical* RUSS will include all of the RUSS that are *capacity related* which can be depleted during expansion. The

Additional criteria may have to be incorporated from best practice frameworks, such as Global GAP (Good Agricultural Practices), Farming for the Future, BRC (British Retail Consortium) Food Technical Standard and Protocol, Bird Friendly standards, and Fair Trade standards.

Step 5: Identify and evaluate alternatives for RUSS replacement/extension

This step will include the evaluation of *farmer-prioritised* RUSS against the design criteria as identified in step 4. After the evaluation of the farmer-prioritised RUSS, step 3 can be executed before continuing to step 4 to identify the *critical* RUSS and then to evaluate the critical RUSS in this step again.

A number of calculations are required to identifying alternative restoration initiatives, also evaluating the alternative initiatives against the design criteria that were identified in step 4:

1. Determine the initial RUSS sizes, given the existing production rate in standardised units.
2. Determine the *first capacity depletion date* for each of the RUSS. Use the *expected production requirements/demand* (calculated in step 3) to determine when the capacity of specific RUSS will be depleted for the first time.
3. For each of the RUSS, use the *first capacity depletion date* to determine *incremental restoration initiatives* for each of the RUSS. *Incremental restoration initiatives* specify the size and quantity of the additional RUSS, based on the standard sizes available in industry and the increase in demand. Since the restored capacity of a resource/structure may be depleted several times within the planning horizon of the FDP, *several/incremental restoration* initiatives will be required for each of the RUSS.
4. Determine *restoration dates for incremental restoration initiatives*. Consider lead times for constructing and/or acquiring RUSS to complete restoration before capacity depletion occurs.

The AHP process can also be used to evaluate different alternatives based on a number of different design criteria. The specific RUSS and situation should be considered to determine whether AHP will add value to the decisions, otherwise only financial and technical criteria should be considered.

Step 6: Compile a series of phase plans, called the facility development plan (FDP)

The purpose of this step is to logically group restoration dates together to form a series of phases (from one month to a year), for the entire planning horizon of the FDP. Phase identification enables budgeting and planning for each phase ahead of time.

Step 7: Represent phase plans graphically in support of the FDP

Draw each phase of the FDP sequentially, starting at the current-state facility layout and ending with a saturation state facility layout (SSFL). Although the SSFL may resemble the initial SSFL compiled step 2, a revised SSFL may be required to reflect changes in strategy, target market, product, or new technology.

Step 8: Validate the facility development plan (FDP)

The purpose is to validate the FDP in terms of the quantitative assumptions that were made during the development of *restoration alternatives* for the critical RUSS. Additional qualitative validation may also be required to ensure that the FDP is useful to management.

6. Implementation of Farm Site Development Method at Waterfall Farm

6.1 Introduction

This section describes the implementation of the extended FSDM (Section 5) at Waterfall Farm for a practical demonstration. The demonstration assists in evaluating the new FSDM with the changes and extensions. For this demonstration, not all of the steps of the FSDM are completed, and the focus of the demonstration is only on the steps with changes / extensions. The logical order of the demonstration is described in Figure 12.

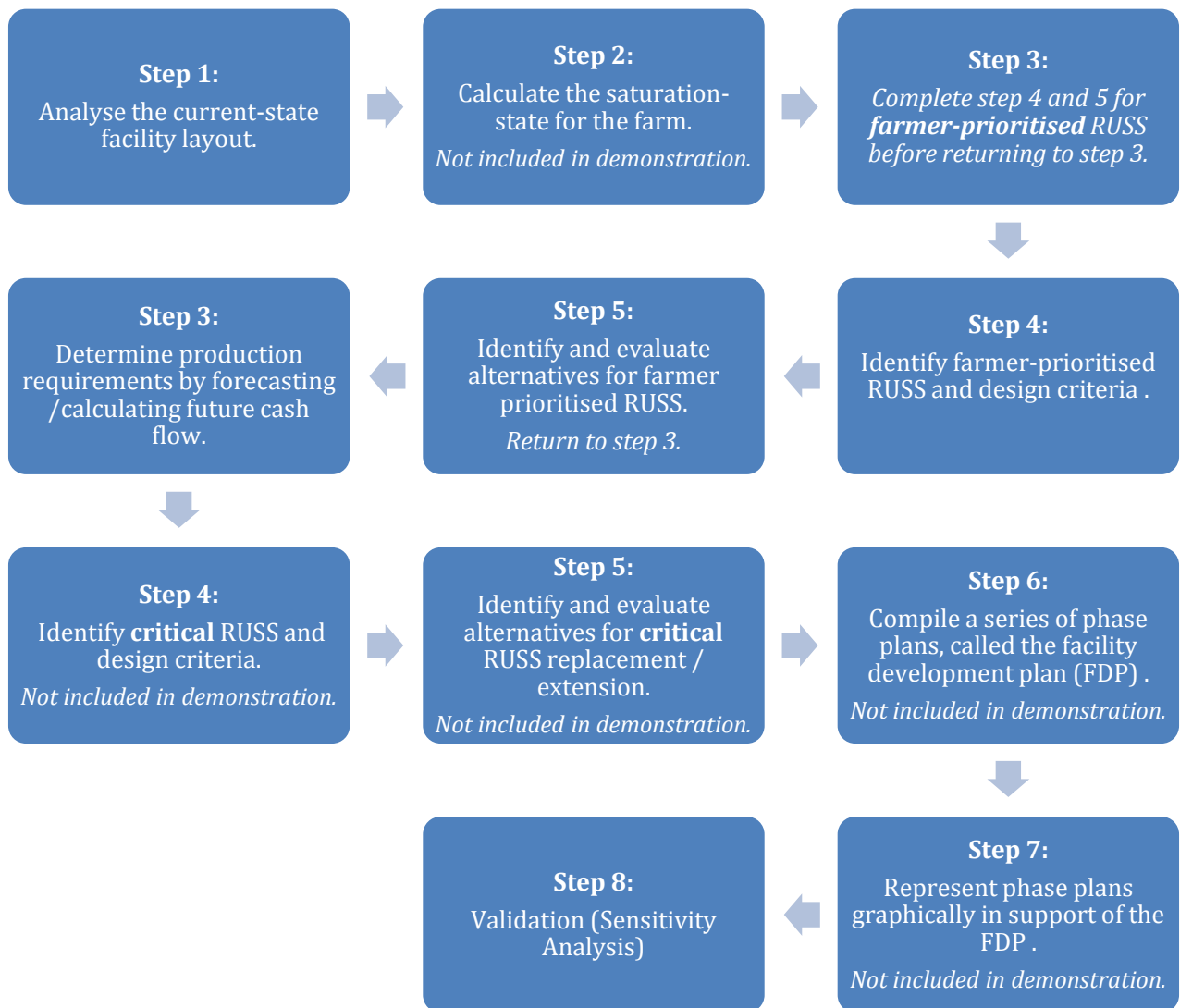


Figure 12: Logical Flow of Demonstration at Waterfall Farm

During the demonstration of the FSDM at Waterfall Farm, an important extension was identified which influences the order in which the FSDM steps are executed. The current state of business at Waterfall Farm is that they have a number of decisions to make between resources that affect the

everyday operations at the farm (once-off decisions). These resources are not the *critical* resources that are taken into account in the first version of the FSDM, but rather resources that are prioritised by the farmer. These *farmer-prioritised* resources are not capacity related and needs to be evaluated *before* the future cash flow can be determined, as it influences the business operations and costs. This resulted in the extension of the FSDM to first identify and evaluate the *farmer-prioritised* resources (step 4 and step 5) before executing step 3 (determine production requirements by forecasting / future cash flow). After step 3 is completed, the normal flow of the FSDM is continued and the *critical* RUSS is then identified and evaluated in step 4 and step 5.

This demonstration includes only the identification and evaluation of farmer-prioritised RUSS and *not* the identification and evaluation of *critical* RUSS. The demonstration of the FSDM at Waterfall Farm in 2013 did evaluate the FSDM in terms of the critical RUSS, and due to time constraints it is not re-evaluated in this demonstration. Thus, step 4 and step 5 is not included in this demonstration which also had the effect that step 5 and step 6 could not be completed due to the fact that the steps are dependent on one another.

This section further consist out of the analysis of the current-state of Waterfall Farm in Section 6.2, the detailed description of product information in Section 6.3 and the identification and evaluation of farmer-prioritised RUSS in Section 6.4. Section 6.5 includes the calculation of future cash flow at Waterfall Farm and finally a sensitivity analysis is conducted in Section 6.6 to validate the assumptions made during the evaluation of farmer-prioritised RUSS.

6.2 Current-State Facility Layout (Step 1)

The first step of the FSDM is to analyse the current-state facility layout of Waterfall Farm. Seeing the FSDM was already applied at the farm, the information that was gathered in 2013 was updated by communicating with the farm owner. Since 2013 little structural changes were made and there are 9 buildings on the farm. The drawing that represents the current-state of the farm is attached in Appendix A.

➤ Structures:

The farmhouse and carport is where the farm owner lives. The chicken shed and old milking shed is used to store equipment and fertilizer that is used in production. The garden shed, garage and the attached shed stores vehicles, equipment and tools. Seedlings are planted and grown in the shaded area for a period of 5 weeks before it is replanted in the crop fields.

➤ Crop Fields:

At the beginning of February 2014, the farm invested R14 440 in planting cabbage crop seeds on 1 hectare. All of the income that Waterfall Farm received for these crops after at the end of the growth cycle was used to replant and expand the cabbage crops. The rest of the income for 2014 is used to plant cabbage, potatoes and lettuce crops. The current-state drawing (Appendix A) illustrates the most Southern part of the farm, with all structures as well as the 4 crop fields that were utilised in 2013.

➤ Supporting Structures:

Furthermore, the farm has 3 water pumps that are located near the Mooi River and is used to irrigate the crop fields. There are also 2 power connections available and 4 septic tanks. It is important that drain fields are at least 30.48m away from any crop fields to ensure that the crops are not exposed and contaminated by pathogens that splash up from the soil surface during irrigation (Friedman, n.d.). To ensure that the crops are not contaminated it is assumed that the drain fields are 10 meters from the septic tank and therefore a 40 meter radius from each septic tank is non-arable (van der Merwe, 2013).

The rondavel and cottage no longer exist and these areas will now be non-arable due to the fact that crops will not be able to grow there.

The area that is used for structures and crop fields were adapted from the work that was done in 2013 based on the structural changes that occurred during the last year. The figures that are shown in Table 6 are adapted from the work done by van der Merwe (2013) and was confirmed by the owner. These figures illustrate the current-state at the end of January 2014.

Structure / Crop Field	Total Area (m²)
Crop Field 1	7 933
Shaded Area	553
Old Milking Shed	249
Non-Arable Field 1	12 853
Non-Arable Field 2	5 817
Non-Arable Rondavel Area	26

Drain Field 1 Area	9 385
Drain Field 2 Area	3 769
Total Area	40 585

Table 6: Non-Arable Land at Waterfall Farm

The total area of Waterfall Farm is 282 852m². 40 585 m² of the land at the farm is either already in use for crop plantations or can not be planted on. Therefore, there is a remaining 242 267m² that can be used for further plantations.

The 10 000m² (1 hectare) of crop field 1 consists of the cabbage crops that were planted from seed with the initial investment mentioned in Section 6.2.

6.3 Product Information

This section describes all of the details regarding the different products that are produced at Waterfall Farm.

6.3.1 Product Groups

For the purpose of this project, Waterfall Farm's products will be divided into the following 5 categories: (1) Cabbage, (2) Potatoes, (3) Exotic varieties, (4) Crisp varieties, and (5) Baby leaf varieties. The last 3 mentioned categories consist of the following individual products:

- Exotic varieties: Ballerina, Triple Play, Concorde, Levistra, Roblesco, Starfighter, and Versai.
- Crisp varieties: Tropical Emperor Lettuce and Baby Spinach.
- Baby leaf varieties: Baby Leaf Rocket and Mizuna.

6.3.2 Growth Periods

The growth time of all crops depend on the season of the year. The different products with their growth periods are shown in Table 7. In this project the winter growth periods will be used for months March – August, and summer growth periods for months September to February.

