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Abstract	South Africa's first commercial urban farm was in need of business process engineering and mapping to guide its supply chain and operations. The project also included a feasibility study to decide if processing and packaging must be done on the farm compared to outsourcing this function.
Category	Business Process Design

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Development of a Business Process Blueprint for commercial Urban Farmers in South Africa

by

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EXECUTIVE SUMMARY

The production of fresh food in and around a city is a relatively new concept. Many urban farms exist in South Africa in the form of community projects and are making a much needed difference in their communities, but the commercial potential of urban farming has not been exploited in South Africa yet. Many successful commercial urban farms opened worldwide in the previous five years. Urban Farms Company (UF) is currently constructing the country's first commercial urban farm east of the Johannesburg CBD to supply gourmet lettuce and herbs to leading restaurants, retailers and hotels.

For the successful operations of the farm and all the commercial urban farms to follow, UF is in need of a roadmap for commercial urban farming activities. The decision must be made as to whether processing and packaging will be done on the farm or outsourced. To aid in this decision making process different approaches for feasibility studies were researched in order to develop an effective feasibility study approach that considers different aspects. As cost is not the only criterion of importance for UF, a multi-criteria decision making (MCDM) approach was incorporated. The Analytic Hierarchy Process (AHP) was selected for this purpose.

Business Process Design (BPD) and modelling is an exciting field of industrial engineering that allows an organisation to understand and define the activities that make it function. New business opportunities were identified as one of the common drivers for modelling business processes. The research has shown that an effective business process model will include all processes, sub-processes and activities, text descriptions of the purpose, triggers, durations and requirements of an activity, the people and departments involved as well as the destination of inflowing and outflowing information. The techniques investigated for this purpose were integrated definition methods (IDEF0 and IDEF3), SIPOC diagrams and business process modelling and notation (BPMN). BPMN was selected as the modelling language for this project.

Literature emphasise the importance of our visual era and stages many opportunities for training in the workplace through visual material. Skills transfer is a buzz word in the South African economic environment. The final stage of this project shows that mapped out business processes can be developed into visual training tools for the workplace to update the traditional farming skills and include the much needed knowledge of modern farming practices and technology.

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1.1 Background

1.1.1 Industry background

The USA Partnership for Sustainable Communities (2011) defines an urban farm as "…a part of a local food system where food is cultivated and produced within an urban area and marketed to consumers within that urban area." Urban Agriculture can include food products from different types of crops (e.g. vegetables and fruits), non-food products (e.g. medicinal herbs and flowers), and animals (e.g. poultry and cattle). The farming activities in a city can furthermore be expanded to include the functions for processing and packaging of the food (Resource Centre on Urban Agriculture and Food Security, n.d.).

There are mainly two types of urban agriculture featuring in literature i.e. commercial urban farming and urban farming as community projects. The latter has a relatively low level of technology implementation while commercial urban farming has a propensity towards the incorporation of advanced technology from the earliest stages of farm development. The world's first commercial urban farm was started by LUFA Farms in Montreal, Canada in 2011 in the form of a rooftop greenhouse. The CEO and founder of LUFA Farms, Mohamed Hage is seen by many as the father of commercial urban farming. China is another example of successful commercial urban agriculture. More than 50% of their capital's vegetable supply comes from farms within the city with advantages such as usage of existing infrastructure, relatively easy water recirculation and reduced transport complexity (Mashala, 2013).

The status quo of South African urban farming is currently limited to community initiatives with a few beneficiaries and stakeholders. Farms such as the Oranjezicht City Farm (Cape Town), Abalimi (Khayelitsha) and Bambanani Food and Herb Garden (Betrams, Johannesburg) share the common goals of providing jobs and food to their local communities with little to no aim for profit.

1.1.2 Enterprise background

The Urban Farms Company (UF) was founded by Wayne Harpur in 2010. With its motto being "responsible food", the main business areas of UF are food waste recycling solutions (commercial and household), supplying of sustainable food farming packages for households as well as commercial urban farming. Amongst UF's corporate clients are the food court at Tsogo Sun's Monte Casino and the Johannesburg Country Club.

UF is currently developing a first of its kind commercial urban farm on the roof of the 6-story Access City Building in the Maboneng Precinct, east of the Johannesburg CBD. The farm will incorporate an automated climate controlled greenhouse of 608m^2 and vertical hydroponic growing systems to produce close to 13,000 plants in a growing cycle of 21-25 days. Herbs and gourmet lettuce for the local hotel, retail and restaurant trade will be produced.

UF's philosophy of responsible food is founded on the following key principles:

Water: Rainwater harvesting and recirculation of water saves up to 85% in water consumption; closed water system eliminates agricultural run-off.

Land: Vertical hydroponics systems maximize land-use.

Local: By growing food in the city, the carbon footprint can be reduced by up to 90% because of reduced transport and refrigeration needs.

Natural: No synthetic pesticides, herbicides or fungicides are used and only biological control is used in greenhouses.

Good food: Delivery on the day of harvest and growing of varieties for their flavour and nutritional value (a revolutionary shift from the current system where food is grown based on its transportability, shelf-life and storage capabilities).

An example of a vertical hydroponic system is shown in Figure 1 (Blank, n.d.).

Figure 1 Vertical hydroponics (Blank, n.d.)

1.2 Need requirement

The urban farm that is currently under construction is UF's first involvement in commercial urban farming. The decision was made to open more farms after the successful implementation of the pilot farm on locations that will be selected by the enterprise. All the technology for the first farm has been selected and purchased. Clear mapped out business processes are however required to facilitate the successful operation of this farm and all the future urban farms that will be developed. First steps towards the training of the workers on these farms are also required. The management of the farm also wants to know what the benefits will be of having a processing and packaging facility on the farm compared to outsourcing these functions. The diagram in Figure 2 (pg. 3) shows where the need for the project fits in with UF's development plans.

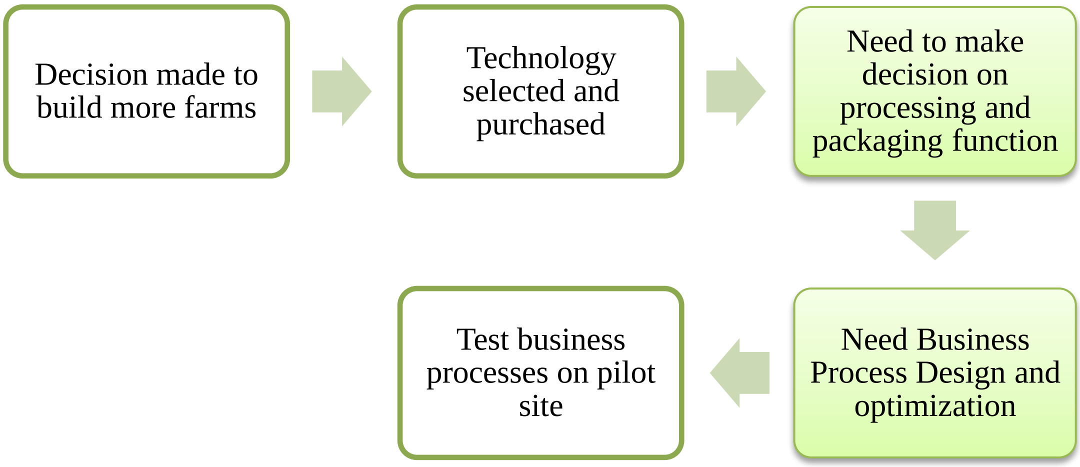


Figure 2 The need for industrial engineering services at Urban Farms

1.3 Key assumptions

This project is based on the following key assumptions:

- ✓ The feasibility of such an urban farm development was investigated before the final decision to build the farm. The only feasibility study that will be part of this project is for an on-site processing and packaging facility.
- ✓ The use of a hydroponics system and the required technology were thoroughly investigated before making the decision to use it on the farm.
- ✓ A business plan and financial model are not necessarily in place yet but the design and mapping of business processes and activities are not dependent on it.

1.4 Project aim / Rationale

1.4.1 Why urban farming?

Urban farming is making our food "as local as possible" (Howard, 2013). Food-miles refer to the distance that fresh produce and other food have to travel from the farmer to the consumer. In his presentation on the world's first commercial urban farm, Mohamed Hage indicated that on average the fresh produce on our plates travelled 1500 miles in refrigerated trucks (Ted^{X}UdeM, n.d.). This all happens in a complicated cold chain with often many interruptions. Hage furthermore mentions that we only find in-store those fresh produce that can transport well, while there are in fact a lot of other possible varieties with more nutrients and better taste. The first advantage of commercial urban farming is therefore the elimination of long-distance transport. This will be a revolution of the fresh produce supply chain and a welcoming idea from a South African point of view due to the weakening road connectivity of the country's rural areas, security risks and increasing fuel prices. It also reduces the carbon footprint from trucks that normally transport produce from farms to the cities, where most of the buyers are located. Furthermore, it ensures delivery on the day of harvest and therefore introduces an incomparable quality and freshness of products.

The South African Institute of Race Relations (2013) reports that in January 2013 two-thirds of the people in South Africa were living in urban areas as well as a 10% increase in urban inhabitants from 1990 to 2011. A. Smith (2012) is of opinion that the growing trend of urbanization is because of an urban bias that values urban development higher than the development of rural areas. The increasing number of urban inhabitants leads to less food security in cities and an increasing need for employment in the cities – both challenges that can be addressed by urban farming. Land availability in rural areas is endangered by, amongst others, mining activities. Urbanization and the changing status of traditional rural farming areas are staging urban farming as an important alternative to traditional farming methods.

There is a worldwide trend to "think and live green". This environmental consciousness is also rapidly emerging in South Africa. Croston (2009) suggests that businesses must capitalize on the consumers' green thinking to boost their bottom line. The purchase of healthier, local and sustainably produced foods is the new way of thinking and increasingly important to consumers.

Another advantage of urban farming is its ability to make cities greener and more aesthetically appealing. The Maboneng Precinct where UF's first farm is situated is currently undergoing major regeneration projects with entrepreneurship, environmental awareness and creativity at its core. The new urban farm will therefore contribute to the development of this area. City space utilization is another major advantage of urban farming. Urban farms can utilise vertical growing systems to maximise the use of space in cities such as rooftops that would have otherwise been unused.

1.4.2 Why Business Process Design (BPD) and modelling?

Business process modelling is becoming a growing priority for businesses of all sizes. Graphically documented processes are essential for the functioning of a team, consistency in operations, traceability and focus towards a goal. Business process modelling is important for (Singh, 2011):

- aligning operational activities with business strategies (e.g. UF's responsible food philosophy);
- communication of operational activities so that team members know what is expected from them;
- allowing consistency and quality control by executing a process the same way every time;
- providing assistance with optimization of available resources; and
- gaining a competitive advantage.

1.4.3 Why conduct a feasibility study?

A feasibility study is an essential first step towards any new undertaking. The need for a feasibility study for the on-farm processing and packaging facility can be justified. The feasibility study will provide (Martins, 2013):

- prove to potential investors whether there is a market for an on-site processing and packaging facility;
- research about the topic and in the process identify flaws, challenges, risks, potential and even more opportunities that may exist and influence the farm; and
- an estimation of the financial, technological and human resources required should it be decided to open the facility.

1.4.4 Why a training guideline?

The well-respected *Entrepreneur.com* website mentions in an article on employee development that "a business learns as its people learn" and that a business that is not learning will not survive (Sarvadi, 2005). The article furthermore indicates that as the employees (farmers in the case of this project) are the ones that produce, protect, manage and deliver the products, the success of the venture will be directly proportional to their skills level. The advanced level of technology planned for the new urban farms will bring with it a need for essential skills to operate the systems. As most of the farmers will be from previously disadvantaged and unschooled groups, training systems are essential.

1.5 Project approach, scope and deliverables

For each solution component, the approach and Industrial Engineering (IE) techniques that were used are listed in Table 1.

Table 1 Project approach

Solution component	Semester	Approach	IE techniques used (see also literature review)
Feasibility study for on-site processing and packaging	S1	Defined criteria for a feasibility study	Multi-criteria decision making tools Feasibility studies Engineering economics / managerial accounting
	S1	Reviewed available methods and constructed feasibility study method	
	S2	Performed the feasibility study	
Business Process Design	S1	Understood the environment (e.g. hydroponics)	Business Process Design (BPD) Business process modelling languages Porter's Value Chain Supply Chain Design
	S1	Performed literature review on farming systems	
	S1	Defined business function and performance criteria	
	S1	Defined modelling requirements	
	S1	Constructed a process design and modelling method	
	S2	Constructed process models	
	S2	Validated process designs against initial requirements	
Training guides	S1	Derived requirements for training	Business process modelling Training guide development
	S2	Developed visual training guidelines using the business process models	
	S2	Validated training guides against initial requirements	

1.6 Document structure

Table 2 explains the structure for this report and can serve as a quick reference to any part of the solution development process.

Table 2 How to read the report

Chapter 2 Literature study	**2.2**	How to understand a business environment
	2.3	How to determine the feasibility of the on-site facility
	2.4	Approaches to Business Process Design (BPD) and modelling
	2.5	About visual training material
	2.6	About farming practices
	2.7	About the farm's supply chain
Chapter 3 Solution requirements	**3.2 – 3.4**	What must the solution deliver?
Chapter 4 Developed method	**4.2**	Method for on-farm processing and packaging feasibility
	4.3	Method for process design and training material development
	4.4	Summary of developed method
Chapter 5 Solution	**5.1 – 5.5**	Project solution
Chapter 6 Validation	**6.1**	Validation of solution against initial requirements and task

2 Literature study and project investigation

2.1 Introduction to literature study

The literature study presents a theoretical background regarding the industrial engineering techniques listed in Table 1. Porter's value chain was selected as a starting point for understanding the different categories of business processes that will form part of an enterprise's operations. The different possible approaches to conducting a feasibility study, doing Business Process Design (BPD) and modelling and developing training material were then researched and reported on. The processes and activities that will form part of hydroponically farming lettuce and herbs were also researched and summarised. The Supply Chain Operations Reference (SCOR) model for designing supply chain processes is included to improve understanding of the complexity of UF's supply chain.

2.2 Understanding business processes and gathering information for BPD

The gathering of the facts and the details of what will happen in a business is an important first step towards BPD. Porter's Value Chain is a useful tool for understanding the typical systems and activities in a business. The value chain aims to show where and how an organisation adds value to what the customer will experience as materials and products move through the organisation. This assists a business in calculating its profit margin (the difference between value created and the cost of creating that value). It is also useful in building competitive advantage by creating a continuously improving customer experience as more value is added for the customer. Porter divides the value adding activities of a business into primary activities and support activities as indicated in Figure 3 on pg. 9. (Business Set Free Ltd, 2013).