Product	Summer Growth Period (weeks)	Winter Growth Period (weeks)
Potatoes	16	16
Cabbage - Seedlings	11	17
Cabbage - Seed	16	22
Exotic Varieties - Seedlings	6	8
Crisp Varieties - Seedlings	8	11
Baby Leaf Varieties - Seedlings	5	7

Table 7: Growth Periods for Products

Cabbage can be grown from either a seed or from a seedling. It takes a seedling approximately 5 weeks to turn into a seedling, and therefore the cash-to-cash cycle time for the seedlings is shorter. Although the cabbage seedlings have a shorter cash-to-cash cycle, they are more expensive than the cabbage seeds (see Section 6.3.3).

6.3.3 Cost Information and Production Requirements

The production expenses and incomes per hectare for all products of Waterfall Farm can be found in Table 8.

	Potatoes	Cabbage	Exotic	Crisp	Baby Leaf
Input Cost	R 15 000 p hectare	R 6 750 p hectare (seedlings) & R 3 240 p hectare (seeds)	R 8 000 p hectare	R 9 500 p hectare	R 7 500 p hectare
Fertiliser	R 7 000 p hectare				
Planting Density	3 tonnes p hectare	27 000 seedlings p hectare	222 222 seedlings p hectare	177 777 seedlings p hectare	1 777 779 seedlings p hectare
Cut Rate (%)	na	15	20	20	20
Yield - After Cut	30 tonnes p hectare	22 950 seedlings p hectare	177 778 seedlings p hectare	142 222 seedlings p hectare	1 422 223 seedlings p hectare
Selling Price	R 4 000 p ton / R 120 000 p hectare	R 6 p unit / R 137 700 p hectare	R 240 000 p hectare	R 2.90 p unit / R 412 443 p hectare	R 120 000 p hectare
Operating expense (Plant)	R 6 600 p hectare	R 4 400 p hectare	R 4 400 p hectare	R 4 400 p hectare	R 4 400 p hectare
Operating expense (Harvesting)	R 6 600 p hectare	R 4 400 p hectare	R 4 400 p hectare	R 4 400 p hectare	R 4 400 p hectare

Table 8: Product Expenses and Incomes

The *input cost* is the cost of the seedlings / seeds that can be planted in 1 hectare and was derived by using the *planting density*. *Fertiliser* is applied to the crops to supply them with the necessary nutrients. The *cut rate* is the percentage of seedlings (units) that can not be sold (waste) and is used to determine the *yield* per hectare. Potato crops do not have a cut rate, but gains 10 times their weight during the growth cycle.

The *operating expense* includes the labour costs related to the harvesting and planting of crops. Workers were paid R105 per working day in 2013 (van der Merwe, 2013); with the adjustment for inflation the rate for 2014 is R110 per worker per day. It takes 20 workers up to 3 days to harvest / plant 1 hectare of potatoes where it takes 20 workers only 2 days to harvest / plant a hectare of the lettuce and cabbage crops separately. The operating expenses shown in Table 6 were calculated accordingly.

Other expenses are estimated at R 5 000 per month and includes electricity expense and property tax.

Waterfall Farm has a Transactional Savings account from Capitec Bank. The current interest rate for this account type is 4.5% annually (Capitec, 2014). The cash in Waterfall Farm's bank account will increase with 4.5% every year.

It is important to consider inflation when doing future cash flow calculations. Table 9 contains the inflation rates for the costs that will be used in this project. The values in the table illustrate the increase in prices from March 2013 to March 2014 and were released by Statistics South Africa (2014a).

Cost	Inflation
Vegetables	4.0 %
Transportation	6.9%
Other Goods (Fertiliser)	4.5%
Other Services (Wages)	4.5%
Electricity	7.3%

Table 9: Inflation Rates

The costs associated with the different products are adjusted for inflation in Table 10. The inflation are calculated for a three year period, as it will be used in the evaluation of RUSS in the following section. A 3 year period is used for the evaluations because it is assumed that any investment that a business make must be paid off within 3 years to be viable. The evaluations of RUSS are explained in more detail in the next section.

POTATOES			
	Year 1	Year 2	Year 3
Input Cost (4%)	15,000.00	15,600.00	16,224.00
Fertiliser (4.5%)	7,000.00	7,315.00	7,644.18
Operating Expense Plant (4.5%)	6,600.00	6,897.00	7,207.38
Operating Expense Harvest (4.5%)	6,600.00	6,897.00	7,207.00
Selling Price (4%)	120,000.00	124,800.00	129,792.00
EXOTIC VARIETIES			
	Year 1	Year 2	Year 3
Input Cost (4%)	8,000.00	8,320.00	8,652.80
Fertiliser (4.5%)	7,000.00	7,315.00	7,644.18
Operating Expense Plant (4.5%)	4,400.00	4,598.00	4,804.91
Operating Expense Harvest (4.5%)	4,400.00	4,598.00	4,804.91
Selling Price (4%)	240,000.00	249,600.00	259,584.00
CRISP VARIETIES			
	Year 1	Year 2	Year 3
Input Cost (4%)	9,500.00	9,880.00	10,275.20
Fertiliser (4.5%)	7,000.00	7,315.00	7,644.18
Operating Expense Plant (4.5%)	4,400.00	4,598.00	4,804.91
Operating Expense Harvest (4.5%)	4,400.00	4,598.00	4,804.91
Selling Price (4%)	412,443.00	428,940.72	446,098.35

BABY LEAF VARIETIES			
	Year 1	Year 2	Year 3
Input Cost (4%)	7,500.00	7,800.00	8,112.00
Fertiliser (4.5%)	7,000.00	7,315.00	7,644.18
Operating Expense Plant (4.5%)	4,400.00	4,598.00	4,804.91
Operating Expense Harvest (4.5%)	4,400.00	4,598.00	4,804.91
Selling Price (4%)	120,000.00	124,800.00	129,792.00
CABBAGE - SEEDLINGS			
	Year 1	Year 2	Year 3
Input Cost (4%)	6,750.00	7,020.00	7,300.80
Fertiliser (4.5%)	7,000.00	7,315.00	7,644.18
Operating Expense Plant (4.5%)	4,400.00	4,598.00	4,804.91
Operating Expense Harvest (4.5%)	4,400.00	4,598.00	4,804.91
Selling Price (4%)	137,700.00	143,208.00	148,936.32
CABBAGE - SEEDS			
	Year 1	Year 2	Year 3
Input Cost (4%)	3,240.00	3,369.60	3,504.38
Fertiliser (4.5%)	7,000.00	7,315.00	7,644.18
Operating Expense Plant (4.5%)	4,400.00	4,598.00	4,804.91
Operating Expense Harvest (4.5%)	4,400.00	4,598.00	4,804.91
Selling Price (4%)	137,700.00	143,208.00	148,936.32

Table 10: Adjustments for Inflation (1 hectare)

Waterfall Farm plans to expand their operations with the following percentages: 50% lettuce plantations, 25% cabbage plantations, and 25% potato plantations. These expansions will be made after every cycle when the crops are harvested and sold.

The next section carries out step 4 and step 5 of the FSDM and includes the identification and evaluation of farmer-prioritised RUSS for Waterfall Farm.

6.4 Farmer-Prioritised Resources and Design Criteria (Step 4 and Step 5)

The farm owner of Waterfall Farm had specific requirements which had to be met when implementing the FSDM. These requirements results in the completion of step 4 and step 5 of the FSDM before step 3 (determine production requirements by forecasting / future cash flow) is completed.

6.4.1 Identification of Farmer-Prioritised Resources, Utilities, Services & Structures

The state of the business at Waterfall Farm determines the RUSS that is prioritised by the farm owner. The 3 main farmer-prioritised RUSS include: (1) cabbage plant types, (2) hail shields, and (3) refrigerated truck.

For this demonstration *multi-criteria decision making* will not be done and the only design criteria that are considered for these alternatives are mainly the financial criteria and also technical criteria. Other criteria are not considered because the financial aspect is the only criteria that truly affect the decisions made during the evaluations. The financial criteria will be evaluated by doing *net present value* calculations for the different alternatives.

Economic analysis is an industrial engineering tool that is very useful when a financial decision regarding different alternatives is made. A cash flow diagram (timeline) of 3 years with all of the business's cash inflows and outflows that is applicable to the specific alternative will be used to calculate the *net present value* (NPV). A period of 3 years is chosen for the cash flow diagrams, because it is assumed that all investments that the business make must be paid off within 3 years time. The alternative with the higher net present value is the alternative that gives the business a greater return on investment. The following formulas will be used to do the calculations in this section (Park, Kumar, & Kumar, 2013):

(1) Inflation

$$F = P(1 + i)^n$$

where i is the inflation rate, n the number of periods and P the present value. When the calculations are done this formula will be referred to as; $F = P*(F/P, i, n)$.

(2) Present Value

$$P = F\left[\frac{1}{(1 + i)^n}\right]$$

This formula is used whenever the net present value of a future value at point 0 is calculated and will be used as; $P = F*(P/F, i, n)$.

(3) Annuities

Annuities are equal payments that repeat over a number of periods. To calculate the present value of an annuity the information is as follows:

$$P = A \left[\frac{(1 + i)^n - 1}{i(1 + i)^n} \right]$$

The annuity formula will be referred to as $P = A*(P/A, i, n)$.

The cost information of Section 6.3.3 is used for the evaluations in the next sections. Inflation and interest gained with money invested at the bank is considered together with incomes and expenditures of Waterfall Farm's operations.

6.4.2 Identify and Evaluate Alternatives for RUSS Replacement / Extension

The 3 farmer-prioritised RUSS that is identified in Section 6.4.1 is now evaluated in terms of different alternatives that are identified.

6.4.2.1 Cabbage Plant Types

Waterfall Farm has the option to plant either cabbage seedlings or cabbage seeds. The difference between seeds and seedlings were discussed in Section 6.3.2 of this report. The difference in cost and growth time will impact the profit made by the business. An economic analysis is done regarding the choice of cabbage seeds or seedlings. The most important criteria for these alternatives are the financial contribution of the alternatives. To test whether the seedlings or seeds will be more profitable it is assumed that 1 hectare is planted with cabbage for 3 years. To avoid that the calculations are over-complicated it is assumed that a month has 4 weeks and therefore there is 48 weeks in a year.

Alternative 1: Cabbage Seedlings

During September to February the growth period of seedlings are 11 weeks, and during March to August seedlings take 17 weeks to grow. In a period of 3 years (144 weeks) there will be approximately 7 cycles that are 11 weeks long and 4 cycles that are 17 weeks long.

The cash flow diagram in Figure 13 illustrates all of the cash inflows and expenses of each cycle. The input costs, planting operating expense and fertiliser are deducted at the beginning of each cycle, while the operating expenses for harvesting are only deducted at the end of every cycle. This is because of the fact that the workers will harvest the crops after it is fully grown. The interest rate for the net present value calculation will be used as a weekly rate of 0.09375% with the expense and income values of Table 10.

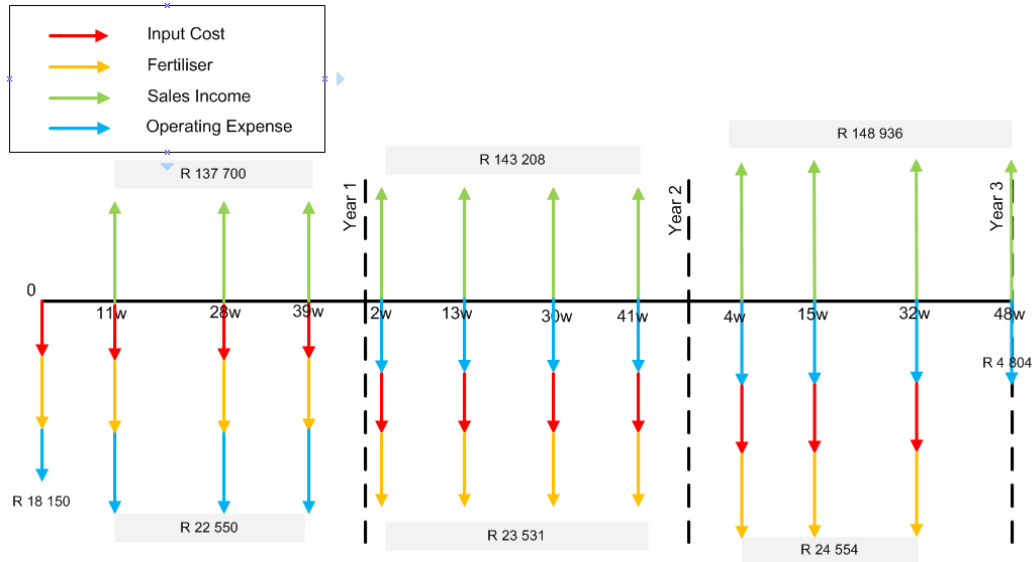


Figure 13: Cash Flow for 1 hectare of Cabbage Seedlings

$$\begin{aligned}
 NPV_0 = & 137\,700(P/F, 0.09375, 11) + 137\,700(P/F, 0.09375, 28) + 137\,700(P/F, 0.09375, 39) + 143\,208(P/F, 0.09375, 50) \\
 & + 143\,208(P/F, 0.09375, 61) + 143\,208(P/F, 0.09375, 78) + 143\,208(P/F, 0.09375, 89) + 148\,936(P/F, 0.09375, 100) + \\
 & + 148\,936(P/F, 0.09375, 111) + 148\,936(P/F, 0.09375, 128) + \\
 & + 148\,936(P/F, 0.09375, 144) - [18\,150 + 22\,500(P/F, 0.09375, 11) + 22\,500(P/F, 0.09375, 28) \\
 & + 22\,500(P/F, 0.09375, 39) + 23\,531(P/F, 0.09375, 50) + 23\,531(P/F, 0.09375, 61) + 23\,531(P/F, 0.09375, 78) \\
 & + 23\,531(P/F, 0.09375, 89) + 24\,554(P/F, 0.09375, 100) + 24\,554(P/F, 0.09375, 111) + 24\,554(P/F, 0.09375, 128) \\
 & + 4\,804(P/F, 0.09375, 144)] \\
 = & \mathbf{R\ 1\ 117\ 943}
 \end{aligned}$$

Alternative 2: Cabbage Seeds

The costs related to the cabbage seeds with the adjustments for inflation are shown in Table 8.

The cash flow for the cabbage seeds (shown in Figure 14) is very similar to the cash flow of the seedlings. Cabbage seeds take up to 16 weeks to grow in the winter and 22 weeks to grow in the summer. A weekly interest rate of 0.09375% is used.

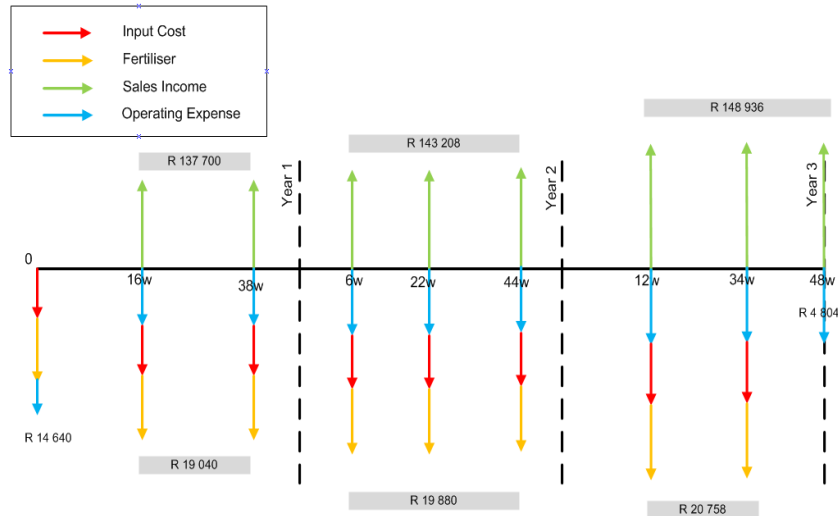


Figure 14: Cash Flow for 1 hectare of Cabbage Seeds

The NPV calculation for the cabbage seeds is as follows:

$$\begin{aligned}
 NPV_0 (+) &= 137\,700(P/F, 0.09375, 16) + 137\,700(P/F, 0.09375, 38) + 143\,208(P/F, 0.09375, 54) + \\
 &143\,208(P/F, 0.09375, 70) + 143\,208(P/F, 0.09375, 92) + 148\,936(P/F, 0.09375, 108) + \\
 &148\,936(P/F, 0.09375, 130) + 148\,936(P/F, 0.09375, 144) \\
 &- [14\,640 + 19\,040(P/F, 0.09375, 16) + 19\,040(P/F, 0.09375, 38) + \\
 &19\,880(P/F, 0.09375, 54) + 19\,880(P/F, 0.09375, 70) + 19\,880(P/F, 0.09375, 92) + 20\,758(P/F, 0.09375, 108) + \\
 &20\,758(P/F, 0.09375, 130) + \\
 &4\,804(P/F, 0.09375, 144)] \\
 &= \mathbf{R\ 917\ 889}
 \end{aligned}$$

Alternative 1 (cabbage seedlings) has a higher NPV (R 1 117 943) than Alternative 2 (R 917 889) and it is therefore more profitable for Waterfall Farm to plant cabbage seedlings. Although a higher input cost is required, shorter cash-to-cash cycles will result in a larger number of turnover times in a certain period which will increase the farm's profit. The only design criteria considered for this evaluation is *financial feasibility* and Waterfall Farm should therefore plant the cabbage seedlings in future operations.

6.4.2.2 Refrigerated Truck

Waterfall Farm has the opportunity to gain additional income by transporting the goods for local farmers to their specific customers. The farm has the following three options: (1) buy the refrigerated truck and keep the income invested in the bank, (2) use the money to further expand plantations, or (3) buy the refrigerated truck and use the income to further expand plantations. The most profitable option will be determined by an economic analysis.

A second hand 4 ton refrigerated truck can be bought for R95 000. This service delivery will increase the farm's operational income with R30 000 (profit) per month.

Alternative 1: Buy the refrigerated truck and invest income in bank account

The amount of operational income received will increase yearly due to inflation. The adjustments for inflation based on a 6.9% annual growth (found in Table 9) are shown in Table 11.

Year	Amount
1	R 30 000
2	R 32 070
3	R 34 282.83

Table 11: Operational Income Adjusted for Inflation

The cash flow diagram for this investment can be seen in Figure 15. The positive cash flow is the monthly income that is received by doing deliveries while the initial investment of R 90 000 can be seen at the starting point. An interest rate of 4.5% annually or 0.375% monthly is used.

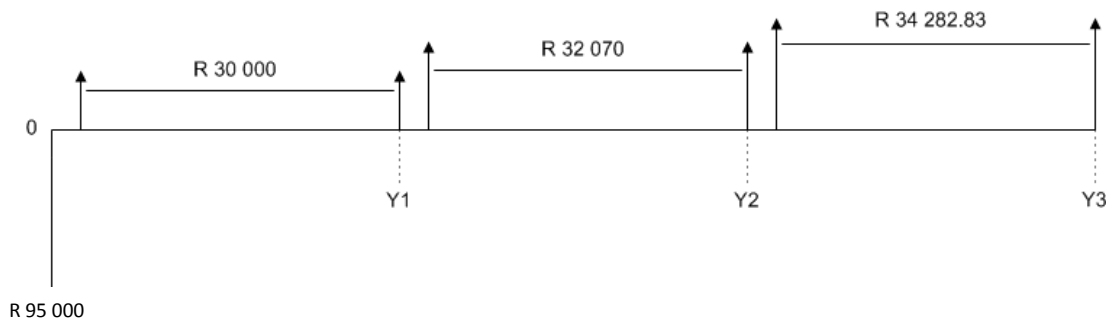


Figure 15: Cash Flow for Buying Refrigerated Truck

$$\begin{aligned}
 NPV_0 &= -95\,000 + 30\,000(P/A, 0.375, 12) + 32\,070(P/A, 0.375, 12)(P/F, 0.375, 12) + \\
 &\quad 34\,282.83(P/A, 0.375, 12)(P/F, 0.375, 24) \\
 &= \mathbf{R\ 953\ 007}
 \end{aligned}$$

In this scenario it is assumed that the monthly profit that is received is kept in Waterfall Farm’s bank account to gain interest. However, seeing that Waterfall Farm is in the process of expanding their crop fields to saturation-state, it can be expected that this income will be used to further expand plantations as evaluated

Alternative 2: Use cash for expanding crop fields

To determine whether it is more profitable for Waterfall Farm to gain other operational income by investing in a refrigerated truck or to rather expand their operations, the percentage split in expansion for the 5 main product groups are considered (50% for the three lettuce categories, 25%

for potato crops and 25% for cabbage crops). Therefore, R 45 000 will be spent on the lettuce groups, R 25 000 on additional potato crops, and also R 25 000 on cabbage crops.

The above mentioned values include the total amount of money that is available to cover all of the costs related to production (input cost, operating expense, as well as fertiliser). The area that can be expanded is the calculated by considering these expenses.

➤ Potatoes:

$$R\ 23\ 750 = R(x*15\ 000 + x*7\ 000 + x*6\ 600 + x*6\ 600), \text{ where } x \text{ is the size in hectare.}$$

$$R\ 23\ 750 = R\ 35\ 200*x$$

$$x = 0.6747 \text{ hectare.}$$

➤ Cabbage:

$$R\ 23\ 750 = R(x*6\ 750 + x*7\ 000 + x*4\ 400 + x*4\ 400), \text{ where } x \text{ is the size in hectare.}$$

$$R\ 23\ 750 = R\ 22\ 550*x$$

$$x = 1.053 \text{ hectare.}$$

It is expected that the lettuce categories will be expanded according to the following proportions: 40% baby leaf varieties, 30% exotic varieties and 30% crisp varieties. The R 45 000 for lettuce expansion will therefore be allocated to the three groups as: R 18 000 for *baby leaf varieties*, R 13 500 for *exotic varieties* and R 13 500 for *crisp varieties*.

➤ Baby Leaf Varieties:

$$R\ 19\ 000 = R(x*7\ 500 + x*7\ 000 + x*4\ 400 + x*4\ 400), \text{ where } x \text{ is the size in hectare.}$$

$$R\ 19\ 000 = R\ 23\ 300*x$$

$$x = 0.8154 \text{ hectare.}$$

➤ Exotic Varieties:

$$R\ 14\ 250 = R(x*8\ 000 + x*7\ 000 + x*4\ 400 + x*4\ 400), \text{ where } x \text{ is the size in hectare.}$$

$$R\ 14\ 250 = R\ 23\ 800*x$$

$$x = 0.5987 \text{ hectare.}$$

➤ Crisp Varieties:

$$R\ 14\ 250 = R(x*9\ 500 + x*7\ 000 + x*4\ 400 + x*4\ 400), \text{ where } x \text{ is the size in hectare.}$$

$$R\ 14\ 250 = R\ 25\ 300*x$$

$$x = 0.5632 \text{ hectare.}$$

These areas are the amount of additional crops that can be planted with the R 95 000 cash available.