The primary activities are:

- **Inbound logistics:** all the processes that will take place when the organisation receives and stores material and also the processes of internally distributing received material to the areas where it will be used
- **Operations:** the operational systems that will transform inputs into outputs
- **Outbound logistics:** all the processes to deliver a product to a customer (storage, distribution and transport)
- **Marketing and sales:** the organisation's approach to inform existing customers about products and to get new customers
- **Service:** the organisation's ability to communicate with a customer after a sale has been completed

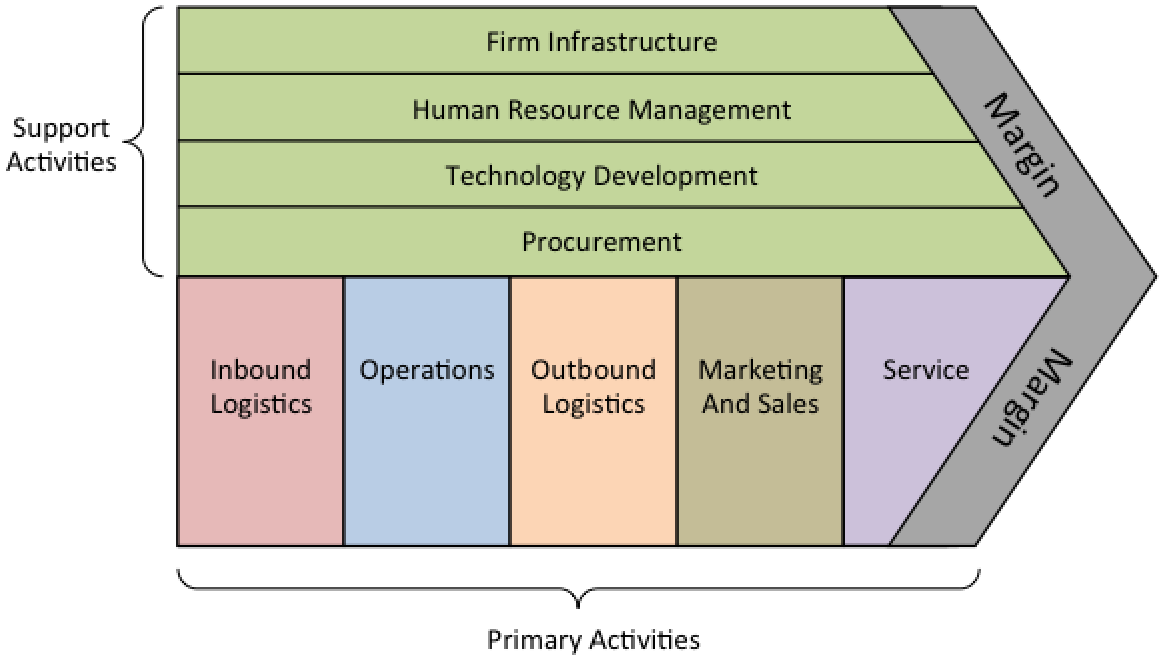


Figure 3 Porter's value chain (Business Set Free Ltd, 2013)

Porter's value chain can be used to establish which systems or processes will form part of a new organisation. MindTools (2014) suggests that the primary activities are used as a starting point to identify the associated **direct activities, indirect activities** and **quality assurance activities.**

Kemsley (2007) stresses the importance of completely understanding business process requirements before starting with BPD and indicates the following important initial questions:

- What will initiate/start the process?
- What type of work will be done at each step? How will work be allocated?
- What information exchange will take place?
- What must the role of documents be in the process?
- What volume of work will be going through the process?
- Do you want the capability to change your process easily?

Graham (2004) highlighted the importance of talking to the people that do the type of work that is mapped out. To simply read available literature about the process and just talk to managers and supervisors about the process is according to Graham "at least one step from reality". Graham suggests that a process modeller walks an example of the planned business process through with a clipboard in hand. More than one worker or work cycle should be observed to allow for any small variation that may exist but it is not recommended that the modeller try to allow for all possible variations.

Similar to Kemsley, Graham suggests that for each step in the process the modeller must ask:

- **What** will be done?
- **Where** will this work come from and how will it get here?
- **Who** will be doing the work?

Details about **how** the work is done should be omitted according to Graham. During the analysis of a process the **why** question can be asked for each step.

Similarly, Bailey (n.d.) proposes the information gathering techniques "shadowing", interviewing and brainstorming. "Shadowing" means to follow a worker in an existing facility as they perform their tasks and is recommended for an analyst that is familiar with the high-level process. Interviewing with individuals is recommended if the analyst is not familiar with the type of business for which processes must be designed and modelled. In a brainstorming session all the processes that were agreed on during the first steps can be written on post-it notes. The notes can then be arranged and re-arranged as the development group discusses the sequence, the people involved and the transactions. This continues until the group is satisfied with the result. It can then be validated with "shadowing" and interviewing.

2.3 Feasibility studies

The University of Wisconsin Center for Cooperatives (1998) defines a feasibility study as "…an overview of the primary issues related to a business idea." A feasibility study determines the practicality and profitability of an idea. It is also useful in indicating important benefits, challenges, risks or opportunities while an idea is researched.

2.3.1 The TELOS acronym

The TELOS acronym that was developed by Hall and presented in his 2007 book *Accounting Information Systems* indicates five important areas to consider during a feasibility study i.e. technological, economic, legal, operational and scheduling (Burgess, 2009). Pavey (2014) suggest that the following questions are asked for each one of the TELOS acronym letters:

Technological

- Does the team have access to the technology required to make the project a success?
- Do the people have the knowledge and skills required to operate the desired technology?
- What will the desired time and money inputs be for the technological component of the project?

Economic

- How will the planned venture be funded?
- How does the finances of the proposed development compare to that of other alternatives?
- What financial constraints can affect the project?

Legal

- Will the proposed new venture be legal?
- Will the success of the development be influenced by any pending legislation?

Operational

- What new procedures will be required to perform operations?
- What will the training needs of the project be?
- What major organisational changes will the project require?
- What impact will the proposed new department have on other departments in the organisation?

Scheduling

- Will the team be able to deliver the project when it is required?
- What scheduling conflicts will arise and how will they be addressed?
- What will the key deadlines be and how will it be met?

2.3.2 Other feasibility analysis guidelines

Bryce (2008) emphasises the importance of the old saying that "a problem well stated is half solved". The scope of the proposed opportunity must be definitive, to the point and without any pointless narratives. All participants, affected-parties and sponsors must be defined. It must be clear what the new project will include and what not.

Similarly to the TELOS acronym, Taylor (2013) suggests clear project description, competitive landscape, operating requirements, financial projections and recommendations as the main headings for a feasibility study. According to the University of Wisconsin Center for Cooperatives (1998) a feasibility study should focus on basic break-even analysis to see how much revenue will be required to meet operating expense and it should not do in-depth long-term financial projections. In this guideline for economic community development, it is further mentioned that a feasibility study must look into market issues, organisational issues, technological issues and financial issues as follows:

Market issues

i. What is the projected demand?

ii. What are the target markets and what are their demographic characteristics?

iii. What is the projected supply?

iv. What competition exists in this market? How are you going to compete?

v. Is the location of the business going to affect its success? If so, is the identified site the most appropriate one available?

Organisational issues

i. What organisational structure will work for this type of business?

ii. Who will serve on the board of directors? What are their qualifications?

iii. What qualifications are needed to manage this business?

iv. Who will manage the business?

v. What other staffing needs exists? How will the staffing needs change in the next three years?

Technological issues

i. What are the technology needs?
ii. What other equipment will be required?
iii. Where will the technology and equipment be purchased?
iv. When can you get the necessary equipment?
v. How does your ability to obtain this technology and equipment affect your start-up timeline?
vi. What is the expected cost of technology and equipment?

Financial issues

i. Start-up costs
ii. Operating costs
iii. Sources of financing
iv. Profitability analysis

Many other authors in literature had similar approaches than the above mentioned over many years. Graaskamp (1972) outlines the components of a feasibility study as objectives; market trends; market segmentation; legal-political constraints; aesthetic-ethical constraints; physical-technical constraints and financial synthesis. For the feasibility of an on-farm milk processing and packaging facility in Tennessee USA, the market feasibility (consumption trends; major retailers; niche sellers; prices and product attributes) and financial feasibility (budget; costs of value-adding activities; projections; comparison of market opportunities; net present value; internal rate of return; break-even point and sensitivity analysis) were considered (Moss, 2012).

To determine the feasibility of a blueberry packaging facility in Southeast Georgia analysts also considered market analysis and financial feasibility including capital cost, variable operating cost, labour and fixed cost (Luke-Morgan & Wolfe, 2008).

2.3.3 Financial feasibility formula

The net present value method is recommended by both Remer (1995) and Garrison, Noreen, and Brewer (2006) for the calculation of economic feasibility. With the net present value method the present value (PV) of a project's cash inflows is compared to the present value of its cash outflows. The difference between the two is called the net present value (NPV). If a company's minimum required rate of return on investment is used as discount rate in NPV calculations, a positive NPV is an acceptable project (since it promises a greater rate of return than required) while a negative NPV is not acceptable. Garrison et al. (2006) indicates that a company's minimum required rate of return is usually its cost of capital. If a project's rate of return is less than the cost of capital it means that a company does not earn enough to compensate its creditors and shareholders. The discount rate formula is shown here.

Discount rate = annual income from project / capital investment

The NPV method keeps the initial required investment, life of the project, annual savings in cost, salvage value and required rate of return on investment in mind. The NPV method can be expanded to the total-cost approach, one of the most flexible methods for comparing competing projects where the NPV is calculated for all the alternatives and the highest NPV value is selected (Garrison et al., 2006).

2.3.4 Multi-criteria decision making

Xu and Yang (2001) define multi-criteria decision making (MCDM) as "making decisions in the presence of multiple, usually conflicting, criteria." MCDM is suggested for decision making about the processing and packaging of products at UF as cost is not the only criterion but factors such as environmental impact and time-to-market will also play a role.

Decision making about future actions can follow the following sequence (UK Department of Communities and Local Government, 2009):

i. Identify objectives

ii. Identify options for achieving the objectives

iii. Identify the criteria to be used to compare the options

iv. Analysis of the options

v. Making choices

vi. Providing feedback

Popular methods for multi-criteria decision-making that feature in literature include the analytical hierarchy process (AHP), multi-attribute utility theory (a complex mathematical formulation) and outranking. Criticism of all the available multi-criteria decision making tools is often voiced and there is no perfect tool. The AHP was selected for review here because of its easy-to-follow logic that allows it to be easily interpreted and understood by non-technical stakeholders. The main criticism against the AHP is that the weights obtained during pairwise comparison are seldom reflecting people's true preferences. This can be overcome by keeping the stakeholders involved in the process and let them validate and accept each step.

The Analytic Hierarchy Process (AHP) has its beginnings in the 1980s when Thomas L. Saaty introduced it to assist in arranging priorities when making a business decision. It was not free of criticism and was reviewed by Saaty in 1994. The reviewed AHP is promoted by Triantaphyllou and Mann (1995) as the most widely accepted MCDM method. The AHP follows the steps listed here (Saaty, 2008).

1. Investigate the problem and decide what type of knowledge it must provide.
2. Construct the hierarchy from the top to bottom as follows: goal, objectives, criteria and alternatives.
3. Compile the pairwise comparison matrices to determine the relative importance of criteria.
4. Using the pairwise comparison matrices in (3), develop intermediate matrices by dividing each value in the matrix with the total of its column.
5. Using the intermediate matrices in (4), develop relative weights for each criterion by calculating the average of its associated row in the intermediate matrix (i.e. criterion 1 = row 1 etc.).
6. Repeat step (3) to (5) for each one of the criteria to compare the available alternatives with respect to that criterion.
7. Use the relative weights of each criterion together with an alternative's relative weight for that criterion to determine how suitable that alternative will be as a solution.

Saaty (2008) developed Table 3 to assist in determining relevant importance. The allocation of intensity of importance is based on experience and judgement.

Table 3 Analytic Hierarchy Process Intensity of Importance

Intensity of importance	Explanation
1	Alternative i and j are of equal value or importance
3	Alternative i is weakly more important than alternative j
5	Alternative i is strongly more important than alternative j
7	Alternative i is very strongly more important than alternative j
9	The evidence favouring i above j is of the highest possible order of confirmation

2.4 Business Process Design (BPD) and modelling

2.4.1 Introduction to BPD and modelling

Stewart (2002) mentions new business opportunities as one of the common drivers to implement BPD and defines BPD as "the method by which an organisation understands and defines the business activities that enable it to function." A business process model enables individuals to see where their roles fit in with the greater organisation and how they contribute to the final goal of satisfying a customer and making a profit. Bider (2005) listed a possible use of process models as "…increase the level of process maturity … to make staff goal and processes-conscious … to educate new employees." Business process models were previously useful for training, performance measurement and planning for automation or process improvement but this project would like to investigate new applications for it in training. According to Stewart (2002) a mapped out business process typically includes the elements listed here.

- All processes, sub-processes and activities that will take place to make and deliver a product or service.
- A text description for each process and activity including its purpose, triggers, timings, duration, and resource requirements.
- Drawings (swim-lane or workflow diagrams) to graphically show the relationship between activities.
- The destinations and characteristics of inflowing and outflowing information.
- Key performance indicators used to determine the success of the process.

In her paper on approaches to BPD, Kemsley (2007), an independent business process modelling architect, emphasizes the importance of having a process specialist to drive process design. According to Kemsley there is a big lack of improvement that ascends when users are doing their own process design. Similarly, when the process design is put in the hands of technologists the business requirements often gets ignored.

Kemsley furthermore linked business process modelling to enterprise architecture. Enterprise architecture can be defined as "the modelling and organisation of business and information systems" (Kemsley, 2007). Kemsley is however of opinion that we are missing the "business systems" part and that too many enterprise architecture efforts are turned into IT architecture efforts. Enterprise architecture can in fact be used to model business goals and strategies and Kemsley is of opinion that enterprise architecture can be seen as "a framework and methodology for describing your enterprise, all the components, all of the relationships, your topology, your principles, guidelines…" and defines this as "the second generation of enterprise architecture" (Kemsley, 2007).

As Figure 4 explains, the approach to second generation enterprise architecture starts with the business strategy. By using the business strategy the analyst identify goals that can assist in maintaining the strategy. The business processes that are required to meet these goals are then developed and all the resources (technology, people, infrastructure etc.) required to execute the processes are identified.

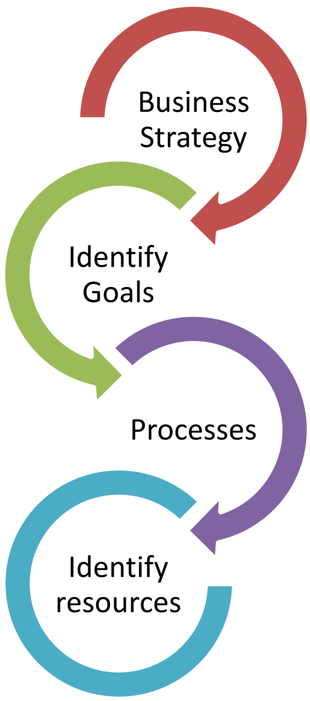


Figure 4 Steps to second generation enterprise architecture

Kemsley suggests the following process design and modelling steps:

I. **Define process flow:** Draw the basic path and flow information to obtain a graphical map of the process and have this map validated and confirmed before it goes any further. Use the available business process modelling tools and standards for this step.

II. **Define step parameters:** Look into each one of the steps and add data flows and sub-processes.

III. **Define conditional routing:** Identify where the process will "split" and what will lead to that split.

IV. **Identify process launch triggers.** Identify the events that will start process.

As a final word on business process modelling design principles, Kemsley suggests incremental implementation of new business processes. Many experts in literature also suggest a pilot site for the implementation of a new process. This approach assists in the validation of the process before it is presented to the wider company or industry.

2.4.2 SIPOC diagram

SIPOC is an acronym for suppliers, input, process, output and customers and presents a high level map of a process. It is recommended by Montgomery (2013) as part of the first step towards a problem solving process for quality and process improvement. The SIPOC diagram (Figure 5 pg. 19) provides a simple overview of a process to improve understanding and visualising of basic process elements and can communicate the scope of a project. Montgomery especially recommends it for areas where a process thinking style was not yet applied such as service industries. Simon (2010) writes about SIPOC diagramming as a very easy process and recommends it for cases where the suppliers or customers are unknown, where specifications for inputs must be developed and where the requirements of the customer must be listed. The SIPOC diagramming process exists of the following steps:

- Step 1: Begin with the processes and construct a high-level process map with four to five high-level steps.
- Step 2: Use the processes to determine what the outputs will be.
- Step 3: Use the outputs to decide who the customers will be.
- Step 4: Using steps 1 through 3 decide what inputs or key requirements exists.
- Step 5: Using the list of inputs required, determine who the suppliers will be.