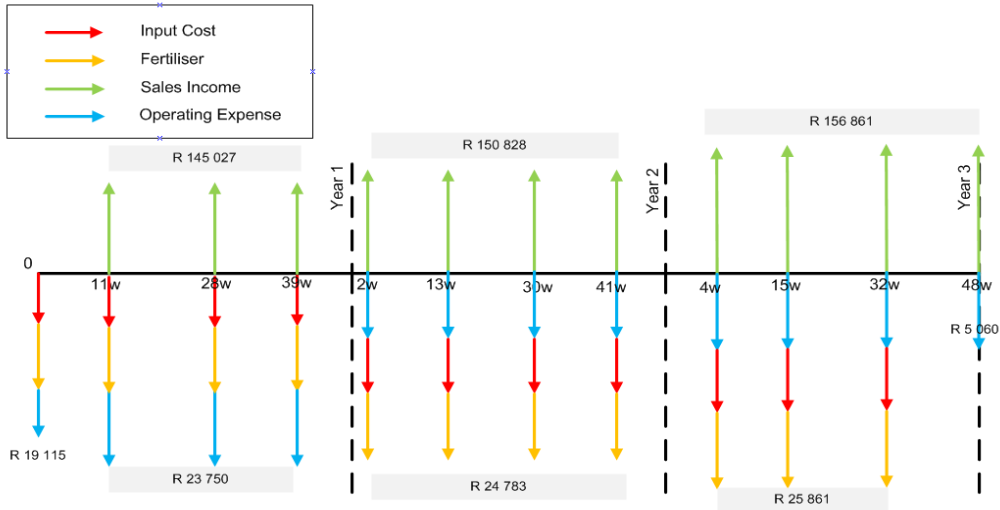
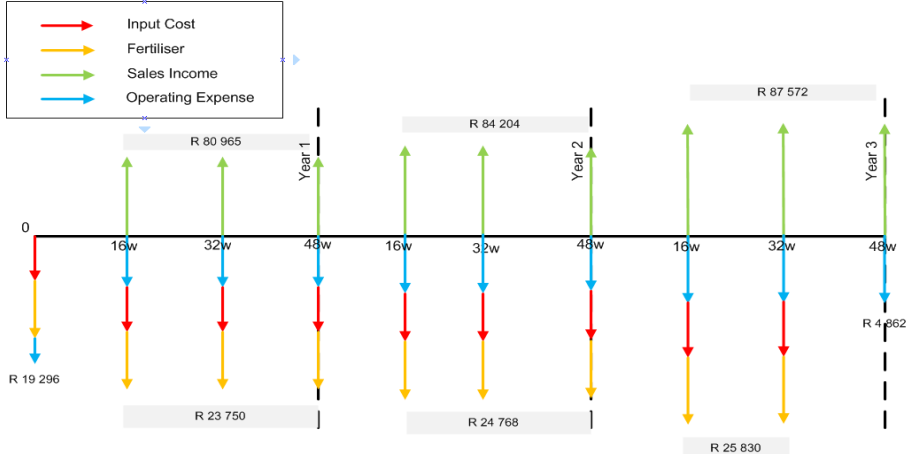
For simplicity, the cash flow of each product will be done separately and the net present values will then be summated to calculate the general net present value of this alternative. The net present value calculations for this section are done in the same method as in Section 6.4.2.1 although all calculations are not shown.

The operating expense, input cost, fertiliser cost and income of the 5 different product groups must be adjusted for inflation. These adjustments are shown in Table 12. The cash flow diagrams and NPV for this alternative is shown in Table 13.

POTATOES (0.6747 ha)			
	Year 1	Year 2	Year 3
Input Cost (4%)	10,120.74	10,525.57	10,946.59
Fertiliser (4.5%)	4,723.01	4,935.55	5,157.65
Operating Expense Plant (4.5%)	4,453.13	4,653.52	4,862.93
Operating Expense Harvest (4.5%)	4,453.13	4,653.52	4,862.93
Selling Price (4%)	80,965.91	84,204.55	87,572.73
EXOTIC VARIETIES (0.5987 ha)			
	Year 1	Year 2	Year 3
Input Cost (4%)	4,789.92	4,981.51	5,180.77
Fertiliser (4.5%)	4,191.18	4,379.78	4,576.87
Operating Expense Plant (4.5%)	2,634.45	2,753.00	2,876.89
Operating Expense Harvest (4.5%)	2,634.45	2,753.00	2,876.89
Selling Price (4%)	143,697.48	149,445.38	155,423.19
CRISP VARIETIES (0.532 ha)			
	Year 1	Year 2	Year 3
Input Cost (4%)	5,350.79	5,564.82	5,787.42
Fertiliser (4.5%)	3,942.69	4,120.11	4,305.52
Operating Expense Plant (4.5%)	2,478.26	2,589.78	2,706.32
Operating Expense Harvest (4.5%)	2,478.26	2,589.78	2,706.32
Selling Price (4%)	232,304.85	241,597.05	251,260.93
BABY LEAF VARIETIES (0.8154 ha)			
	Year 1	Year 2	Year 3
Input Cost (4%)	6,115.88	6,360.52	6,614.94
Fertiliser (4.5%)	5,708.15	5,965.02	6,233.45
Operating Expense Plant (4.5%)	3,587.98	3,749.44	3,918.17
Operating Expense Harvest (4.5%)	3,587.98	3,749.44	3,918.17
Selling Price (4%)	97,854.08	101,768.24	105,838.97
CABBAGE - SEEDLINGS (1.054 ha)			
	Year 1	Year 2	Year 3
Input Cost (4%)	7,109.20	7,393.57	7,689.31
Fertiliser (4.5%)	7,372.51	7,704.27	8,050.97
Operating Expense Plant (4.5%)	4,634.15	4,842.68	5,060.60
Operating Expense Harvest (4.5%)	4,634.15	4,842.68	5,060.60
Selling Price (4%)	145,027.72	150,828.82	156,861.98

Table 12: Inflation Adjustments Related to Expansion for Alternative 2 (Section 6.4.2.2)

Table 11 shows the cash flow diagrams and NPV for the different product groups according to this alternative.

Product Group	Cash Flow Diagram	Net Present Value
Cabbage Seedlings		R 1 294 596
Potatoes		R 495 360

Product Group	Cash Flow Diagram	Net Present Value
Exotic Varieties	<p> <ul style="list-style-type: none"> Input Cost (Red arrow) Fertiliser (Yellow arrow) Sales Income (Green arrow) Operating Expense (Blue arrow) </p> <p> Year 1: R 143 697 Year 2: R 149 444 Year 3: R 155 422 </p> <p> Initial Investment: R 11 615 Annual Operating Expenses: R 14 250, R 14 867, R 15 511 Final Value: R 2 876 </p>	R 2 632 967
Crisp Varieties	<p> <ul style="list-style-type: none"> Input Cost (Red arrow) Fertiliser (Yellow arrow) Sales Income (Green arrow) Operating Expense (Blue arrow) </p> <p> Year 1: R 232 304 Year 2: R 241 596 Year 3: R 251 260 </p> <p> Initial Investment: R 11 771 Annual Operating Expenses: R 14 250, R 14 864, R 15 505 Final Value: R 2 706 </p>	R 3 165 133

Product Group	Cash Flow Diagram	Net Present Value
Baby Leaf Varieties		R 1 817 836
Total Net Present Value		R 9 405 895

Table 13: Section 6.4.2.2, Alternative 2 NPV and Cash Flow Diagrams

The total NPV for Alternative 2 (use cash for expanding crop fields) is **R 9 405 895**, this NPV is significantly higher than the NPV for Alternative (buy the refrigerated truck) R 953 007. This major difference can be explained by the fact that Waterfall Farm receives a greater return on investment if their capital is invested in crop plantations than they received when the capital is invested in the bank. To make this evaluation more reasonable, a third alternative is required where the farm buys the refrigerated truck and invests the operational income in additional plantations.

Alternative 3: Buy refrigerated truck and expand crop fields

Waterfall Farm will receive the operational income of deliveries on a monthly basis; however this income will only be used to expand crop fields after every 6 months (2 times per year). This decision was made by considering the ease of expansions at the farm. Temporary workers are hired whenever the seeds and seedlings are planted and Waterfall Farm decided to rather expand a larger portion of the crop fields at a time, which will reduce the risk of temporary workers not being available when the seed and seedling planting are done.

This implicates that for year 1, R 180 000 of crops are expanded in the middle and at the end of the period. For year 2 and year 3, this income increase according to the inflation as stated in Table 9. The amount of cash and hectares that will be expanded every 6 month period is shown in Table 14 based on the percentage split of production:

Product	Cash to Expand	Area to Expand
Cabbage	R 45 000	1.995 ha
Potato	R 45 000	1.278 ha
Exotic Varieties	R 27 000	1.134 ha
Crisp Varieties	R 27 000	1.067 ha
Baby Leaf Varieties	R 36 000	1.545 ha

Table 14: Area to Expand for Product Groups with R 180 000

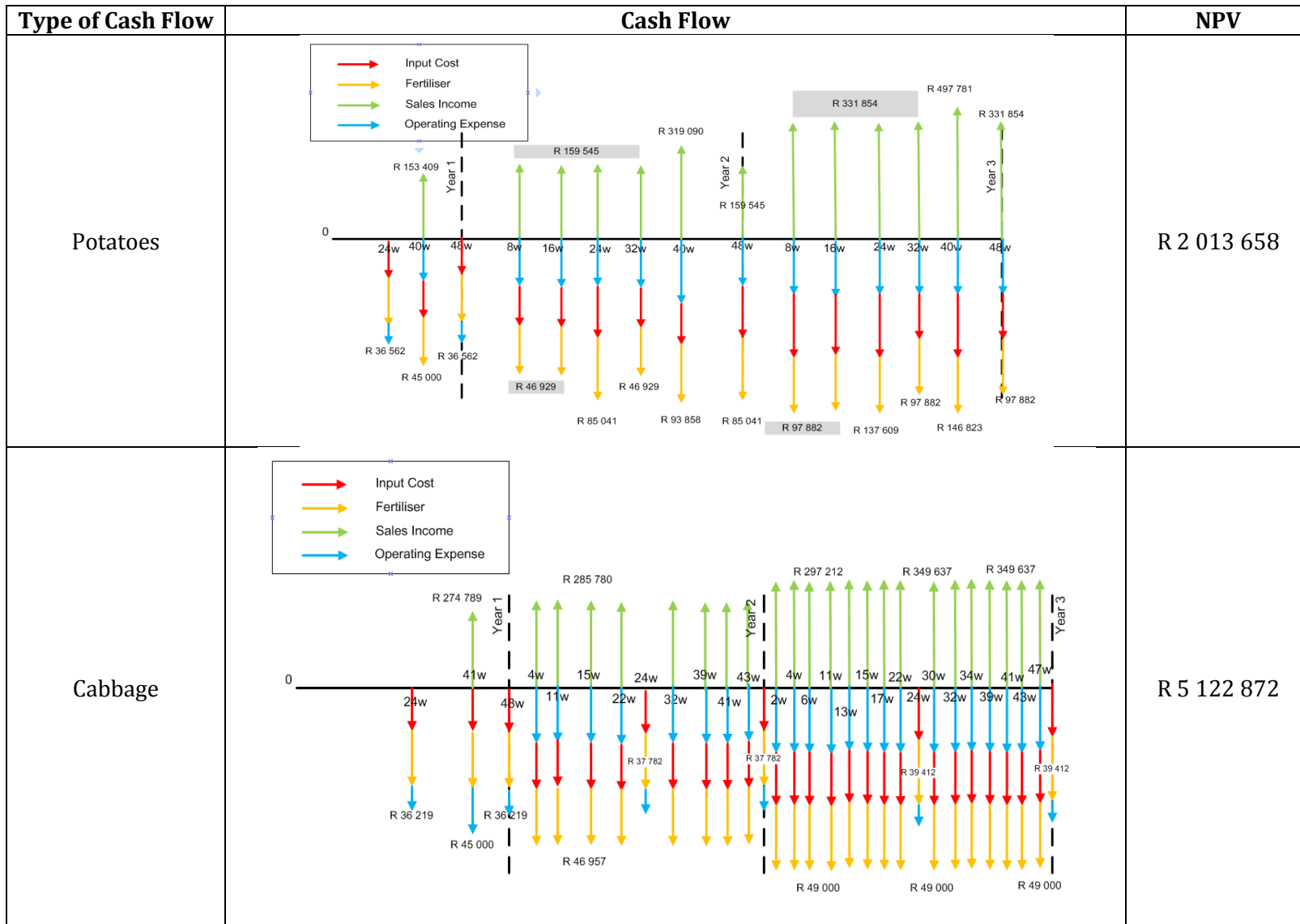
Table 15 shows the costs that are used for the cash flow timelines according to inflation for the 3 year period and the area that is shown in Table 14.

POTATOES (1.278 ha)			
	Year 1	Year 2	Year 3
Input Cost (4%)	19,176.14	19,943.18	20,740.91
Fertiliser (4.5%)	8,948.86	9,351.56	9,772.39
Operating Expense Plant (4.5%)	8,437.50	8,817.19	9,213.98
Operating Expense Harvest (4.5%)	8,437.50	8,817.19	9,213.98
Selling Price (4%)	153,409.09	159,545.45	165,927.27
EXOTIC VARIETIES (1.134 ha)			
	Year 1	Year 2	Year 3
Input Cost (4%)	9,075.63	9,438.66	9,816.20
Fertiliser (4.5%)	7,941.18	8,298.53	8,671.97
Operating Expense Plant (4.5%)	4,991.60	5,216.22	5,450.95
Operating Expense Harvest (4.5%)	4,991.60	5,216.22	5,450.95
Selling Price (4%)	272,268.91	283,159.66	294,486.05
CRISP VARIETIES (1.067 ha)			
	Year 1	Year 2	Year 3
Input Cost (4%)	10,138.34	10,543.87	10,965.63
Fertiliser (4.5%)	7,470.36	7,806.52	8,157.82
Operating Expense Plant (4.5%)	4,695.65	4,906.96	5,127.77
Operating Expense Harvest (4.5%)	4,695.65	4,906.96	5,127.77
Selling Price (4%)	440,156.56	457,762.82	476,073.34

BABY LEAF VARIETIES (1.545 ha)			
	Year 1	Year 2	Year 3
Input Cost (4%)	11,587.98	12,051.50	12,533.56
Fertiliser (4.5%)	10,815.45	11,302.15	11,810.75
Operating Expense Plant (4.5%)	6,798.28	7,104.21	7,423.90
Operating Expense Harvest (4.5%)	6,798.28	7,104.21	7,423.90
Selling Price (4%)	185,407.73	192,824.03	200,537.00
CABBAGE - SEEDLINGS (1.995 ha)			
	Year 1	Year 2	Year 3
Input Cost (4%)	13,470.07	14,008.87	14,569.22
Fertiliser (4.5%)	13,968.96	14,597.56	15,254.46
Operating Expense Plant (4.5%)	8,780.49	9,175.61	9,588.51
Operating Expense Harvest (4.5%)	8,780.49	9,175.61	9,588.51
Selling Price (4%)	274,789.36	285,780.93	297,212.17

Table 15: Inflation Adjustments Related to Expansion for Alternative 3 (Section 6.4.2.2)

The cash flow diagrams for this alternative are shown in Table 16. These diagrams take into account the different growth period per product and also the additional expansion that is made after every 6 month period. These expansions increase the *input cost* and *fertiliser expense* at that specific point in time, and also the revenue of the future cycles. An interest rate of 0.09375% (weekly) is used for the calculations.



Type of Cash Flow	Cash Flow	NPV
Exotic Varieties	<p>The cash flow diagram for Exotic Varieties shows weekly cash flows over 48 weeks, divided into three years (Year 1: 0-12w, Year 2: 12-24w, Year 3: 24-48w). The legend indicates: Input Cost (red arrow), Fertiliser (yellow arrow), Sales Income (green arrow), and Operating Expense (blue arrow). Key values are: R 22 008 (Input Cost at 24w), R 27 000 (Operating Expense at 32w), R 272 268 (Sales Income at 32w), R 283 159 (Sales Income at 10w), R 281 699 (Sales Income at 24w), R 51 123 (Operating Expense at 24w), R 56 339 (Operating Expense at 36w), R 566 319 (Sales Income at 36w), R 588 972 (Sales Income at 12w), R 883 458 (Sales Income at 40w), and R 53 094 (Operating Expense at 48w).</p>	R 11 241 163
Baby Leaf Varieties	<p>The cash flow diagram for Baby Leaf Varieties shows weekly cash flows over 48 weeks, divided into three years (Year 1: 0-12w, Year 2: 12-24w, Year 3: 24-48w). The legend indicates: Input Cost (red arrow), Fertiliser (yellow arrow), Sales Income (green arrow), and Operating Expense (blue arrow). Key values are: R 29 201 (Input Cost at 24w), R 35 999 (Operating Expense at 31w), R 75 124 (Operating Expense at 10w), R 112 686 (Operating Expense at 31w), R 156 768 (Operating Expense at 43w), R 185 407 (Sales Income at 31w), R 385 648 (Sales Income at 10w), R 578 472 (Sales Income at 31w), R 802 148 (Sales Income at 17w), R 1 002 685 (Sales Income at 17w), and R 227 728 (Input Cost at 48w).</p>	R 8 464 013

Type of Cash Flow	Cash Flow	NPV
Crisp Varieties		R 14 627 167
Refrigerated Truck		R 953 007
Total Net Present Value		R 42 421 909

Table 16: Section 6.4.2.2, Alternative 3 NPV and Cash Flow Diagrams

The NPV for alternative 3 is **R 42 421 909**, this large amount can be explained by the fact that the monthly revenue that is created by doing deliveries is continuously used to expand the crop fields. These expansions then increase the future revenue of the business which results in a higher NPV.

Waterfall Farm will gain larger revenue if the refrigerated truck is bought and the income used to expand the crop fields. The economical best alternative for this section is Alternative 3, because it has the highest NPV.

6.4.2.3 Hail Shields

Waterfall Farm does not have any measures in place that provide the crops with protection against weather conditions such as hail storms. These storms have the probability to occur between the months of November and January every year. Hail storms do not affect the potato plantation, because these plants grow underground, but all cabbage and lettuce crops can be destroyed in the event of a hail storm.

Waterfall Farm has the option to cover cabbage and lettuce plantations with hail shields, but it is not necessarily economically viable for the farm to do so. Hail shields are a very expensive structure to invest in, and it may be more profitable for the farm to invest all of the capital into further expansion of the crop plantations and not invest any capital into hail shields. In this scenario the profit gained from the crops will be large enough to restart operations after a hail storm. This important decision that affects cash flow will be done by doing an economic analysis.

Hail shields are available for Waterfall Farm at the cost of R 150 000 per hectare. Alternative 1 is for Waterfall Farm to invest in hail shields for the 3 lettuce varieties and cabbage crops which will ensure the revenue of the crops during hail season (November to January). Alternative 2 is to not invest in hail shields and use the 50% probability of hail to determine an *expected value* of revenue during hail season. In this scenario, the income of Waterfall Farm during hail season will be divided by 2 to compensate for the probability of hail.

Alternative 1: Buy hail shield

The calculations for this alternative are based on 1 hectare of cabbage crops, 1 hectare of potato crops and also another 3 hectare of lettuce crops (1 hectare for each of the groups). The cash flows for this alternative are shown in Table 17, based on the income and expenses that are present for 1 hectare of each of the product types. Hail shields are not bought for the potato crops, due to the fact that hail storms only affects lettuce and cabbage crops.

Type of Cash Flow	Cash Flow (1ha)	NPV
Cabbage	<p>The diagram for Cabbage shows a timeline from week 0 to 48. At week 0, there is an initial investment of R 18 150 (blue arrow down). Weekly inputs include Fertiliser (yellow arrows down), Input Cost (red arrows down), and Operating Expense (blue arrows down). Sales Income (green arrows up) begins at week 11. The total sales income for each year is: Year 1 (R 137 700), Year 2 (R 143 208), and Year 3 (R 148 936). At the end of each year, there is a residual value (grey box): R 22 550 at the end of Year 1, R 23 531 at the end of Year 2, and R 24 554 at the end of Year 3. A final residual value of R 4804 is shown at week 48.</p>	R 1 229 185
Potatoes	<p>The diagram for Potatoes shows a timeline from week 0 to 48. At week 0, there is an initial investment of R 28 600 (blue arrow down). Weekly inputs include Fertiliser (yellow arrows down), Input Cost (red arrows down), and Operating Expense (blue arrows down). Sales Income (green arrows up) begins at week 16. The total sales income for each year is: Year 1 (R 120 000), Year 2 (R 124 800), and Year 3 (R 129 792). At the end of each year, there is a residual value (grey box): R 35 200 at the end of Year 1, R 36 709 at the end of Year 2, and R 38 282 at the end of Year 3. A final residual value of R 7 207 is shown at week 48.</p>	R 734 176

Type of Cash Flow	Cash Flow (1ha)	NPV
Exotic Varieties	<p>The diagram for Exotic Varieties shows a timeline from week 0 to 48 weeks. At week 0, there is an initial investment of R 19 400 (red arrow down). Weekly cash flows are shown as follows: <ul style="list-style-type: none"> Year 1 (Weeks 0-48): Total R 240 000. Weekly flows include Input Cost (red), Fertiliser (yellow), Sales Income (green), and Operating Expense (blue). Year 2 (Weeks 48-96): Total R 249 600. Year 3 (Weeks 96-144): Total R 259 584. Additional values shown in grey boxes: R 23 800 (at week 0), R 24 831 (at week 48), and R 25 906 (at week 96). A dashed line at the end of Year 3 indicates a final value of R 4 804.</p>	R 4 397 534
Crisp Varieties	<p>The diagram for Crisp Varieties shows a timeline from week 0 to 48 weeks. At week 0, there is an initial investment of R 20 900 (red arrow down). Weekly cash flows are shown as follows: <ul style="list-style-type: none"> Year 1 (Weeks 0-48): Total R 412 443. Weekly flows include Input Cost (red), Fertiliser (yellow), Sales Income (green), and Operating Expense (blue). Year 2 (Weeks 48-96): Total R 428 940. Year 3 (Weeks 96-144): Total R 446 098. Additional values shown in grey boxes: R 25 300 (at week 0), R 26 391 (at week 48), and R 27 529 (at week 96). A dashed line at the end of Year 3 indicates a final value of R 4 804.</p>	R 5 619 522

Type of Cash Flow	Cash Flow (1ha)	NPV
Baby Leaf Varieties	<p>The diagram shows weekly cash flows for Baby Leaf Varieties over 48 weeks (3 years). The legend indicates: <ul style="list-style-type: none"> Red arrow: Input Cost Yellow arrow: Fertiliser Green arrow: Sales Income Blue arrow: Operating Expense Key values shown in the diagram: <ul style="list-style-type: none"> Initial investment: R 18 900 Year 1 total: R 120 000 Year 2 total: R 124 800 Year 3 total: R 129 792 Operating Expense (Year 1): R 23 300 Operating Expense (Year 2): R 24 311 Operating Expense (Year 3): R 25 365 Final value at week 48: R 4 804 </p>	R 2 247 365
Hail Shields	<p>The diagram shows annual cash flows for Hail Shields over three years (Y1, Y2, Y3). Each year has an outflow of R 150 000.</p>	- R 600 000
Total Net Present Value		R 13 627 784

Table 17: Section 6.4.2.3, Alternative 1 NPV and Cash Flow Diagrams

Alternative 2: Use cash for expanding crop field

In this scenario, there are no expenses for hail shields and the amount of cash that is spent on expanding the crops depend on the percentage split in production. These details can be seen in Table 18 and are based on a R 600 000 expansion.