Figure 5 SIPOC process

2.4.3 Integrated Definition Methods (IDEF)

IDEF offers a collection of modelling languages and is accentuated by Menzel and Mayer (2004) for its multi-perspective approach to modelling an organisation. IDEF0 and IDEF3 are applicable on this project and were selected for a detailed literature review.

2.4.3.1 IDEF0

IDEF0 is a well-featured technique in literature and has its base in well-established theory namely the Structured Analysis and Design Technique (SADT). The technique was developed for the United States Air Force with the goal to analyse and communicate the functional perspective of a system. IDEF0 is often used to establish the scope of a process analysis project as it highlights the functions, resource requirements and existing opportunities to the modeller and is therefore often the first step towards a process design and modelling project. The basic IDEF0 construct expresses the function as a box with arrows showing the interfaces that activates and controls it. This basic “box-and-arrow” approach is shown in Figure 6 (Knowledge Based Systems Inc, 2010).

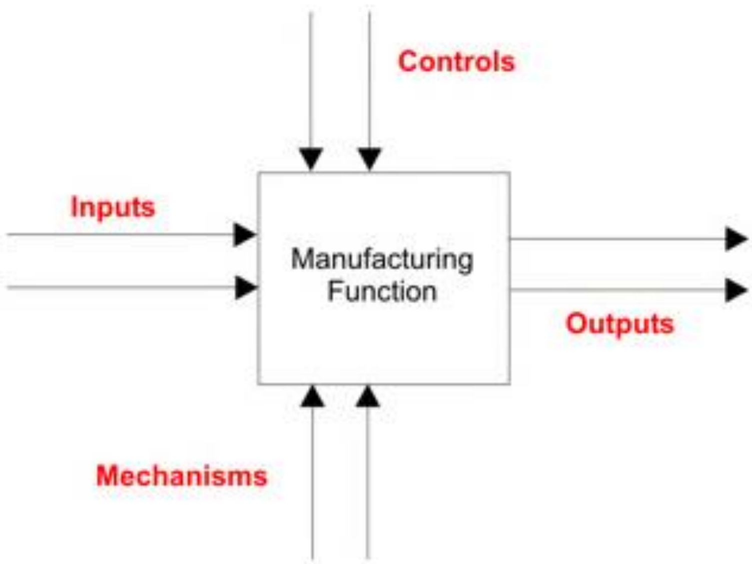


Figure 6 IDEF0 “box-and-arrow” approach (Knowledge Based Systems Inc, 2010)

2.4.3.2 IDEF3

The IDEF3 technique has the aim to document a complete process and is recommended by, amongst others, List and Korherr (2006) and Hommes (2003) as a good business process modelling language. IDEF3 captures the knowledge of a proposed or existing system and presents it in a chronological scenario showing all connections and relationships in a structured and descriptive manner. A process in IDEF3 (also called a unit of behaviour or UOB) includes the objects that form part of it, the interval of time when it occur, and its relations to other processes. Menzel and Mayer (2004) stages IDEF3 as "…particularly well-suited to the construction of models of general enterprise processes in which the timing and sequencing of the events in a process is especially critical." An IDEF3 model explains a process and its relation with other processes within a context of a broader project or scenario.

2.4.4 Business Process Model Notation (BPMN)

BPMN is an internationally accepted modelling standard that was developed by the Object Management Group (OMG). According to the OMG BPMN "…will provide businesses with the capability of understanding their internal business procedures in a graphical notation and will give organisations the ability to communicate these procedures in a standard manner." (Owen & Raj, 2003). BPMN delivers the business process diagram that is easy to use and understand. Emphasis is put by Owen and Raj on BPMN's ability to be easily understandable by non-technical users such as managers.

A business process diagram exists of events, business processes, sub-processes, end results and business decisions. As the analysis of the business process continues, BPMN allows the analyst to indicate who will be performing the process by placing events and processes in pools linked to, for example, departments. Pools can be furthermore parted into lanes to show, for example, the people in a department. The different components of a business process diagram with BPMN are discussed here (Owen & Raj, 2003).

Business events can be an event that starts a process, an event that forms part of a process or an event that is the final step of a process. BPMN syntax makes provision for events that carry messages, events that have time limits (or that is triggered at a certain time), events triggered by a rule that becomes true, exceptions, compensations and cancellations.

A straight-forward business **process** is indicated as a simple rounded rectangle linked to other processes. This is called a **task**. A more complex business process is marked with a "+" that links to a detailed BPMN diagram of just that process. This is called a child-diagram or a **sub-process**. As the BPMN language is dedicated to ease of understanding, modelling tools allow for a thumbnail of the child-diagram to be included on the main diagram.

BPMN allows for the recording of not only process flow but also **message flow** between pools.

BPMNs **gateway** symbol is similar to the diamond in traditional flowcharting. A gateway represents a question that is asked of which the answer will determine what route will be followed next. Gateways include inclusive decisions, exclusive decisions and complex decisions.

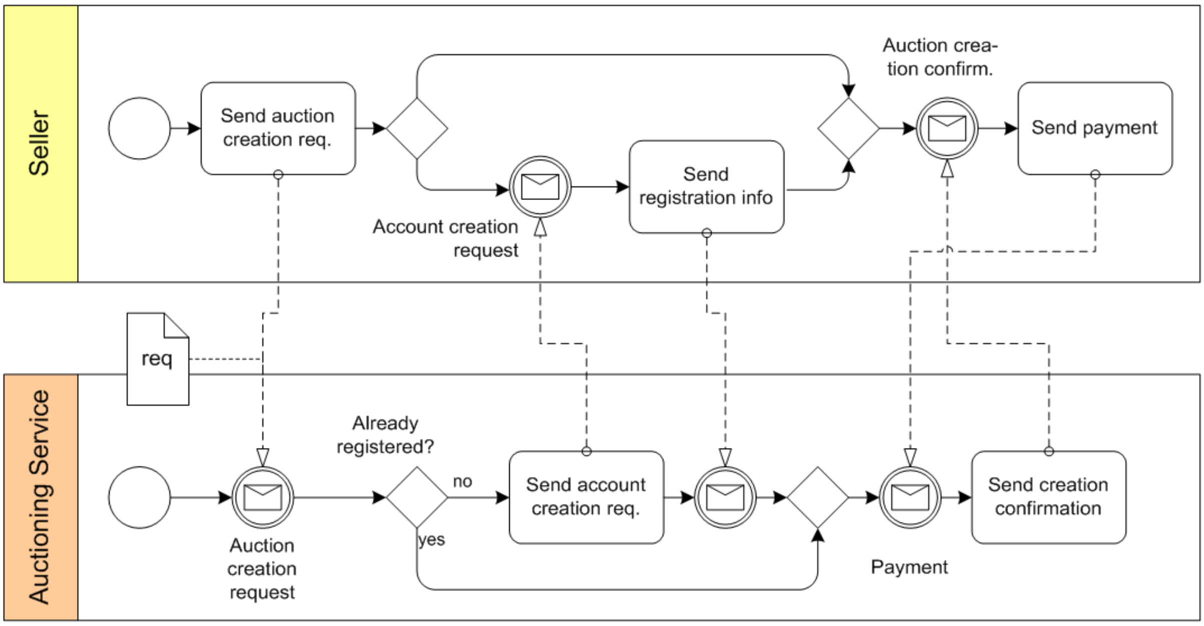
A pool can be left blank in which case it is called a **black box**. This represents an actor outside the control of the company, over which the company has no control and whose processes are not of interest to the company.

BPMN process diagrams allow for the inclusion of **data objects** as the processes in an organisation transform data. The modelling of data objects is optional as they do not influence the process flow but simply provides more information.

To furthermore increase the understanding of a BPMN model, the notation allows for a **text annotation** to be linked to any element. This allows the analyst to add any additional information about that element in as many words as required.

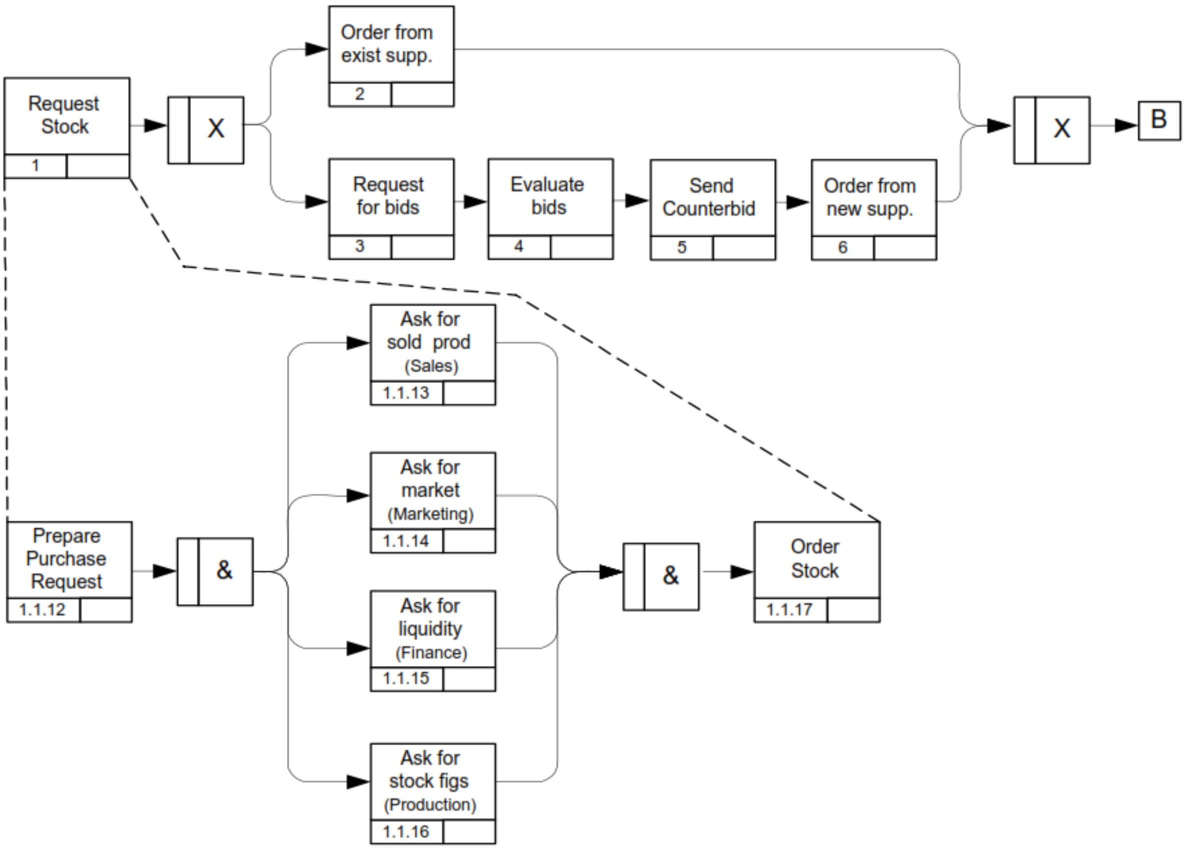
It becomes clear that BPMN and IDEF3 are two useful methods for mapping complete businesses. An example of a basic BPMN diagram compared with a basic IDEF3 diagram is shown in Figure 7 on pg. 22. The selected method is announced and justified in section 4 at the developed method.

BPMN



Source: BPMN.info (2007)

IDEF3



Source: BPM Professional (2013)

Figure 7 BPMN compared with IDEF3

2.5 Training guide development

2.5.1 The power of visual communication

"Something is happening. We are becoming a visually mediated society. For many, understanding of the world is being accomplished, not through words, but by reading images." - Paul Martin Lester (Syntactic Theory of Visual Communication)

In its report on the power of visual communication, Hewlett Packard states that we are in the visual age and that it is an exciting time for those wanting to carry over a message or educate with visuals. Numerous research studies concluded that visual communication is more effective than verbal or written instructions or notes. A New York University psychologist, Jerome Bruner, founded that people remember 10% of what they hear, 20% of what they read and 80% of what they see and do (Lester, 2006). Correspondingly, the Wharton School of Business asked researchers to compare visual presentation and verbal presentations and concluded that people find a presenter using visual language more influential. 67% of people involved in the study stated that a combination of visual and verbal communication is the most effective. It can therefore be stated that a combination of visual and verbal methods is the most effective way of carrying over a message. Such a guide can be easily compiled using flow charts, graphs, tables or diagrams.

Clark (2009), expert on cognitive methods for training and performance improvement, is of opinion that one of the biggest misconceptions in the practice of employee training is that some people learn visually and others learn auditory. Clark argues that all employees that are relatively new to a content area will benefit from visuals in their training.

2.5.2 Skills transfer

Knowledge transfer and skills development are buzz words in the South African economic environment. The Africa Institute of South Africa (2011) motivates this with the fast pace of technology and science developments on the continent. Theresa Fredericks, owner of the Tshwane Fresh Produce Market and board member of the Agriculture Agents Council, comments on the transformation and skills transfer that the agricultural sector of South Africa requires. Fredericks argues that although currently most emerging farmers have skills about traditional farming methods, there is an intense need for skills transfer in modern farming practices. The rapidly changing farming technology stages the need for farm workers to be innovative and adjustable. She concludes that transformation in the South African agricultural industry is almost non-existing for internships (to gain qualifications) and mentorships (to gain experience) (Fredericks, 2012). A project that can include the development of the much needed modern farming skills of previously disadvantaged farmers will therefore be a project that makes a difference.

2.6 Farming practices

2.6.1 Seedling propagation

According to The University of Kentucky Department Of Agriculture an urban farm using hydroponics should include a germination area where seedlings can be propagated and states that propagation happens by manually placing plants into a germination medium in a tray. This can either be part of the greenhouse or in an environmentally controlled room using benches and artificial lighting such as white fluorescent or high pressure sodium lamps (University of Kentucky: College of Agriculture, n.d.). H. Smith (2014) explains that the propagation of lettuce plants is done in pieces of mineral wool called *plugs*. The plugs are firstly soaked in a conditioning solution with a pH of 5.5 until the pH of the mineral wool is approximately 6.2. One lettuce seed is then placed into each plug. If it becomes clear that multiple seeds ended up in a plug, the best plant should be allowed to grow while the others must be removed. Farmers should be careful that lettuce seeds do not become overheated and should cover the tray of plugs with a plastic humidity sheet and place it close to a light source such as natural light or a fluorescent light. When roots start growing out of the plugs the plants are ready to be transplanted into the farm’s hydroponics system. According to University of Kentucky: College of Agriculture (n.d.), farmers can expect seedlings to grow 2 to 3 weeks before transplanting.

According to Brechner and Both (n.d.), the first 11 days of lettuce production happen in the germination area and it is important to have a reservoir (either fibreglass or plastic but durable enough to handle sunlight) for housing a nutrient solution that can keep the seedlings moist. This can either be done manually with a hosepipe or with an automatic system without human involvement and 250 litre of nutrient solution is recommended to be sufficient for the propagation of 2000 seedlings for 11 days. This leads to the following calculation for UF’s first farm:

250 l nutrient solution / 2000 seedlings = 0.125 l nutrient solution / seedling

0.125 l x 13 000 plants per cycle = 1625 l nutrient solution required for first 11 days of each cycle

They furthermore recommend the specifications listed here for each day of the 11 day germination cycle.

Day 0

- A nutrient pH of 4.5 is required to soak the mineral wool plugs in.
- A certain light exposure must be maintained for the first 24 hours.
- A temperature of 20°C is required.

Day 1-11

- Electrical conductivity of 1200 μS/cm should be maintained.
- A pH of 5.8 (add a base such as potassium hydroxide or nitric acid if it is higher) is required.
- Temperature should be kept at 25°C
- Light exposure is according to a specification.
- Plugs must be kept moist at all times.

Day 2

- Remove humidity covers.

Day 3

- Remove any double seedlings.

Day 6-11

- Water at least once a day.

Day 11

- Transport for transplanting.
- Prior to transplanting, propagated plants need to be thoroughly irrigated.