Product	Cash to Expand	Area to Expand
Cabbage	R 150 000	6.651 ha
Potatoes	R 150 000	4.261 ha
Exotic Varieties	R 90 000	3.781 ha
Crisp Varieties	R 90 000	3.557 ha
Baby Leaf Varieties	R 120 000	5.150 ha

Table 18: Area to Expand for Product Groups with R 600 000

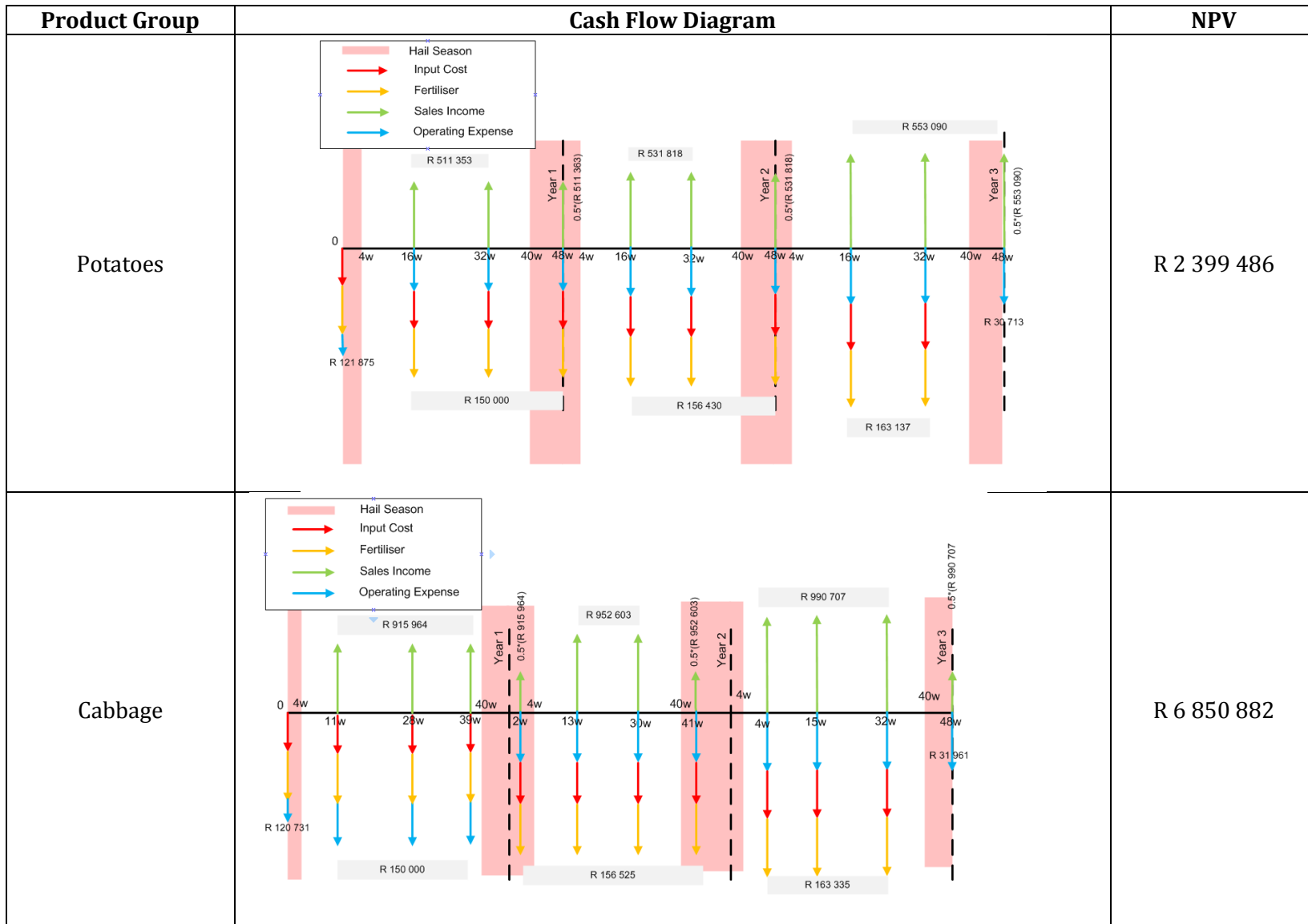
Table 19 shows the adjustments of costs according to inflations. These costs are used for the NPV calculations.

POTATOES (4.261 ha)			
	Year 1	Year 2	Year 3
Input Cost (4%)	63,920.45	66,477.27	69,136.36
Fertiliser (4.5%)	29,829.55	31,171.88	32,574.63
Operating Expense Plant (4.5%)	28,125.00	29,390.63	30,713.27
Operating Expense Harvest (4.5%)	28,125.00	29,390.63	30,713.27
Selling Price (4%)	511,363.64	531,818.18	553,090.91
EXOTIC VARIETIES (3.781 ha)			
	Year 1	Year 2	Year 3
Input Cost (4%)	30,252.10	31,462.18	32,720.67
Fertiliser (4.5%)	26,470.59	27,661.76	28,906.56
Operating Expense Plant (4.5%)	16,638.66	17,387.39	18,169.83
Operating Expense Harvest (4.5%)	16,638.66	17,387.39	18,169.83
Selling Price (4%)	907,563.03	943,865.55	981,620.17
CRISP VARIETIES (3.557 ha)			
	Year 1	Year 2	Year 3
Input Cost (4%)	33,794.47	35,146.25	36,552.09
Fertiliser (4.5%)	24,901.19	26,021.74	27,192.74
Operating Expense Plant (4.5%)	15,652.17	16,356.52	17,092.57
Operating Expense Harvest (4.5%)	15,652.17	16,356.52	17,092.57
Selling Price (4%)	1,467,188.54	1,525,876.08	1,586,911.12
BABY LEAF VARIETIES (5.15 ha)			
	Year 1	Year 2	Year 3
Input Cost (4%)	38,626.61	40,171.67	41,778.54
Fertiliser (4.5%)	36,051.50	37,673.82	39,369.17
Operating Expense Plant (4.5%)	22,660.94	23,680.69	24,746.32
Operating Expense Harvest (4.5%)	22,660.94	23,680.69	24,746.32
Selling Price (4%)	618,025.75	642,746.78	668,456.65

CABBAGE – SEEDLINGS (6.651 ha)			
	Year 1	Year 2	Year 3
Input Cost (4%)	44,900.22	46,696.23	48,564.08
Fertiliser (4.5%)	46,563.19	48,658.54	50,848.20
Operating Expense Plant (4.5%)	29,268.29	30,585.37	31,961.71
Operating Expense Harvest (4.5%)	29,268.29	30,585.37	31,961.71
Selling Price (4%)	915,964.52	952,603.10	990,707.23

Table 19: Inflation Adjustments Related to Expansion for Alternative 2 (Section 6.4.2.3)

Table 20 shows the 3 year cash flow diagrams for this alternative. The periods between November and January which pose a risk for hail storms are highlighted, and the incomes for these risk periods are based on the *expected value*. The income generated by the 4.261 hectare of potato crops are not affected by hail storms and are indicate accordingly.



Product Group	Cash Flow Diagram	NPV
Exotic Varieties	<p>Cash Flow Diagram for Exotic Varieties:</p> <ul style="list-style-type: none"> Year 1: Initial investment of R 73 361 at week 0. Weekly operating expenses of R 90 000. Weekly input costs of R 907 563. Weekly sales income of R 943 865. A hail season occurs between weeks 42 and 48. Year 2: Weekly operating expenses of R 93 898. Weekly input costs of R 943 865. Weekly sales income of R 981 620. A hail season occurs between weeks 42 and 48. Year 3: Weekly operating expenses of R 97 966. Weekly input costs of R 981 620. Weekly sales income of R 981 620. A hail season occurs between weeks 42 and 48. 	R 14 034 014
Crisp Varieties	<p>Cash Flow Diagram for Crisp Varieties:</p> <ul style="list-style-type: none"> Year 1: Initial investment of R 74 347 at week 0. Weekly operating expenses of R 90 000. Weekly input costs of R 1 467 188. Weekly sales income of R 1 525 876. A hail season occurs between weeks 42 and 48. Year 2: Weekly operating expenses of R 93 881. Weekly input costs of R 1 525 876. Weekly sales income of R 1 586 911. A hail season occurs between weeks 42 and 48. Year 3: Weekly operating expenses of R 97 929. Weekly input costs of R 1 586 911. Weekly sales income of R 1 586 911. A hail season occurs between weeks 42 and 48. 	R 17 898 467

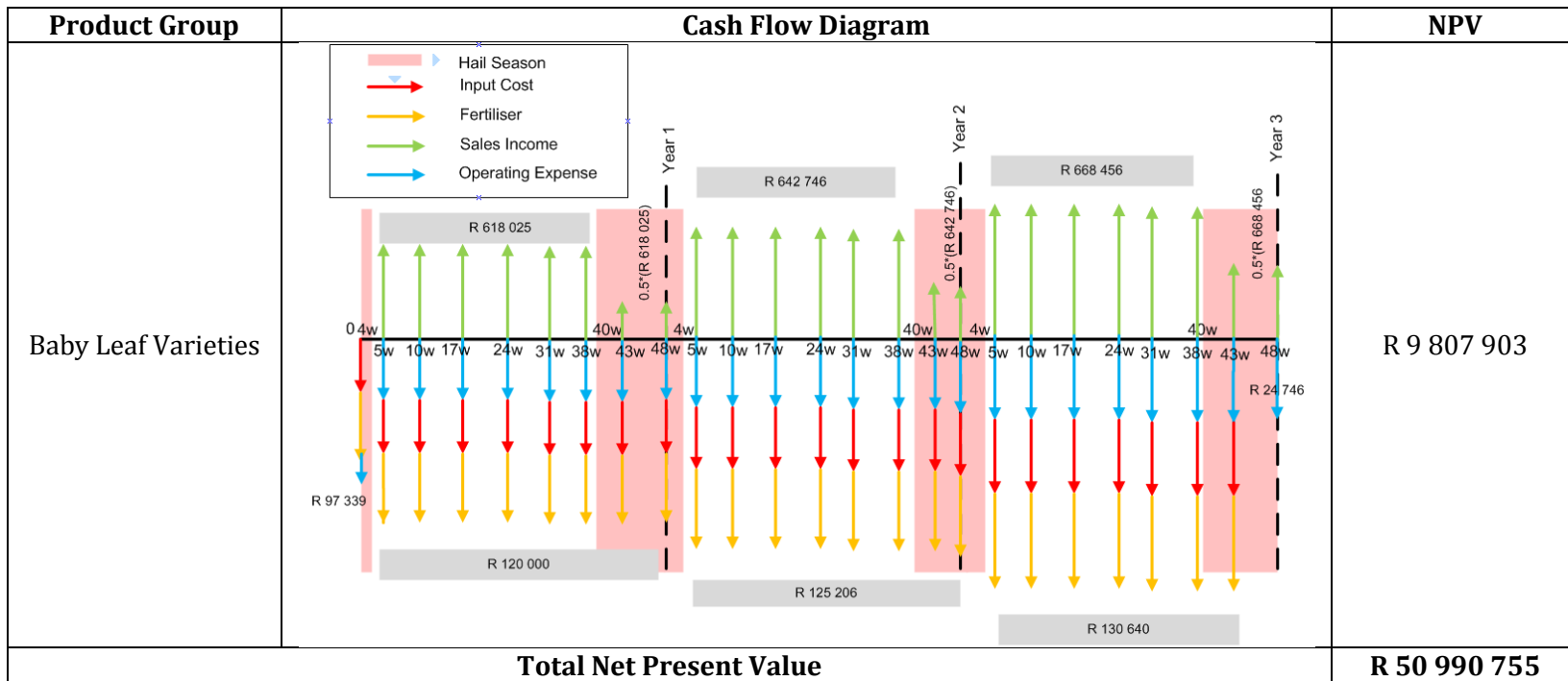


Table 20: Section 6.4.2.3, Alternative 2 NPV and Cash Flow Diagrams

The NPV for Alternative 2 (use cash for expanding crop fields) is much larger than the NPV for Alternative 1 which is **R 13 627 784**. Waterfall Farm should therefore not invest any money in buying hail shields, and rather take the risk of losing crops in a hail storm. In this case Waterfall Farm should keep more money in their bank account to manage their risk profile.

6.4.3 Net Present Value Calculation Summary

The 3 farmer-prioritised RUSS that are discussed in Section 6.4.1 are of great importance for Waterfall Farm's future business plan. The decisions that are made during the economic analysis in Section 6.4.2 are used in the next section of this report to determine future cash flow.

The economic analysis had the following outcomes: (1) Waterfall Farm should plant cabbage seedlings instead of cabbage seeds, (2) the farm should also invest in a refrigerated truck and use the additional income to expand crop fields, and (3) the farm should not invest in hail shields.

Step 3 of the FSDM is completed in Section 6.5 after the farmer-prioritised RUSS has been identified and evaluated (Step 4 and Step 5).

6.5 Determine Production Requirements and Cash Flow

This section describes the implementation of Step 3 (determine production requirements by forecasting / calculating future cash flow) of the FSDM. The future demand is not a constraint when implementing the FSDM at Waterfall Farm, as discussed earlier in the report it is assumed that the demand of the products is greater than the saturation-state of the farm, therefore the production requirements will increase as the business has cash available to expand. This assumption also has the effect that the forecasting technique discussed in the Literature Review is not used in Step 3 of the FSDM, seeing that the production requirements is determined by the cash available for expansion.