A typical seedling germination process with germination plugs is shown in Figure 8 (Practicing Hydroponics, 2010).

Figure 8 Seedling propagation tray (Practicing Hydroponics, 2010)

2.6.2 Hydroponics

2.6.2.1 Definition

Hydroponics is a well-known and new method of growing plants without the need for soil. In traditional farming methods, soil is only required to house nutrients until they are dissolved when the plant is watered and then absorbed by roots. By manually placing the required nutrients in the water supply, the need for soil is eliminated. One of the key characteristics of this farming method is that it is a closed system and any water that is used can be re-used later. Hydroponic farming takes place in controlled environments such as greenhouses, eliminating the need for pesticides (Huxley, 2013).

Figure 9 (H_2O Growing, n.d.) shows the working of an hydroponics growing system.

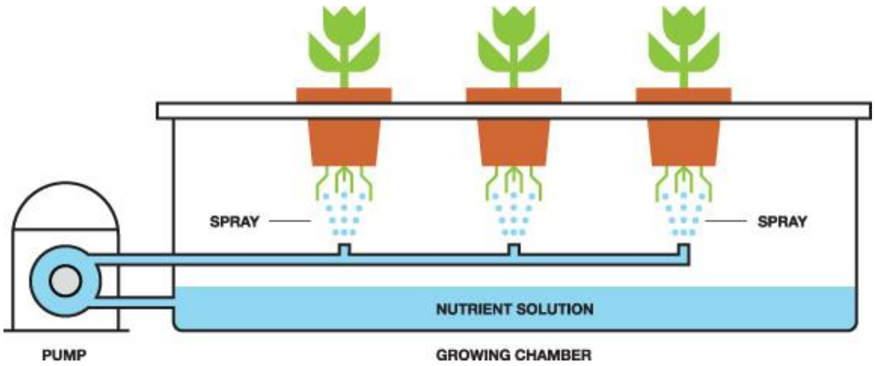


Figure 9 Hydroponics growing system (H_2O Growing, n.d.)

2.6.2.2 Control and maintenance

Brechner and Both (n.d.) emphasise the importance of having computer technology to monitor the parameters in the greenhouse and suggest the following set points for environmental control purposes:

- **Temperature** determines the rate of growth as higher temperatures speed up the chemical processes in plants. Also, the enzymes in plants require a small temperature range to enable these processes. Air temperature of 24°C for days and 19°C for nights are recommended while water temperature should remain between 25°C and 26°C at all times.
- The **relative humidity** of the greenhouse for hydroponically farming lettuce influences the rate of transpiration in plants. A humidity higher than 70% should be prevented as it encourages disease growth and reduces the movement of nutrients from roots to leaves. The minimum humidity specification should be set at 50%.

- **CO_2** is required by plants for the process of photosynthesis and therefore directly influences plant growth. CO_2 levels are measured in *parts per million* (ppm) and a parameter of 1200 ppm is recommended if the plants are exposed to light and 390 ppm when plants are not exposed to light.
- **Light** availability is measured with a quantum sensor that measures the availability of light that is useful for the process of photosynthesis. This is called the Photosynthetically Active Radiation (PAR, measure in µmol/m). A control of 17 µmol/m should be in place.
- The levels of **dissolved oxygen** in the nutrient solution determine how easy roots can undergo respiration. A control of 7 mg/*l* (or ppm) is recommended and it is important to note that crops will be devastated if this reading is less than 3 ppm.
- **pH** levels indicates the balance between the hydrogen ions (H+) and hydroxide ions (OH-) in the nutrient solution and indicates the acidity of the solution. A pH reading of between 5.6 and 7 is recommended.
- **Electrical conductivity** is a measure of the dissolved salts in the nutrient solution. The electrical conductivity is influenced when plants take up water and nutrients or when water evaporates. A too low electrical conductivity is fixed by adding concentrated nutrients while a too high electrical conductivity is addressed by adding pure water to the solution. Electrical conductivity should be kept at 1150-1250 µS/cm above the source water.

In its guide on hydroponically growing lettuce, the University of Kentucky: College of Agriculture (n.d.) reports about **water and nutrient control**.

- Harvested water is almost always used for hydroponics and is suitable as long as it is not overly chlorinated.
- Watering is by means of an overhead mist irrigation system with nutrients included in the water.
- As the plants grow in a closed system (i.e. water and nutrient mixes are re-used), monitoring and adjusting of the solution is important before it can circulate through the system again.
- Solution tanks must be drained and cleaned thoroughly before planting succeeding crops.

Kessler, Williams, and Howe (2006) states that the roots of plants must be kept moist at all times in order for the plant to put its energy in developing leaves rather than developing a root system.

Preventative management of diseases is extremely important in hydroponics as there are almost no cures for the diseases that can occur here. Plants must be inspected daily for signs of insects, diseases or mites. Workers doing this inspection must have knowledge of these signs (University of Kentucky: College of Agriculture, n.d.).

Brechner and Both (n.d.) list the following general disease prevention principles:

- Have a plan in place for the treatment of mildew and access to the appropriate chemical controls.
- If root disease is observed, the relevant crop must be discarded and the solution tanks as well as entire germination area must be drained and cleaned with bleach before any new crop can be started.
- All equipment must be washed with bleach between uses.
- Keep the solution tanks in shade as well-lit and wet areas encourage algae growth.
- Know the difference between the insects that are in the greenhouse for biological control and those that must be seen as threats.

According to University of Kentucky: College of Agriculture (n.d.), harvesting of hydroponically grown lettuce is generally with its roots attached. Excessively long roots may be trimmed or wrapped around the stem before packaging. By leaving the roots attached, the storage life of the product increases. Plants can stay fresh for 2 to 4 weeks when stored near freezing temperature and with high humidity. Plants do not require any washing as there was no soil involved and they remained clean. Plants can be packaged in any way according to market demand.

2.7 Supply chain

For researching the inbound and outbound logistics applicable to an urban farm, the Supply Chain Operations Reference (SCOR) model was used. SCOR is a methodology, diagnostics and benchmarking tool that provides a model that links supply chain business processes with metrics and best practices to improve the effectiveness of supply chain management. The SCOR framework is shown in Figure 10 on pg. 29 (Supply Chain Council, 2013).

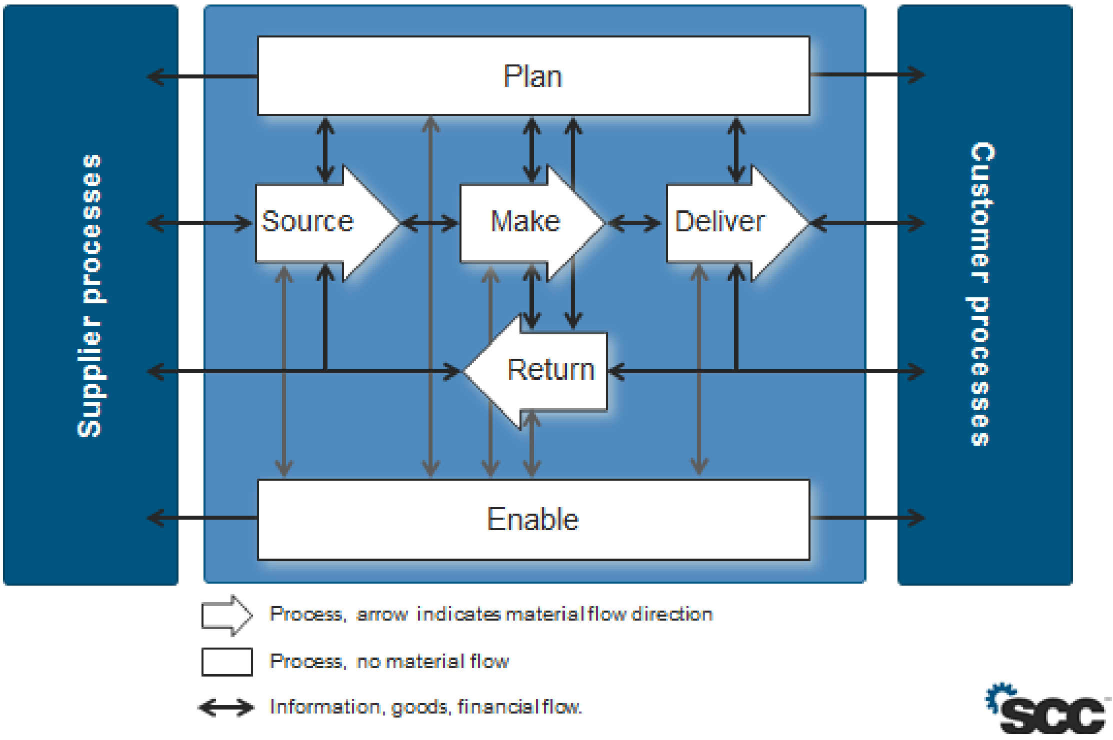


Figure 10 SCOR Model (Supply Chain Council, 2013)

The SCOR model exists of the following processes (Supply Chain Council, 2012):

- sP Plan
- sS Source
- sM Make
- sD Deliver
- sR Return
- sE Enable

The SCOR model can be used to know which elements will form part of a typical supply chain. The elements of the SCOR model that are applicable to the farm are:

Plan Source

- sP2.1: Identify, prioritise and aggregate product requirements
- sP2.2: Identify, assess and aggregate product resources
- sP2.3: Balance product resources with product requirements
- sP2.4: Establish sourcing plans

Plan Make

- sP3.1: Identify, prioritise and aggregate production requirements
- sP3.2: Identify, assess and aggregate production resources
- sP3.3: Balance production resources with production requirements
- sP3.4: Establish production plans

Plan Deliver

- sP4.1: Identify, prioritise and aggregate delivery requirements
- sP4.2: Identify, assess and aggregate delivery resources
- sP4.3: Balance delivery resources with delivery requirements
- sP4.4: Establish delivery plans

Source make-to-order product

- sS2.1: Schedule product deliveries
- sS2.2: Receive product
- sS2.3: Verify product
- sS2.4: Transfer product
- sS2.5: Authorise supplier payment

Make-to-order

- sM2.1: Schedule production activities
- sM2.2: Issue sourced/in-process product
- sM2.3: Produce and test
- sM2.4: Package
- sM2.5: Stage finished product
- sM2.6: Release finished product to deliver
- sM2.7: Waste disposal

Deliver make-to-order product

- sD2.1: Process inquiry and quote
- sD2.2: Receive, configure, enter and validate order
- sD2.3: Reserve inventory and determine delivery date
- sD2.4: Consolidate orders
- sD2.5: Build loads
- sD2.6: Route shipments
- sD2.7: Select carriers and rate shipments
- sD2.8: Receive product from make
- sD2.9: Pick product
- sD2.10: Pack product
- sD2.11: Load product and generate shipping documents
- sD2.12: Ship product
- sD2.13: Receive and verify product by customer
- sD2.15: Invoice

2.8 Summary of literature study

The literature study highlighted the importance of completely understanding all aspects of a system before attempting decision making or BPD. The similarities in the different approaches for feasibility studies validate the worth of Hall's TELOS framework (technological, economical, legal, operational and scheduling). The comparison between IDEF3 and BPMN as business process modelling languages staged BPMN as the most user-friendly language available for the project. The section furthermore presented more justification for the development of a training guide to be used by the company. Very important knowledge of the working of hydroponic farming systems were gained from the literature study. This is used in section 5.3 where the greenhouse processes are designed. Lastly, the SCOR model improved the understanding of the processes that must be included in process design for having an efficient supply chain and is also used in section 5.3 to determine the activities that will form part of a farm's operations.

3 Solution requirements

3.1 Introduction to solution requirements

This section distinguishes between three types of requirements and expectations that the project must meet. Business function requirements refer to the operational specifications and limitations that the farm will have and that must be kept in mind during the solution design phase. The sections for feasibility study requirements and BPD list all the different aspects that these two sections must include.

3.2 Business function requirements

The business function requirements for UF were investigated to improve the understanding of what processes must be designed for UF. From Porter's value chain the following business functions will be applicable to UF:

- Inbound logistics: UF will have to source and procure raw materials (e.g. seedlings and nutrients) from suppliers.
- Operations: This will include all the planning, preparations, planting, maintenance, harvesting and processing & packaging (if decided to do processing and packaging on the farm).
- Outbound logistics: UF will be responsible for the storing, loading and transport of plants either to a packaging partner or to customers.

Other business function requirements that will influence the design of UF's business processes can be summarised as:

- A total of 3000 lettuce heads / plants will be harvested and sold per week.
- UF's intended customers are ten Johannesburg restaurants and local Woolworths Foodmarkets.
- The farm will produce five varieties of gourmet lettuce. In addition to this, the farm will also produce *basil*, *chard* and *cavalo nero*.
- Harvesting, processing, packaging and delivery to the customer of all produce must happen on the day of harvest.
- Include investigation of the specific protocols and standards expected by Woolworths if a company wants to supply to them.
- Available technologies that can reduce the carbon footprint and improve the sustainability must be considered in the construction of all solutions.

- Compliance with all standards, regulations and laws applicable are non-negotiable.
- The company's approach towards dealing with water, land, carbon footprint reduction and healthy products will influence the type of activities and processes that will take place.
- Emphasis must be put on job creation and empowerment of previously disadvantaged farmers.

3.3 Feasibility study requirements

The results from the feasibility study segment of the project must present the following (as indicated by the enterprise and elaborated on by the student):

- Include the economic considerations in decision-making.
- Comment on the possibility and profitability of expanding UF's core business beyond farming to including packaging and processing as well.
- Indicate clearly the benefits that an on-site processing and packaging facility will have for UF.
- Keep all standards and regulations of food processing and packaging in mind when comparing alternatives.
- Develop a generic approach to allow it to be reused on other farms with similar or different circumstances.
- Use a feasibility study approach that are understandable and can easily be followed by any relevant stakeholders.

3.4 Business process models and training material

The requirements from the physical process models are:

- Mapped out business processes must be understandable and easy to follow for a non-technical farm worker as well as management. It should also allow for the development of pictorial training material in the form of flow charts.
- Two versions of process mapping are required i.e. detailed process maps (for use by management) and basic flow charts (for use by field employees).
- Process maps must include all activities that will take place from seeding to delivery and show the human resource requirements or job description for each activity.

- Company policies and procedures must be included in the processes and the logical flow of the diagram must ensure that all policies and procedures are complied with.
- Wherever documentation will be part of the process the generation, handling and storage of such documentation (together with indication of a responsible person) must be included in the diagram.
- Key performance indicators must be included in the diagram as to ensure that only quality products proceed to the end of the supply chain and that available resources are used efficiently. Indicators include temperature at each stage of the process, water levels, nutrient levels, and expected plant characteristics (such as size or colour).
- Process models must be adaptable and maintainable and will be used on other farms than the pilot site in Johannesburg.

3.5 Summary of solution requirements

This section described the requirements that the different areas of the project must comply with in order to be a successful project that adds meaningful value. It is listed again in section 5.5 where it is used as a checklist for validating the developed solution against the initial requirements.

4 Developed method

4.1 Introduction

This section uses the literature that was reviewed in section 2 to develop a project approach that will meet the solution requirements listed in section 3. Questions that will be asked about the feasibility of on-farm processing and packaging were formulated from the approaches and examples reviewed. Secondly, it uses Porter's value chain as a starting point in conjunction with the suggestions of other authors to derive an approach for BPD and modelling and the development of training material. Lastly, it explains how the developed process models will be used to develop a starting point for training material.

4.2 Feasibility study

4.2.1 Feasibility questions

The developed feasibility study has the TELOS framework as its base and was improved by adding the approaches of other authors. This section of the project exists of a feasibility study as well as a multi-criteria decision making process (see Figure 11 p. 39). The feasibility study follows the following sequence:

1. Start with a clear definition of the facility, as suggested by various authors in the literature study.
2. Ask the technological, economical, legal, operational and scheduling questions.