An Excel Spreadsheet is used to determine the cash flow of the business based on the decisions that is made in Section 6.4 regarding the farmer-prioritised RUSS. All incomes and expenses are also considered and the arable area is expanded according to the specified split in production based on the *profit* generated by the farm. The main aim of the spreadsheet is to calculate the profit of Waterfall Farm; this amount is then used to expand the existing crop fields according to a percentage that is specified by the farm owner. This percentage is the portion of the farm's profit that the farm owner is willing to spend on expanding the crop fields.

Furthermore, the amount of cash to use in expansion is allocated to different product groups based on the percentage split in production. These *rand values* are then converted to the amount of area in *hectare*, which represents the area that Waterfall Farm should expand for each of the products at that specific point in time.

The spreadsheet works on a yearly base, and all incomes and costs are calculated accordingly (with adjustments for inflation for future values). These calculations consider the number of cycle times each product undergoes in a year, which are based on the different growth periods of the products. The spreadsheet also considers the current state of the farm, and only expands the crop fields up until the farm's saturated state.

Spreadsheet considerations:

The spreadsheet uses the same rationale as the cash flow diagrams that are used for evaluation in Section 6.4.

- Include all costs that occur during planting, growing, and harvesting: (1) input cost / cost of seeds and seedlings, (2) expenses of fertiliser, and (3) labour costs occurred in planting and harvesting.
- Electricity expense of the farm which increase as the production increase (variable cost).
- Property tax expense.
- An estimation of unknown costs of the farm; this estimation is used because not all of the data is available for the business expenses.
- The expenses and income related to investing in the refrigerated truck for additional operational income.
- The *expected value* of income for crops that are affected by hail storms, based on the probability of hail storms.
- The amount of cash to *keep* in the business bank account, due to the risks of hail storms which may lead to crop destruction.
- Planting densities and waste / cut rate during production.
- The area of different crops to expand at the end of each year.
- Calculation of the expected saturation date for the farm.

Spreadsheet Key Findings:

The main findings of the Excel Spreadsheet according to the considerations mentioned above are as follow:

- Seeing that the demand is not a constraint for expansion, the farm will reach saturated state much faster than it did during the demonstration in 2013 when a forecast was used.
- Waterfall Farm will reach the saturated state during 2017, at that stage the complete 25.02 hectare will be utilised.
- The following areas will be utilised at saturation state:
 - 5.35 hectare of potatoes.
 - 7.21 hectare of cabbage.
 - 3.75 hectare of exotic varieties.
 - 3.66 hectare of crisp varieties.
 - 5.05 hectare of baby leaf varieties.
- The expansion areas for each year are shown in the Table 21 below.

	2014	2015	2016	2017
Total Arable Farm Area (ha)	25.02			
Total Area Utilised (ha)	0.79	1.04	11.20	25.02
Potatoes	0.00	0.04	1.90	5.35
Cabbage	0.79	0.86	3.75	7.21
Exotic	0.00	0.04	1.68	3.75
Crisp	0.00	0.04	1.58	3.66
Baby Leaf	0.00	0.05	2.29	5.05
Area Available After Expansion (ha)	24.23	23.98	13.82	0.00

Table 21: Yearly Expansion of Products at Waterfall Farm

- The graph in Figure 16 illustrates the growth described in Table 21.

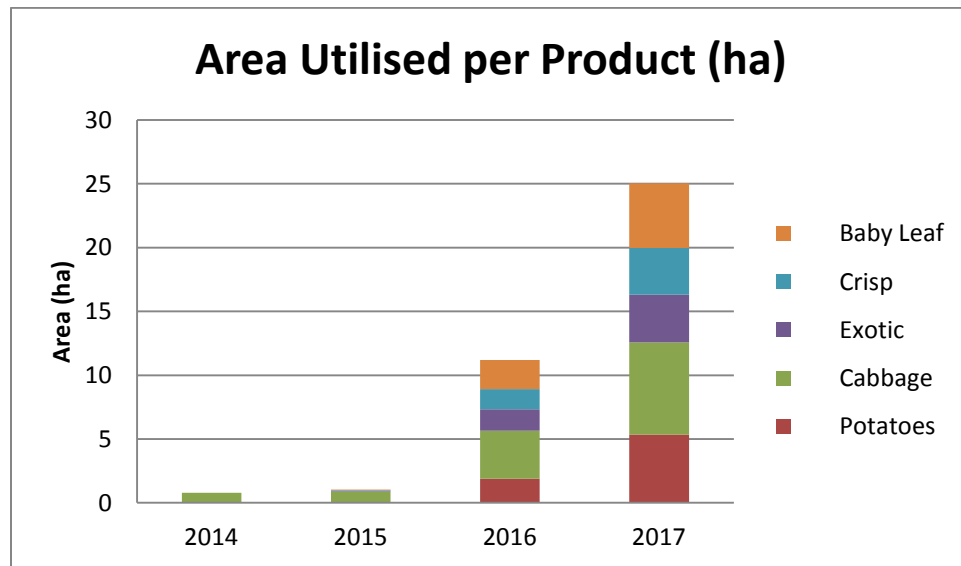


Figure 16: Yearly Utilisation of Products to Saturation State

- The *production requirements* are based on the area utilised at the specific year.

6.6. Sensitivity Analysis

This section demonstrates Step 8 of the FSDM (Validation) by using a sensitivity analysis. The focus of this sensitivity analysis is to validate the assumptions that are made during the evaluation of the farmer-prioritised resources (Section 6.3). The main assumptions made during the evaluation of the farmer-prioritised RUSS are the inputs of inflation. The latest values for different types of inflation are used; and it is assumed that these inflation rates remain constant in the future.

6.6.1 Collection of Data

To test the sensitivity of this assumption, the inflation rates are adjusted to demonstrate the *worst case scenario*. This worst case is represented by the inflation rates deviating from the expected inflation rate to a higher inflation rate. The *highest* inflation rate is determined by looking at historical data for the different types of inflation rates used in the evaluations.

Labour

The yearly change in labour cost is shown in Figure 17; this data is collected from Statistics South Africa (2014c). The highest labour inflation rate is reported as 19% in May 2010. To ensure that the worst case scenario is tested, the inflation rate for labour will be adjusted to 19%.



Figure 17: Historical Labour inflation Rate

Fertiliser

The graph in Figure 19 illustrates the change in cost of *other goods* for 2007 up until 2014 which include fertiliser expense. The data from this graph is collected from Statistics South Africa (2014a) and shows the highest inflation rate as 11.9% in 2009.

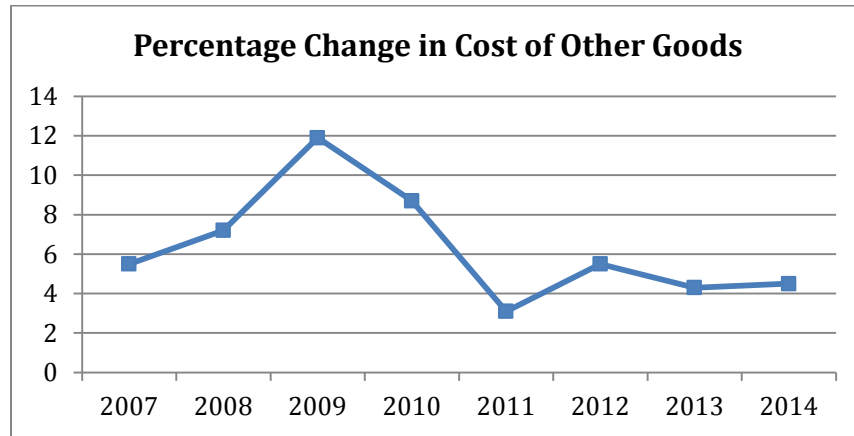


Figure 18: Historical Inflation Rate for Other Goods

Transportation

The yearly change in labour cost is shown in Figure 19; this data is collected from Statistics South Africa (2014b). The lowest transportation inflation rate is reported as 2.2% in November 2013. To ensure that the worst case scenario is tested, the inflation rate for transportation will be adjusted to 2.2%. The lowest inflation rate is used because this inflation rate is used to determine the *increase* in *operational income* of transporting goods for customer. In order to represent the worst case, the lowest increase in income is used.

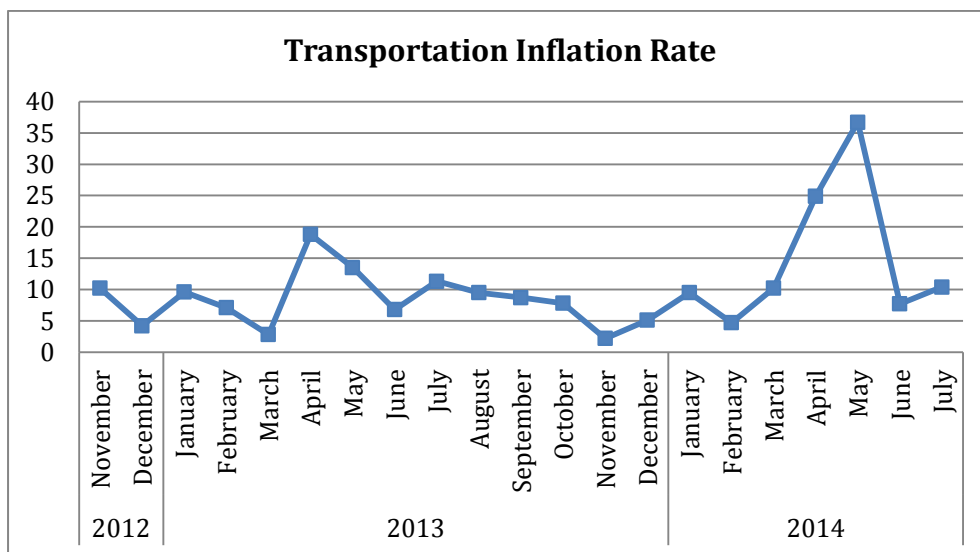


Figure 19: Historical Inflation Rate for Transportation

Vegetables

The graph below illustrates the inflation rate for food since 2009 and is retrieved from Trading Economics (2014). The highest inflation rate for this period is reported as 15.75% and will be used for the worst case scenario for the *input costs* (expenses).



Figure 20: Historical Food Inflation Rate

6.6.2 Sensitivity of Data

The evaluation of farmer-prioritised RUSS and the NPV calculations are done in Excel, which allows the user to change inputs such as the inflation rate in order to validate the sensitivity. An example of this spreadsheet is shown in Appendix B-1 and Appendix B-2; the spreadsheets for the cabbage seedlings and cabbage seeds with the NPV calculations are included. In the sensitivity analysis, inflation rates are changed according to the worst case values discussed in Section 6.6.1 and the results is shown in Table 22.

	RUSS Evaluation Results (Selected Alternative)	Worst Case Results (Selected Alternative)
Cabbage Plant Types	1	1
Refrigerated Truck	3	3
Hail Shields	2	2

Table 22: Sensitivity Analysis Results

The results of the sensitivity analysis show that the farmer-prioritised RUSS evaluations are not sensitive to the assumptions made regarding inflation. The outcomes of which alternative to select remains the same when comparing the inflation rates used during evaluation with the worst case inflation rates. The output of the model developed is therefore not affected by the uncertainty in future inflation rates and the decisions made for Waterfall Farm can be seen as reliable.

7. Conclusion

This report highlights the main steps that are followed in order to extend the *farm site development method*. The literature review (Section 4) on the subject of the industrial engineering techniques made it possible to extend the FSDM as described in Section 5. The techniques that are successfully extended into the FSDM are: (1) demand forecasting techniques, (2) cash flow projections, (3) multi-criteria decision making, (4) and finally the FSDM is also adapted in terms of utility.

The extended FSDM is successfully applied at Waterfall Farm for a practical demonstration with a central focus on the cash flow of the business (Section 6.5). This demonstration allows a greater understanding of the difficulties that are present in the extended FSDM, which assists in the further development and circumscription of the FSDM.

After the implementation of FSDM at Waterfall Farm, a sensitivity analysis is conducted to evaluate the impact of certain assumptions made during the application of the FSDM. The results of the sensitivity analysis indicate that the assumptions that are made during the demonstration do not affect the outcomes of the resource evaluations. The decisions made for farmer-prioritised RUSS are therefore reliable and not affected by changes in the South African economy.