Technological questions:

i. What technology and equipment will be necessary for the operation of the processing and packaging plant? Does the team have access to this technology in the required time and how will the waiting time for technology influence the start-up timeline?

ii. What skills does this technology require from human resources?

iii. Does the farm have access to employees that have the knowledge and skills required to operate the desired technology?

iv. What will the cost of such technology and equipment be?

Economic questions:

i. What are the start-up cost items?

ii. What are the operating cost items?

iii. What additional revenue/saving will the on-site facility bring?

iv. How will the facility be funded?

v. How does the financial implication of building the facility compare to that of outsourcing the functions?

vi. What financial constraints can affect the project?

vii. How will a template look for net present value calculations?

Legal questions:

i. Is the venture legal?

ii. Does UF have the knowledge of the legal aspects for doing business?

iii. What policies will be enforced by Woolworths?

Operational questions:

i. What processes will happen in the new facility?

ii. What will the human resources and training needs of each one of these processes be?

iii. Who will be the manager and what qualifications must such a manager have?

iv. What impact will the proposed new facility have on other departments at the farm?

Schedule questions:

i. Will the facility be completed when required?

ii. Which scheduling conflicts will arise and how will they be addressed?

iii. What will the key deadlines be and how will they be met?

After answering all the questions, the process must be repeated as some answers may have impacted other factors such as economic feasibility or equipment requirements.

4.2.2 Multi-criteria decision making

The results of the above mentioned feasibility study influences the AHP process (see Figure 11 p. 39) in such a way so that the AHP result can be seen as the final decision. The AHP decision making follows the following steps:

1. Identify the objectives or requirements of a processing and packaging facility (Done in section 3).
2. Identify alternatives available for achieving the objectives.
3. Identify the criteria to be used to compare the options in conjunction with the enterprise.
4. Analyse the options using AHP and get a result.

4.3 Process design and modelling method

The decision made about the processing and packaging facility determines whether processes will be designed for such a facility and is therefore an input to this section (see Figure 11 p. 39).

The fact-finding questions of Graham and Kemsley directly fills each other's shortcomings. A combination of the two approaches was made for the purpose of this project together with Porter's value chain and yields the following BPD and modelling approach:

1. List all the **high-level** activities that must happen with lettuce and herbs during hydroponic farming in inbound logistics (everything that is supplier facing), operations (seeding, planting, growing cycle, harvesting, processing and packaging) and outbound logistics (everything that is customer facing) and quality assurance activities (e.g. maintenance and control). Keep the business function requirements, business strategy and goals in mind. Do not include anything other than high-level actions at this stage.
2. For each activity, determine what actions will be part of it.
3. Determine what starts or initiates the process.
4. For each action, answer the questions **who** and **where.**
5. An IDEF0 or SIPOC diagram can be completed at any step to improve understanding if required.
6. Write down each action on a post-it note and arrange the notes during a brainstorming session until its flow is corresponding to the inputs and outputs of the IDEF0 diagrams. Start with the initiating activity.
7. For each activity, list the information exchange and documents involved.

8. Draw an informal flow chart of the process as it is understood at this stage. Use this flowchart in several iterative and collaborative sessions with the enterprise until the process is as required by UF. Optimisation of the process is included during this step by continuously reviewing the process for opportunities to improve it.
9. Do the final business process modelling using BPMN. BPMN is selected mainly because of its reader-friendly syntax. It is easy to follow for a non-technical reader with little to no knowledge of BPD. It is the only available model that allows for easy inclusion of all the solution requirements.
10. Using the BPMN models, derive informal and easy-to-understand visual "story boards" that can be used in the workplace to aid employees in what they are to do next.
11. Derive resource requirements from business processes as suggested by Kemsley (2007) in the literature study.

4.4 Summary

The method that was developed for this project is summarised in the diagram in Figure 11.

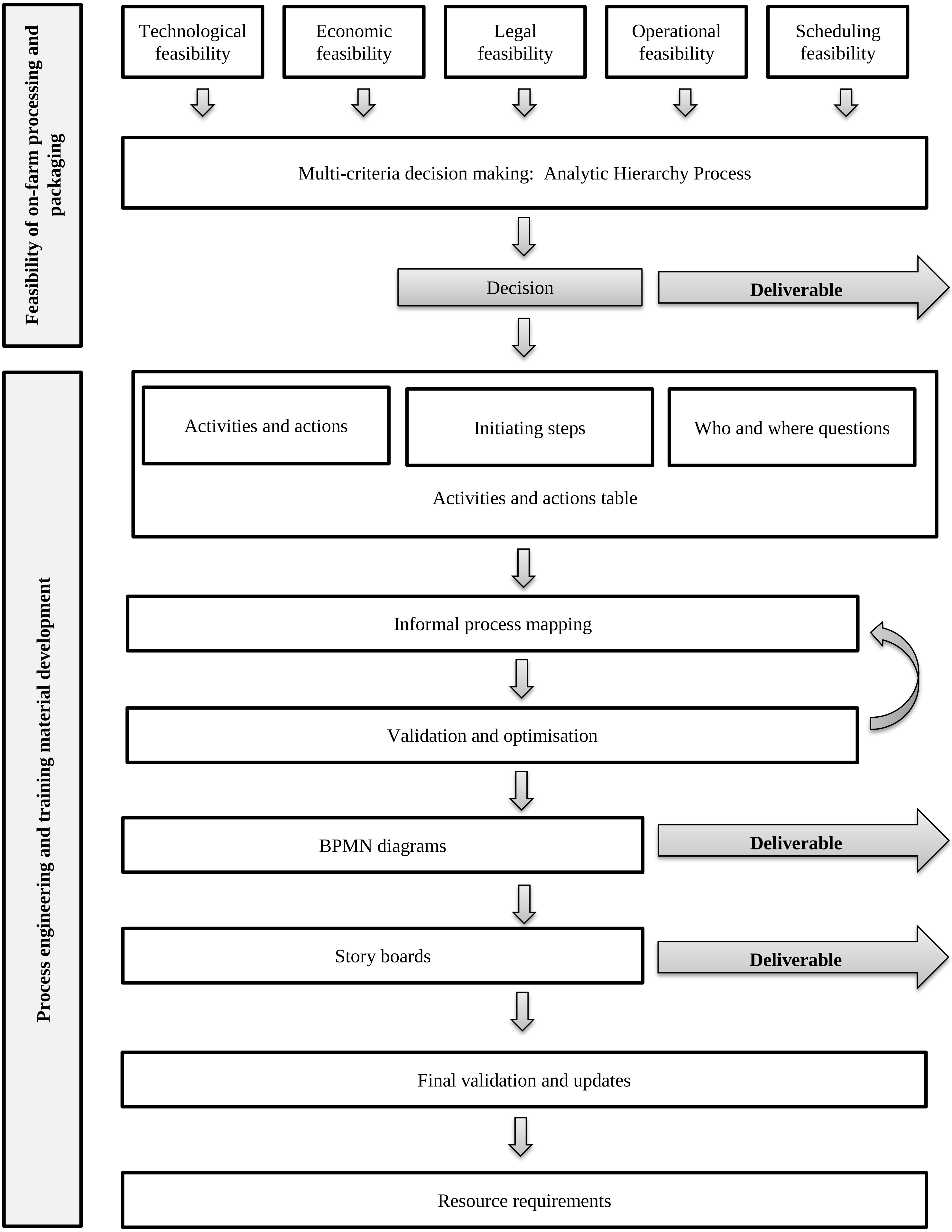


Figure 11 Developed method

5 Solution

5.1 Introduction to solution

The method developed and explained in section 4 is applied step by step in this section. It starts with the feasibility study and multi-criteria decision making process and then contains the Business Process Design (actions and activities table and BPMN diagrams). Lastly it translates the BPMN diagrams into visual training material story boards.

5.2 Feasibility study

5.2.1 Definition

The business function requirements and feasibility study requirements (see chapter 3.1 and 3.2) formed the base of the feasibility study approach. The participants in the feasibility study process of this project were the owner and manager of UF and the student. The processing and packaging facility can be defined as a group of separate functions that are adjacent to the greenhouse and to a delivery area on the outside of the farm. The following functions are implied:

- Receiving, washing and drying of lettuce;
- Printing labels and attaching it to bags;
- Bagging lettuce according to delivery lists;
- Picking from stock and consolidating orders; and
- Management to ensure quality products and correct order fulfilment.

5.2.2 Technological feasibility

The UF team has all the required technology and equipment for the operation of a processing and packaging plant available. The technologies and equipment to be used are:

- Washing basins;
- Benches / work stations for processing activities;
- A single bagging machine;
- Labelling equipment; and
- Barcode scanner technology

Should the processing and packaging plant be built, the farm's human resource and training needs will undergo small changes due to the addition of these technologies. The majority of the required skills are available to the farm with only a need for minor skills upgrade and training initiatives.

5.2.3 Economic feasibility

The processing and packaging plant will lead to the following **savings and additional income**:

- Cold storage and transport to outsourced packaging and distribution partner;
- Fee charged by outsourced packaging and distribution partner;
- Occasional losses in spoiled products that cannot be packaged on day of harvest due to transport challenges or complexity of supply chain; and
- The possibility to do processing and packaging for other clients

The processing and packaging plant will yield the following **additional capital expenses** for UF:

- Installing equipment in the facility;
- Obtaining a license to process and package food;
- Additional training material development; and
- Recruitment of manager.

The processing and packaging plant will yield the following **additional operational expenses** for UF:

- Maintenance of the facility and its equipment;
- Labour and training expenses;
- Transport of produce to customers; and
- Manager salary.

The net present value template in Table 4 was developed to assist UF in making financial decisions. The template can be used together with budgets and quotes for cash flows, the company's desired discount rate and the present value tables to see the profitability of financial decisions.

Table 4 Template for net present value calculations

Item	Year(s)	Amount of cash flow	% factor from table	Present value of cash flow
Build processing and packaging facility				
Equipment installation	Now			
License	Now			
Additional training material development	Now			
Maintenance	1-5			
Labour	1-5			
Transport to clients	1-5			
Manager salary	1-5			
Salvage value of equipment	5			
PRESENT VALUE				
Outsource processing and packaging				
Storage and transport	1-5			
Outsourced company fee	1-5			
Additional income from other clients	1-5			
PRESENT VALUE				

5.2.4 Legal feasibility

UF complies with all the legal requirements for operating a business and is in possession of the required business licences. A copy of the South African National Standards applicable to the farm will be supplied to UF. Investigation of the Woolworths policies yielded that Woolworths requires a formal meeting and presentation with UF management as well as a visit to the farm before their specifications and requirements can be made available. It is recommended as a future research project.

5.2.5 Operational feasibility

The processing and packaging facility will add the following activities and processes to UF:

- Washing and inspection;
- Sorting;
- Bagging;
- Labelling; and
- Outbound logistics (temporary storage, vehicle loading, route planning and transport).

If the advanced packaging method is selected the following steps are also added:

- Root ball cutting (for some packaging methods);
- Weighing;
- Additional handling of produce; and
- Sorting of lettuce and herbs into combination packs according to a recipe.

Processing and packaging protocols will have to be developed in accordance to strict food safety practice and employees should then be trained in them. Monitoring of the compliance to these protocols will be important for the successful operation of such as a facility.

To illustrate the impact and the complexity of interactions between the proposed new facility and the other departments on the farm, a context diagram was used. The context diagram is suggested by Kossiakoff, Sweet, Seymour, and Biemer (2011) as an effective tool to show external entities and their interactions with the system that is being studied. The context diagram for the on-farm processing and packaging facility is being showed in Figure 12.

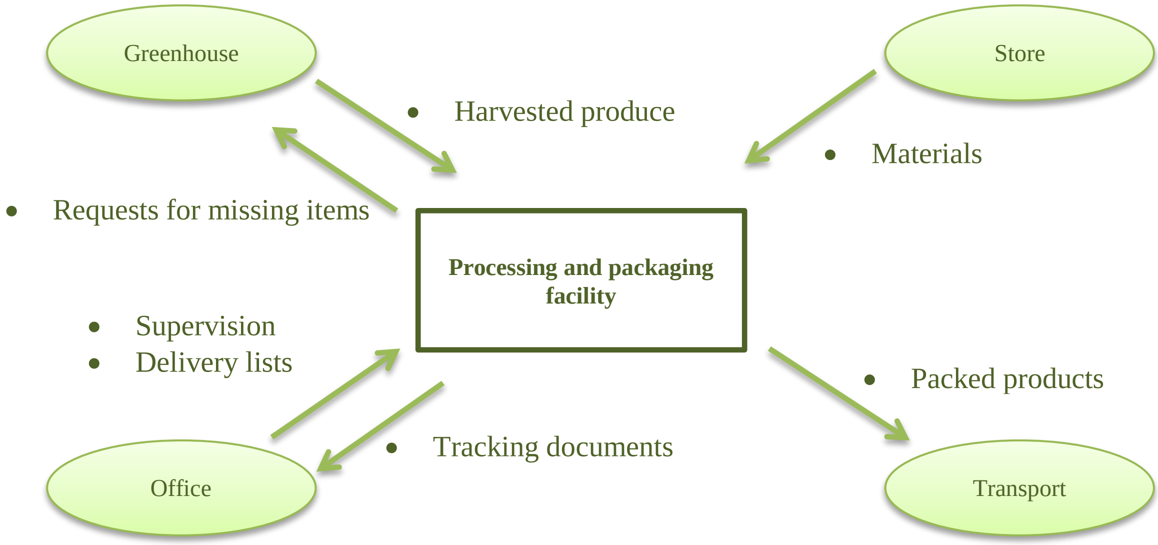


Figure 12 Context diagram

In the context diagram it becomes clear that the processing and packaging facility will be in interaction with the greenhouse, the supply store, the farm office and the transport provider. The biggest impact that the facility will have on another department is the administrative functions required from the office. The interactions with the store, transport provider and greenhouse are minor and limited to transferring material and basic communication.

A challenge arose with the target to supply to Woolworths. A meeting with representatives from the company yielded that, in order to directly supply to Woolworths, the farm must be able to deliver 7 days a week and 365 days a year. If an intermediate supplier is used (e.g. Fresh2Go) the farm must be able to deliver 3 to 4 times per week and sacrifice 5% of profit mark-up. Woolworths will expect the farm to have a full-time and well-experienced food nutritionist working on the farm as well as several audits per year. This feedback together with the contact details of Woolworths and Fresh2Go representatives will be provided to UF.

5.2.6 Schedule feasibility

With all the technology already available to UF, the completion date of the facility can be planned accurately. Development activities will be limited to installing all equipment, training of staff and administrative activities. Possible scheduling conflicts to avoid are preparation of available equipment to be ready for installation. Key deadlines and the feasibility of meeting them on time are commented on in Table 5.

Table 5 Key deadlines that influence feasibility

Activity	Deadline	Feasibility of meeting deadline
Make decision	September 2014	Done in this report
Do a high level facility layout	End-October 2014	Not time consuming
Confirm that all equipment is available	End-October 2014	Feasible – list of required equipment available
Prepare equipment for installation	Mid-November 2014	One month to get any equipment that is not available should be enough as equipment is limited to small machines
Install equipment	End November 2014	Easy installation such as benches and small machines
Train labour force	End December 2014	Will depend on availability of employees
Start operation	January 2015	High possibility for opening on time

5.2.7 Multi-criteria decision making

5.2.7.1 Criteria for decision making

The following criteria were developed by UF and the student for the decision making process:

i. Job creation and empowerment

This is one of UF's core business values and is therefore included for the decision making process. This will be influenced by the number of additional processes or activities that will take on UF's facilities and that will lead to the need for the development of more skills.

ii. Product quality and offering

Since the products will be delivered to high-income and prestige markets, the quality of the product can be seen as the most important criteria for UF's decision making. Two main factors will influence product quality i.e. more product handling (reduce quality) and final product uniqueness (increase quality).

iii. Final product price

The total amount of money spent on a product from harvest time to reaching the customer will be considered for all methods. This will be influenced by fees, labour, and transport cost. Price is not as important as quality and empowerment as products will be delivered to markets that will be willing to pay high prices for good quality and unique products.

iv. Supply chain simplification and control

A simpler supply chain is easier to manage and control and this is an important criteria for UF that wants to deliver products to the customer on the day of harvest. Supply chain complexity is determined by the number of premises that a product has to visit and the number of kilometres that it is transported from harvest to delivery.

5.2.7.2 Alternatives available for achieving the objective

A total of three processing and packaging alternatives will be compared in this chapter. They are:

A. Own facility, advanced packaging (mixed salad bags and picked herb bags)

This alternative will result in the highest possible level of empowerment as it will exist of a large number of additional processes and therefore more skills development. Should this be the selected method, it will also present the highest possible product quality for its combination of control over the product and uniqueness in product offering. Although more expensive than the simpler on-farm method, the advanced on-farm method will be more economical than outsourcing these functions. Similarly, this alternative scores average with regards to simplification of the supply chain.

B. Own facility, simpler packaging (live/whole plants with root ball intact in simple plastic sleeve type packaging)

This alternative is the average option if compared for its job creation and empowerment of previously disadvantaged farmers as well as the quality of the final product. Its performance increases in the category for price where it is by far the most attractive possibility. It is also the simplest alternative available to UF for its ease of processing and packaging and no need for additional transport or handling.

C. A local packaging and distribution partner

If this is the selected alternative, UF's desire to empower emerging farmers will not be addressed in the processing and packaging facility as little to no new jobs will be created for processing and packaging functions. Job creation may be present but will be limited to administrative and handling roles with no specialist labourers. With regards to quality this option does not score well for the lack of control of herbs and lettuce during transportation and handling by an outsourced partner. The outsourced option also seems to be the most expensive and most complex option available.

5.2.7.3 AHP Results

The extract from MS Excel in Figure 13 shows the relative importance of each criterion in comparison with the other criteria. Quality is listed as weakly more important than empowerment due to the quality demands of UF's planned prestige market. Also, having a good quality product is very strongly more important than price and simplification. Empowerment is weakly more important than price while being very strongly more important than simplification as it is one of UF's key values.

	Empowerment	Quality	Price	Simplification	Intermediate Matrix				Criteria Weights
Empowerment	1.00	0.33	3.00	7.00	0.22	0.21	0.26	0.39	0.27
Quality	3.00	1.00	7.00	7.00	0.67	0.62	0.62	0.39	0.57
Price	0.33	0.14	1.00	3.00	0.07	0.09	0.09	0.17	0.10
Simplification	0.14	0.14	0.33	1.00	0.03	0.09	0.03	0.06	0.05
	4.48	1.62	11.33	18.00	Consistency Index CI / RI =				0.0610

Figure 13 Criteria pairwise comparison matrix

With regards to **empowerment**, it can be assumed that the on-farm advanced method will be better than the on-farm simple method due to its added complexity that will result in more skills development and/or job creation. On-farm simple (to a less extent) and on-farm advanced (to a bigger extent) will both be better options than outsourcing as outsourcing will limit job creation. The pairwise comparison of the alternative together with the associated intermediate matrix is shown in Figure 14.

PAIRWISE COMPARISON - EMPOWERMENT

	Alternative Weights		On-farm simple	On-farm advanced	Outsource
	0.23	On-farm simple	1.00	0.33	2.00
Consistency Index	**0.65**	On-farm advanced	3.00	1.00	5.00
	0.12	Outsource	0.50	0.20	1.00
CI / RI =	**0.0032**		**4.50**	**1.53**	**8.00**

Intermediate Matrix

0.22	**0.22**	**0.25**
0.67	**0.65**	**0.63**
0.11	**0.13**	**0.13**

Figure 14 Pairwise comparison of alternative w.r.t. empowerment

Evaluation of the alternatives with regards to the quality of products that will be delivered is shown in Figure 15. The main reasoning behind the scoring is that advanced processes will lead to a more unique and therefore a higher quality product while outsourcing will reduce the control over quality and is therefore a less preferred option than any of the on-farm options.

PAIRWISE COMPARISON - QUALITY

	Alternative Weights		On-farm simple	On-farm advanced	Outsource
	0.26	On-farm simple	1.00	0.33	3.00
Consistency Index	0.63	On-farm advanced	3.00	1.00	5.00
	0.11	Outsource	0.33	0.20	1.00
CI / RI =	0.0334		4.33	1.53	9.00

Intermediate Matrix

0.23	0.22	0.33
0.69	0.65	0.56
0.08	0.13	0.11

Figure 15 Pairwise comparison of alternative w.r.t. quality

When comparing the impact of the different alternatives on product price it can be seen that the alternatives from most economical to most expensive are on-farm simple, on-farm advanced and then outsourcing. This is shown in Figure 16.

PAIRWISE COMPARISON - PRICE

	Alternative Weights		On-farm simple	On-farm advanced	Outsource
	0.72	On-farm simple	1.00	5.00	7.00
Consistency Index	**0.19**	On-farm advanced	0.20	1.00	3.00
	0.08	Outsource	0.14	0.33	1.00
CI / RI =	**0.0567**		**1.34**	**6.33**	**11.00**

Intermediate Matrix

0.74	**0.79**	**0.64**
0.15	**0.16**	**0.27**
0.11	**0.05**	**0.09**

Figure 16 Pairwise comparison of alternative w.r.t. price

With regards to simplification of processes, the alternative on-farm simple is seen as the best option while outsourcing is seen as the most complex alternative due to its added logistical involvement. This comparison is shown in Figure 17.

PAIRWISE COMPARISON - SIMPLIFICATION

	Alternative Weights		On-farm simple	On-farm advanced	Outsource
	0.72	On-farm simple	1.00	5.00	7.00
Consistency Index	0.19	On-farm advanced	0.20	1.00	3.00
	0.08	Outsource	0.14	0.33	1.00
CI / RI =	0.0567		1.34	6.33	11.00

Intermediate Matrix

0.74	0.79	0.64
0.15	0.16	0.27
0.11	0.05	0.09

Figure 17 Pairwise comparison of alternative w.r.t. simplification

The objective hierarchy for the decision making is shown in Figure 18.

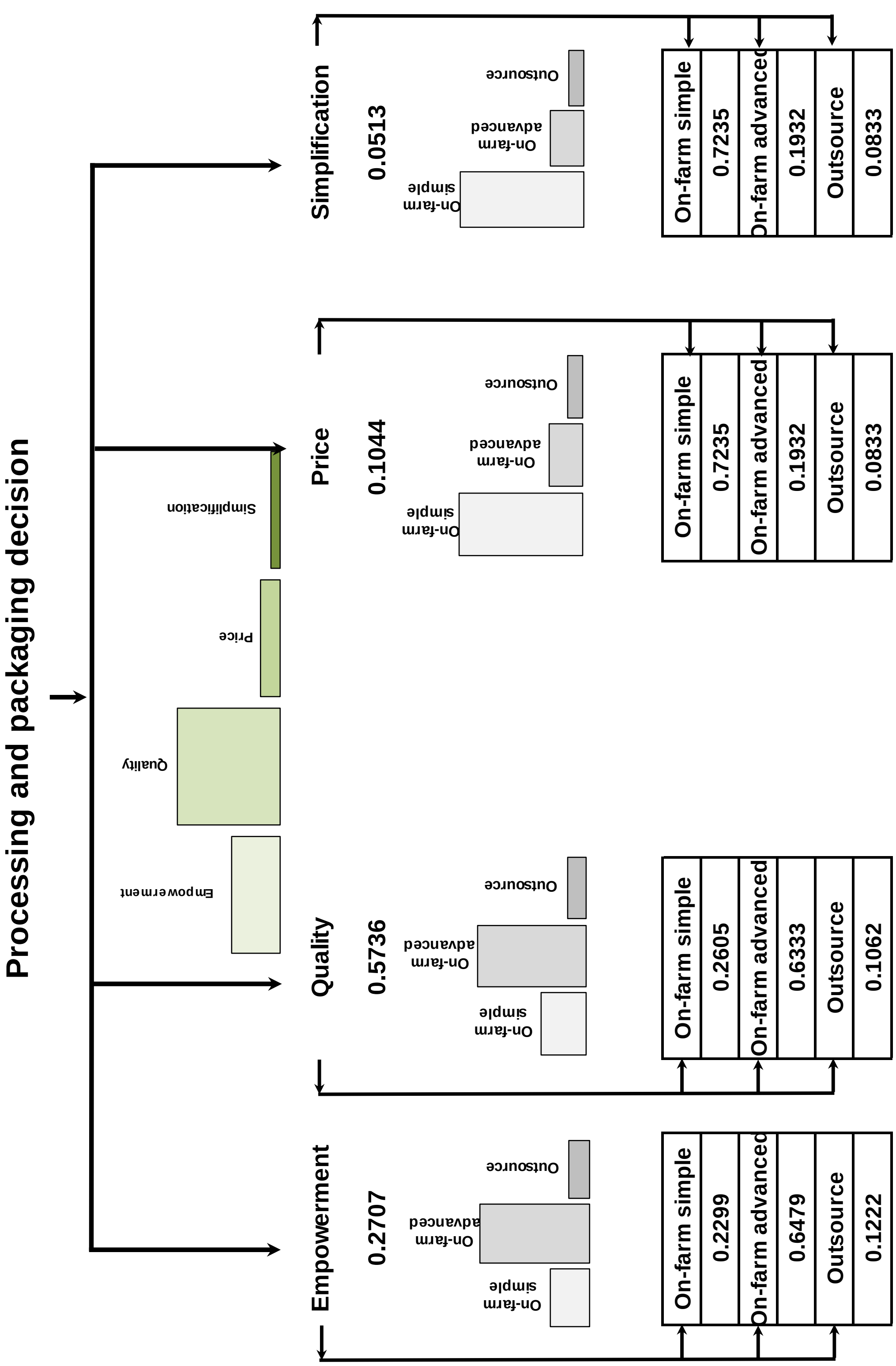


Figure 18 AHP Objective Hierarchy

5.2.7.4 Recommendation

The final relative weights obtained after calculation with the AHP are shown in Figure 19. In the chart it can be seen that on-farm advanced processing and packaging will meet the farm's expectations and values best. This is mainly because of this packaging method's contribution to the quality of products and the empowerment of people – two of the most important aspects at UF. This chart is also another prove to UF that outsourcing is the least feasible option and that the farm has no other option than to build its own on-farm processing and packaging facility. An added benefit of this decision is that with future farms outsourcing may not be an option at all and the first farm can therefore be a complete pilot site for future farms.

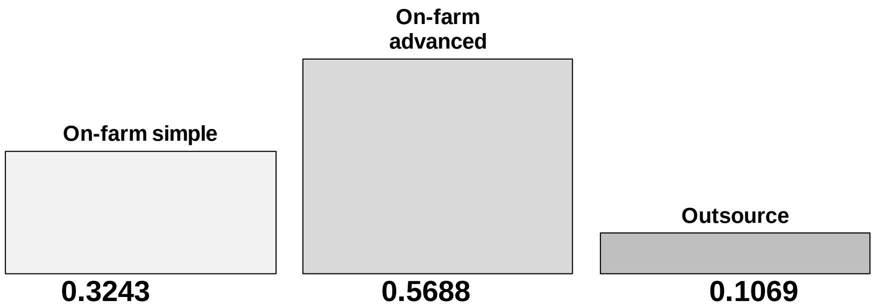


Figure 19 AHP Decision

5.3 Business process models

5.3.1 Activities and actions

This subsection was the first step towards to development of business process models. The table started with the high level activities in column one after research and brainstorming. It is divided into the equivalent sections of Porter's value chain i.e. inbound logistics, operations and outbound logistics. Each activity was then expanded with the typical activities or tasks that will form part of it as well as the responsible person/(s) and where the action will take place.

Table 6 Activities and actions table

Activity	Actions	Start/initiated by	Who?	Where?	Comments
PORTER's VALUE CHAIN CATEGORY: INBOUND LOGISTICS					
Place supplier order	Identify supplies requirements	Production requirements list (received by farm office after customer placed order)	Administrative assistant	Farm office	Allow for input from farmer that has knowledge of local suppliers
	Identify supplies availability				
	Balance supplies needs with availability				
	Prepare supplies shopping list				
	Request quotes				
	Receive quotes				
	Compare quotes				
	Select supplier				
	Place order				
	Schedule delivery date				
Receive supplies	Open received parcel	Supplier arrival	Senior staff member	Receiving bay; office; supply store	Contact supplier if error in parcel Allow for backorders that are indicated accordingly
	Verify content with order				
	Sign delivery note				
	File delivery note				
	Send invoice to office and authorise payment				
	Transfer received parcel to supply store				

Activity	Actions	Start/initiated by	Who?	Where?	Comments
Manage supplier accounts	Receive invoice Verify invoice against initial quote/budget Pay supplier Email supplier proof of payment File proof of payment	Invoice received	Administrative assistant	Farm office	Request new invoice if invoice is not as expected
PORTER's VALUE CHAIN CATEGORY: OPERATIONS					
Plan planting and harvesting	Receive production requirements Derive requirements for harvesting Develop harvesting job cards from employee schedule Derive planting requirements from harvesting plan Develop planting job cards from employee schedules Send al job cards to supply store	New production requirements list	Administrative assistant	Farm office; supply store	

Activity	Actions	Start/initiated by	Who?	Where?	Comments
Prepare for planting and harvesting	Pick required supplies from store	Start of workday where planting / harvesting is scheduled	Stores manager	Supply store	Done for each job card for the day
	Add planting instructions for specific plant				
	Place required supplies in basket				
	Document supplies issued and have documents signed by issuer and planter				
	Fill nutrient solution tank for next cycle				
Planting	Check job card for aisle and tray number	Planting job card	Planter; stores manager	Greenhouse; supply store	Record employee involvement for future tracking
	Soak plugs in conditioning solution				
	Establish plug pH on 6.2				
	Place seedlings in plugs according to instructions in basket				
	Cover with humidity cover				
	Set light exposure				
	Set temperature on 20°C				
	Return any excess seeds or material to supplies room				

Activity	Actions	Start/initiated by	Who?	Where?	Comments
Germination maintenance	Maintain electrical conductivity Maintain pH of 5.8 Maintain temperature of 25°C Maintain light exposure Keep plug and seedling moist Remove humidity covers (day 2) Remove double seedlings (day 3) Water daily (day 6 – 11) Irrigate thoroughly (day 11) Transplant to trays according to schedule (day 11)	New seedlings planted	Multi-skilled staff member	Greenhouse	Day 1 – 11 Record employee involvement for future tracking
Harvesting	Obtain job card from supply store Move to aisle and tray as on harvesting job card Remove plant from tray Remove damaged leaves and add to compost Inspect job card for root cutting task and cut roots if necessary Take plant to processing area's receiving hatch	Harvesting job card	Harvesters; stores manager	Greenhouse; supply store; compost; processing area.	Harvesting job card must include whether roots must be cut or not; scissors must only be available if root cutting is necessary Record employee involvement for future tracking

Activity	Actions	Start/initiated by	Who?	Where?	Comments
Maintenance	Drain solution tank Fill solution tank from harvesting tank Take water sample Insert sample into testing equipment Read results Use results to add nutrients as required Document results and report at office	Start of work day	Farm manager	Water harvesting tank; solution tanks; testing laboratory	Record maintenance activities performed
Control temperature	Take temperature reading on thermometer in greenhouse Compare temperature reading with policy Adjust temperature control accordingly	Start of work day	Farm manager	Thermometer	Record control activities performed

Activity	Actions	Start/initiated by	Who?	Where?	Comments
Plant inspection for signs of diseases, insects or mites	Walk through assigned aisle and inspect every plant for any of the signs indicated on symptom list If any symptoms are observed, treat with the treatment method suggested on the symptom list Meet with supervisor / management for any major disease observations Report on inspection and all treatments applied	Start of work day	Senior staff member	Greenhouse	Stop all activities if major disease observed Record inspection activities performed
Washing	Receive plants from greenhouse through hatch Rinse plant Dry plant Compare plant with descriptions on crates Put plant in correct crate	Receive produce	Multi-skilled staff	Washing room	Allow for tracking employee involvement Washing is included on request of UF
Weighing, bagging and labelling	Use the day's bagging list to bag as required Print and attach labels as indicated on bagging list Put bags in assigned specific areas	Receive produce and bagging list	Multi-skilled staff	Bagging room	Take note of special requests Allow for tracking employee involvement

Activity	Actions	Start/initiated by	Who?	Where?	Comments
PORTER's VALUE CHAIN CATEGORY: OUTBOUND LOGISTICS					
Receive, enter and validate order	Receive order Derive plant requirements and transport requirements from order content Identify production and delivery resources available Balance resources and requirements for production and transport Enter order and produce delivery list	Receive order	Administrative assistant	Farm office	Allow for backorders (request customer approval)
Order preparation and loading	Pick orders from stock Pack boxes Print invoice and add to box Print delivery note and add to box Move box to loading bay Load vehicle with all crates in loading bay Tick orders on delivery list Load vehicle and transport to customer	Daily delivery list and packaged produce received	Multi-skilled staff	Outbound store; loading bay	Include the resolution of missing items

Activity	Actions	Start/initiated by	Who?	Where?	Comments
Manage customer accounts	Receive proof of payment	Receive proof of payment	Administrative assistant	Farm office	Track employee involvement
	Compare proof of payment to farm's banking account				
	Compare amount received with invoice amount				
	Generate receipt				
	Send receipt to customer				

5.3.2 BPMN Models

The main BPMN diagram in Figure 20 shows the end-to-end process of a typical day's operations at UF.