A flaw of the FSDM is the underlying assumption that all of the arable land of the farm is homogeneous and therefore suitable to grow all of the crops, while in fact there may be cases where certain areas are not suitable for growing specific crops. This deficiency can be considered when applying another design cycle to improve the FSDM.

Although not all of the FSDM steps are re-applied at Waterfall Farm, the critical extension points of the FSDM is demonstrated and it can be concluded that the FSDM is successfully extended. The extension points of the FSDM are also fully described and can be used for future applications.

8. References

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APPENDIX A: Current-State Facility Layout for Waterfall Farm

Drawing Description:
Current state facility plan for Watersill Farm

Project Description:
Validating and Extending the Farm Site Development Method

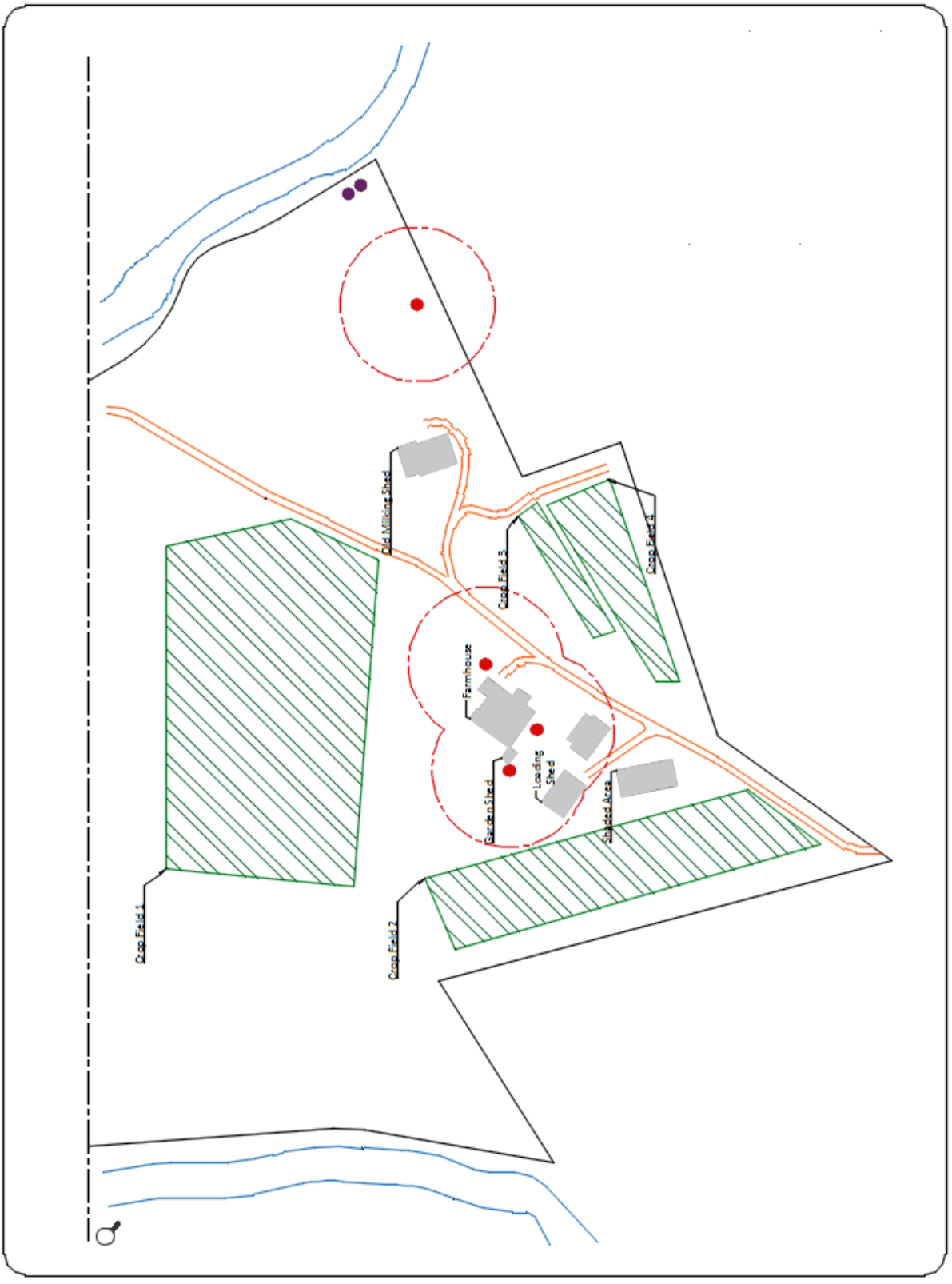
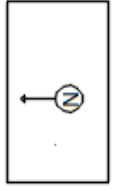
- Legend:**
- Moatline
 - Crop Fields
 - Gravel Roads
 - Buildings
 - Water Pump

Scale:
Not to Scale

Location of Drawing:
Watersill Farm,
Moonline

Institution:
University of Pretoria

Drawn By:
Marissa Vos
11042220



APPENDIX B-1: Excel Spreadsheet for Alternative 1 of Cabbage Plant Types

Cost	Inflation
Input Cost	12.80
Vegetables Income	12.80
Transportation	6.90
Other Goods (Fertiliser)	4.50
Other Services (Wages)	4.50

	Year		
	1	2	3
Input Cost (12.8%)	6750	7614	8588.592
Fertiliser (4.5%)	7000	7315	7644.175
Operating Expense (4.5%)	4400	4598	4804.91
Operating Expense Harvest	4400	4598	4804.91
Selling Price (12.8%)	137700	155325.6	175207.2768

Interest Rate, i (yearly)	4.50
Weekly i	0.0938

Week	Year 1				Year 2			Year 3			
	0	11	28	39	50	61	89	100	111	128	144
Input	6,750.00	6,750.00	6,750.00	6,750.00	7,614.00	7,614.00	7,614.00	8,588.59	8,588.59	8,588.59	
Fertiliser	7,000.00	7,000.00	7,000.00	7,000.00	7,315.00	7,315.00	7,315.00	7,644.18	7,644.18	7,644.18	
Operating Expense Plant	4,400.00	4,400.00	4,400.00	4,400.00	4,598.00	4,598.00	4,598.00	4,804.91	4,804.91	4,804.91	
Operating Expense Harvest		4,400.00	4,400.00	4,400.00	4,598.00	4,598.00	4,598.00	4,804.91	4,804.91	4,804.91	4,804.91
Income		137,700.00	137,700.00	137,700.00	155,325.60	155,325.60	155,325.60	175,207.28	175,207.28	175,207.28	175,207.28
Profit	-18,150.00	115,150.00	115,150.00	115,150.00	131,200.60	131,200.60	131,200.60	149,364.69	149,364.69	149,364.69	170,402.37
(P/F,i,n)	-18,150.00	113,969.17	112,168.02	111,017.77	125,195.24	123,911.39	120,702.52	136,004.07	134,609.39	132,482.04	148,892.68
NPV		1,240,802.28									

APPENDIX B-2: Excel Spreadsheet for Alternative 1 of Cabbage Plant Types

Cost	Inflation
Input Cost	12.80
Vegetable Income	12.80
Transportation	6.90
Other Goods (Fertiliser)	4.50
Other Services (Wages)	4.50

	Year		
	1	2	3
Input Cost (12.8%)	3,240.00	3,654.72	4,122.52
Fertiliser (4.5%)	7,000.00	7,315.00	7,644.18
Operating Expense (4.5%)	4,400.00	4,598.00	4,804.91
Operating Expense Harvest	4,400.00	4,598.00	4,804.91
Selling Price (12.8%)	137,700.00	155,325.60	175,207.28

Interest Rate, i (yearly)	4.50
Weekly i	0.09375

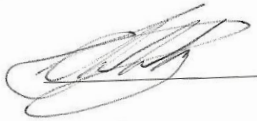
week	Year 1			Year 2			Year 3		
	0	16	38	54	70	92	108	130	144
Input Cost	3,240.00	3,240.00	3,240.00	3,654.72	3,654.72	3,654.72	4,122.52	4,122.52	
Fertiliser	7,000.00	7,000.00	7,000.00	7,315.00	7,315.00	7,315.00	7,644.18	7,644.18	
Operating Expense Plant	4,400.00	4,400.00	4,400.00	4,598.00	4,598.00	4,598.00	4,804.91	4,804.91	
Operating Expense Harvest		4,400.00	4,400.00	4,598.00	4,598.00	4,598.00	4,804.91	4,804.91	4,804.91
Income		137,700.00	137,700.00	155,325.60	155,325.60	155,325.60	175,207.28	175,207.28	175,207.28
Profit	-14,640.00	118,660.00	118,660.00	135,159.88	135,159.88	135,159.88	153,830.76	153,830.76	170,402.37
(P/F,i,n)	-14,640.00	116,894.20	114,509.06	128,490.77	126,578.68	123,995.93	139,024.54	136,187.84	148,892.68
NPV		1,019,933.71							

APPENDIX C: Informed Consent Form

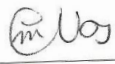
**Informed consent form
(Form for research subject's permission)**

(Must be signed by each research subject, and must be kept on record by the researcher)

- 1 Title of research project: **Validating and extending the farm site development method**
- 2 I Andri KREWANG..... hereby voluntarily grant my permission for participation in the project as explained to me by Ms Marinda Vos.....
- 3 The nature, objective, possible safety and health implications have been explained to me and I understand them.
- 4 I understand my right to choose whether to participate in the project and that the information furnished will be handled confidentially. I am aware that the results of the investigation may be used for the purposes of publication.
- 6 Upon signature of this form, you will be provided with a copy.

Signed:  Date: 10 Agustus

Witness:  Date: 10 Agustus

Research Participant:  Date: 10 Agustus

APPENDIX D: Industry Sponsorship Form

Department of Industrial & Systems Engineering
Final Year Projects
Industry sponsorship and participant consent

All Final Year Projects are published by the University of Pretoria on *UPSpace* and thus freely available on the Internet. In addition, journal articles may also be published as a result of the final year project. The publications have the potential of exposing sensitive company information. It is important that both students and company representatives or sponsors are aware of such implications.

Key responsibilities and consent required from the main Project Sponsor:

A project sponsor is the key contact person within the company. This person should thus be able to provide the best guidance to the student on the project. The sponsor is also very likely to gain from the success of the project. The project sponsor has the following important responsibilities:


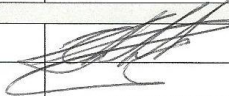



1. Confirm his/her role as project sponsor, duly authorised by the company. Multiple sponsors can be appointed, but this is not advised. The duly completed form will be considered as acceptance of sponsor role.
2. Review and approve the Project Proposal, ensuring that it clearly defines the problem to be investigated by the student and that the project aim, scope, deliverables and approach is acceptable from the company's perspective.
3. Review the Final Project Report (delivered during the second semester), ensuring that information is accurate and that the solution addresses the problems and/or design requirements of the defined project.
4. Acknowledges the intended publication of the Project Report on UP Space.
5. Ensure that any sensitive, confidential information or intellectual property of the company is not disclosed in the Final Project Report and other journal publications that are produced from the project.

Consent required from the student as Research Participant:

The student, within the role of research participant, provides consent to the following:

1. Granting permission for participation of the project as explained to me by Dr Marné de Vries and Mr André Liebenberg.
2. The nature, objective, possible safety and health implications have been explained to me and I understand them.
3. I understand my right to choose whether to participate in the project and that the information furnished will be handled confidentially. I am aware that the results of the investigation may be used for the purposes of publication.
4. Upon signature of this form, I will be provided with a copy.

Details of project participant (student), project sponsor and researchers:

Company:	Waterfall Farm	
Project description:	Validating & extending the farm site development method.	
Project participant (student):		
Student name:	MC Vos	
Student number:	11043220	
Student signature:		
Project sponsor:		
Sponsor name:	 André Liebenberg	
Designation:		
E-mail:	industrial.andre@gmail.com	
Tel No:	-	
Cell No:	072 319 3278	
Sponsor Signature:		Date: 2 April 2014
Researchers:		
Researcher 1 name:	Dr M de Vries	
Signature:		Date: 27 March 2014.
Researcher 2 name:	Mr A Liebenberg	
Signature:		Date: 2 April 2014