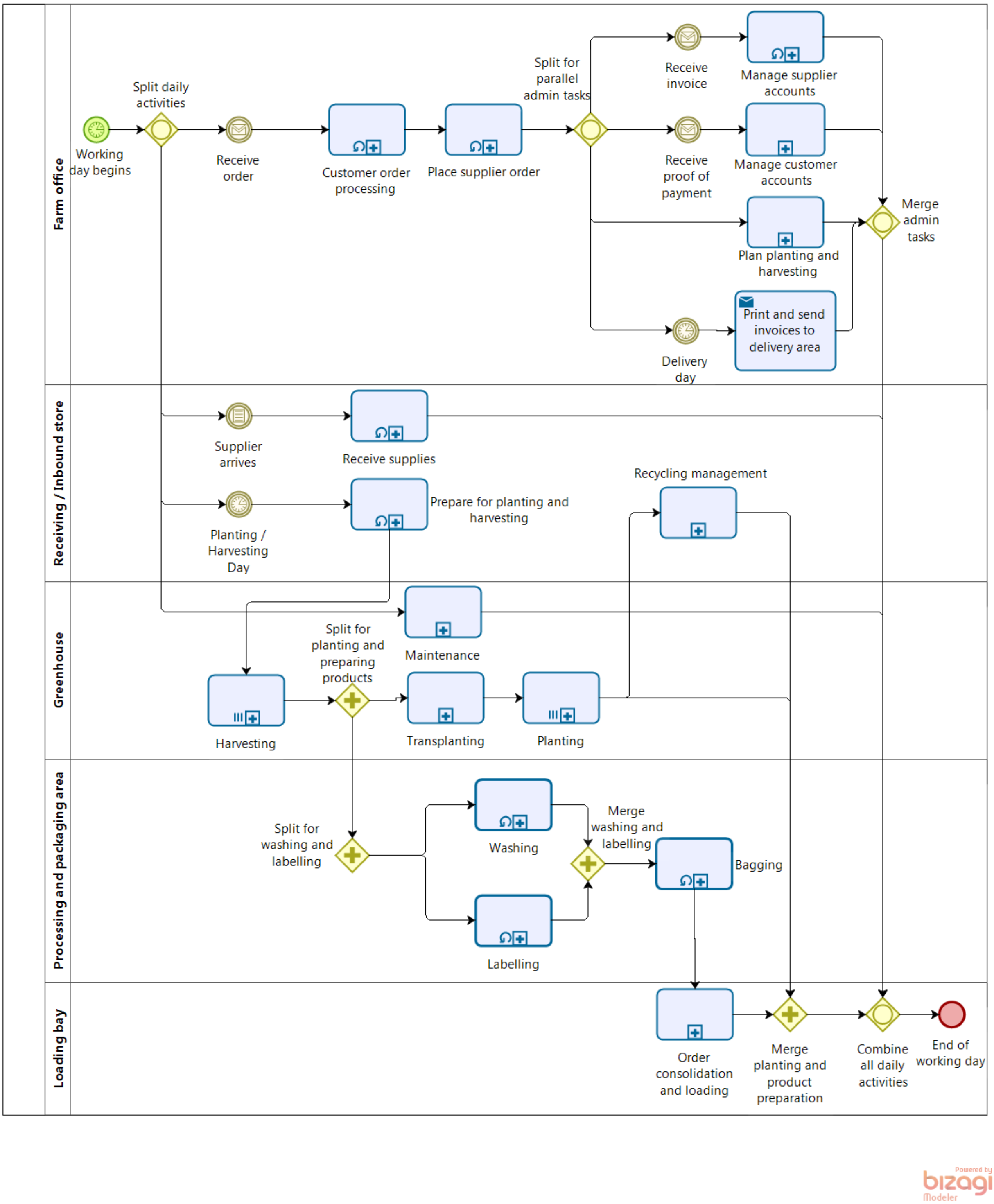


Figure 20 Main BPMN diagram

5.3.2.1 Sub-process: Customer order processing

In Figure 21 the sub-process for processing the orders that were received by customers is elaborated on. Each order will be expanded into a list of plants required to be able to fulfil the order (e.g. the herb mix pack may exist of two lettuce plants, one basil plant). The production resources required for the order will be compared with the resource availability. If the farm cannot produce the customer's demand, the customer will be asked if a backorder will be sufficient. It is important to record a lost sale due to lack of resources here so that management can take actions to prevent it in future and also ensure that the customer is not lost. The order will then be entered into a computer system to allow for developing a delivery list that will be sent to the processing, packaging and loading functions so that they all know when to perform their functions. Traceability of user-involvement in this process should be built into the order process rather than adding additional complexity. Order processing will end with a customer invoice being generated.

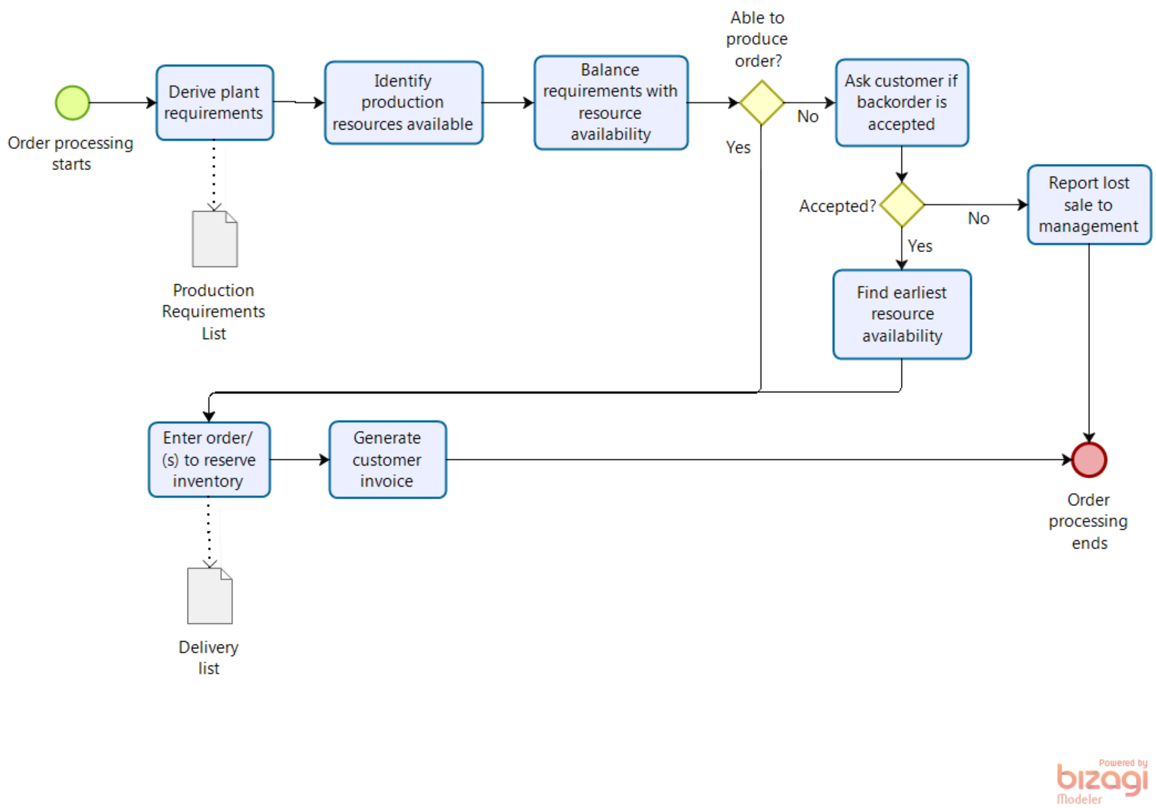


Figure 21 Customer order processing

5.3.2.2 Sub-process: Manage supplier accounts

The supplier accounts sub-process (Figure 22) will start when an invoice is received from a supplier. The process ensures that the invoiced amount is first compared to the amount that the farm expected to pay for the supplies before payment is authorised. The proof of payment serves as the main document here and will be filed and sent to the supplier. No payment will be made if the invoice is not the same as the initial quote. Traceability of user involvement will again be built into systems to ensure that the required steps are minimised.

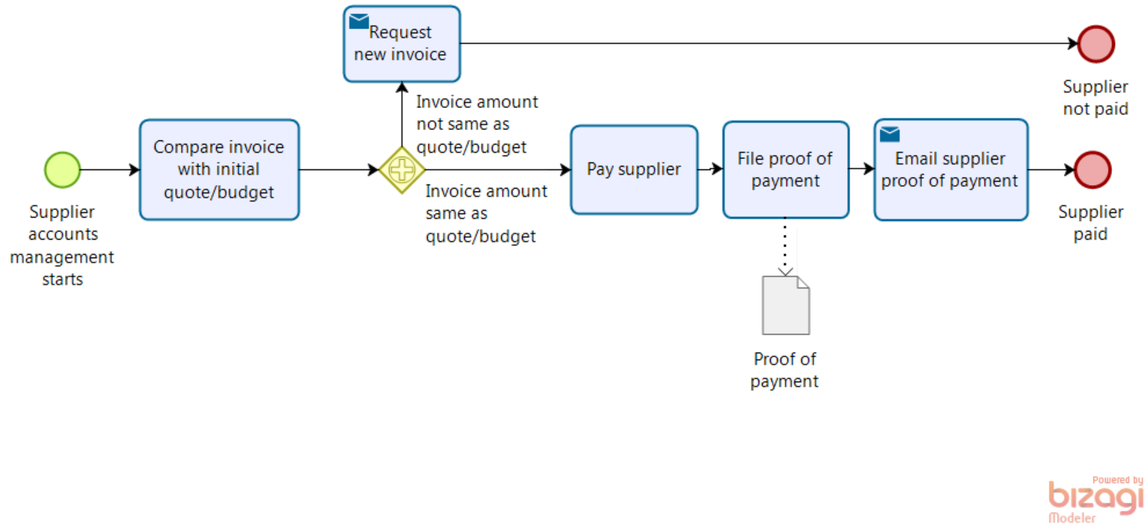


Figure 22 Managing supplier accounts

5.3.2.3 Sub-process: Place supplier order

The sub-process for placing orders (Figure 23 pg. 64) will be triggered after each new customer order that is received. The raw material requirements for the customer's order will be derived and then compared to the supply store inventory. All shortcomings will then be ordered through this sub-process. The process allows for products that have fixed suppliers and fixed prices as well as products where the input into supplier selection is required and quotes must be obtained. Software used for this process should record the user involvement. The sub-process ends with a scheduled receiving date and an update to the receiving bay's expectations.

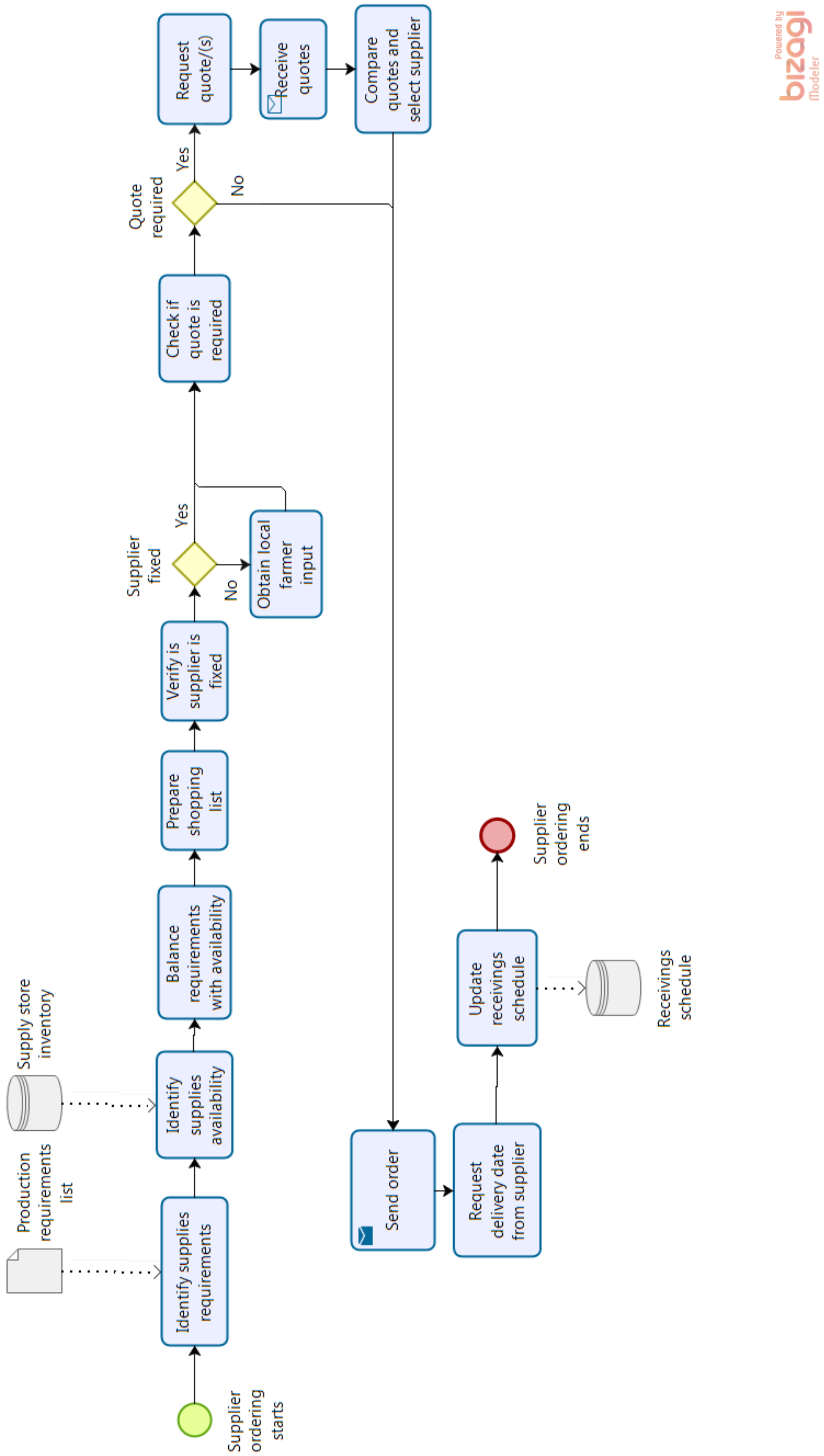


Figure 23 Place supplier order

5.3.2.4 Sub-process: Manage customer accounts

As indicated in Figure 24 the sub-process for managing customer accounts start when a customer sends a proof of payment to the farm office. Before acknowledging receipt of payment the farm office will first confirm that the payment was received and that the correct amount was paid by the customer. The details of the employee that executed the process will be recorded on all applicable documentation.

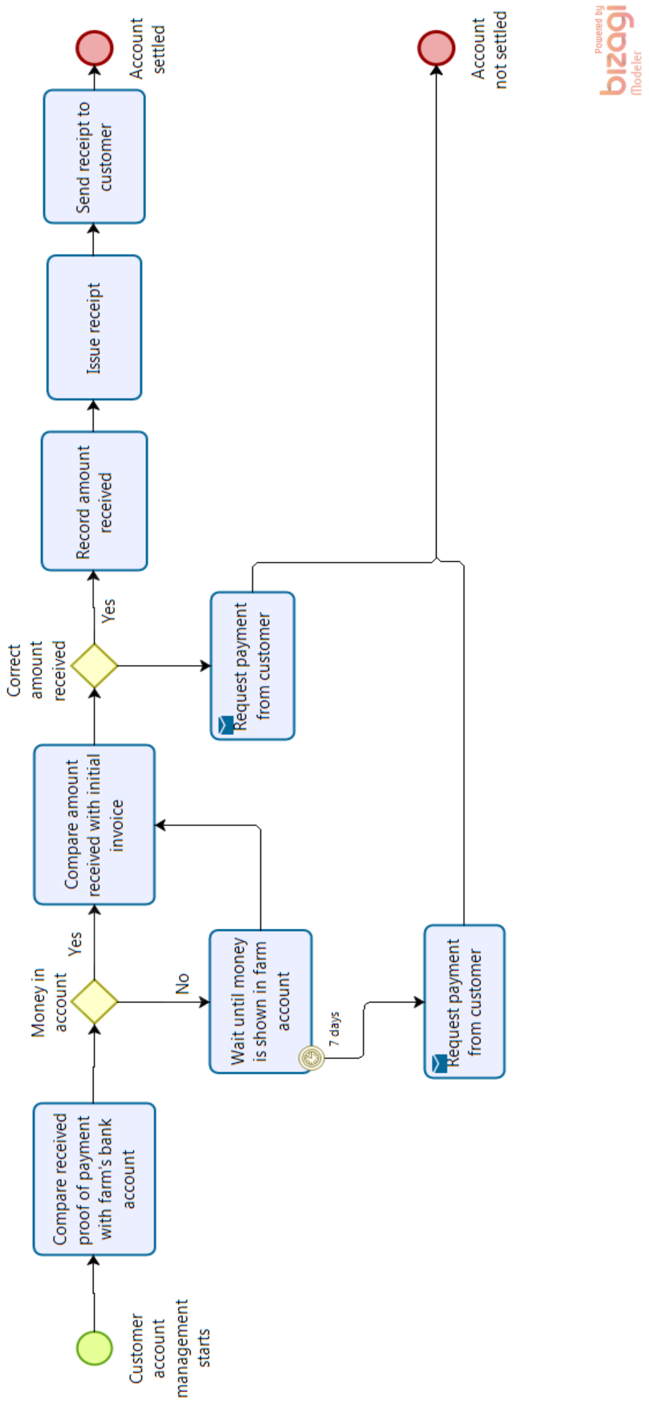


Figure 24 Manage customer accounts

5.3.2.5 Sub-process: Plan planting and harvesting

After receiving orders from customers the associated planting and harvesting for the produce ordered must be planned. Again, the production requirements derived from the order will be used here to determine the dates that seeds must be planted to be able to fulfil the order on the day of harvest. Job cards are being developed by using worker schedules that shows the availability of planters and harvesters. Job cards must be sent to the supplies store to allow for preparing for planting and harvesting.

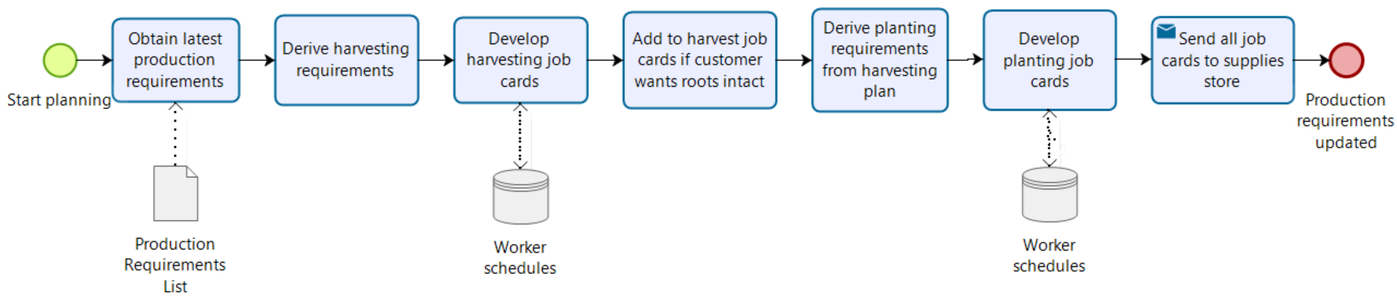


Figure 25 Plan planting and harvesting

5.3.2.6 Sub-process: Receive supplies

When suppliers or couriers arrive at the receiving bay the sub-process in Figure 26 is activated. This sub-process ensures that a received parcel is first compared with what was ordered before the delivery is accepted. After receiving, supplies are added to the supply store inventory and stored until required by the supply store manager. All documentation should include traceability of user involvement.

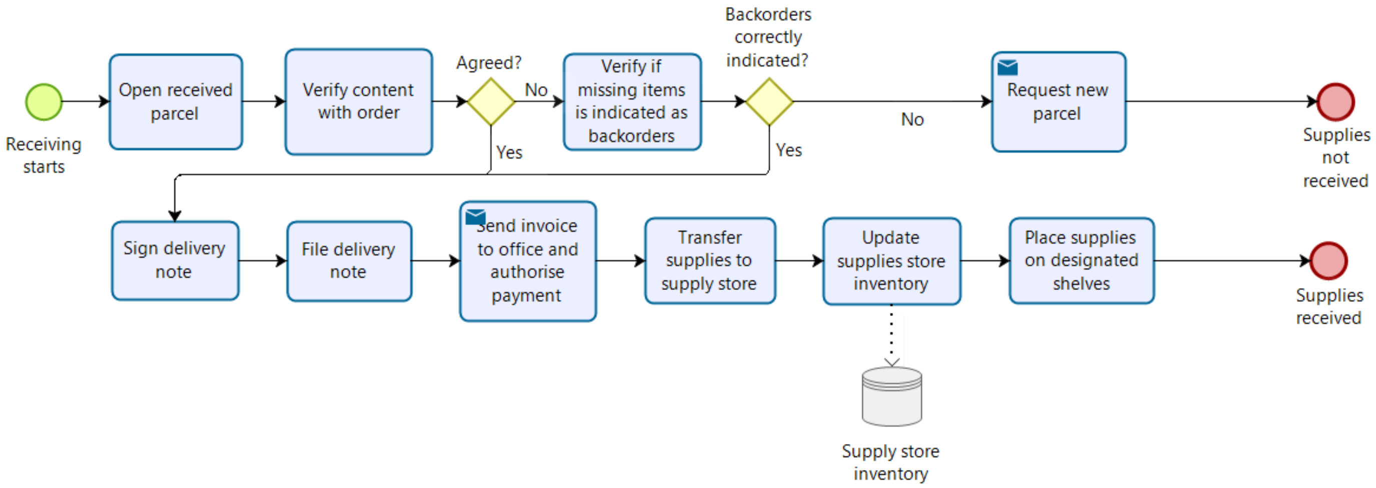


Figure 26 Receive supplies

5.3.2.7 Sub-process: Prepare for planting and harvesting

Figure 27 shows the sub-process that will occur in the supply store in preparation for the planting and harvesting activities. The supply store manager will take the job cards that were received after the planning function and prepare a basket with the supplies and accessories required for the successful completion of the task on the job card. The supply store manager will then be responsible for handing the baskets and job cards to planters and harvesters as well as the recording of user involvement.

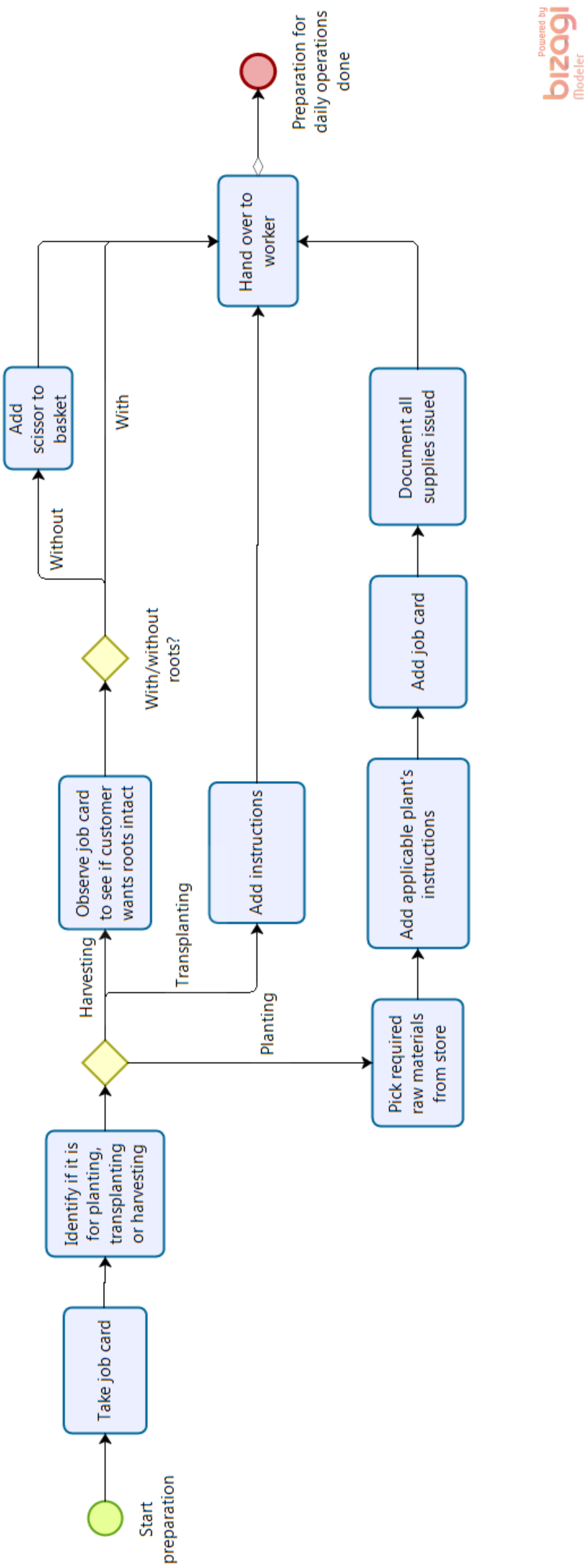


Figure 27 Prepare for planting and harvesting

5.3.2.8 Sub-process: Maintenance

As proved by the literature review, maintenance is essential for the successful operations in a hydroponic farming environment. As result thereof the daily maintenance sub-process (Figure 28) can be considered one of the most important processes at the farm. This sub-process addresses water management, temperature control, disease control and the maintenance of germination activities according to predetermined policies.

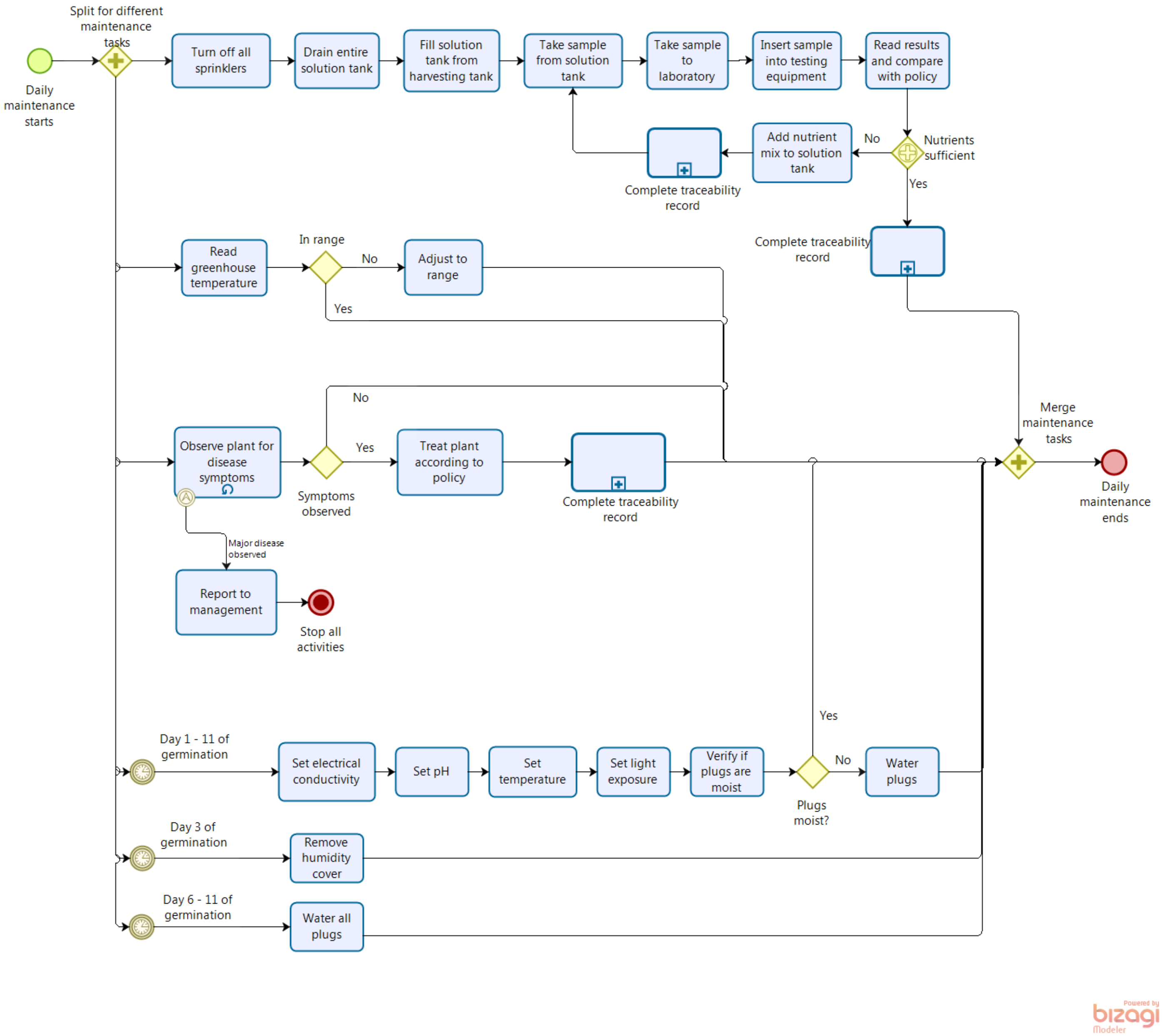


Figure 28 Maintenance

5.3.2.9 Sub-process: Harvesting and planting

Figure 29 and Figure 30 will guide a harvester and planter through the basic steps when harvesting and planting the hydroponically farmed lettuce and herb products.

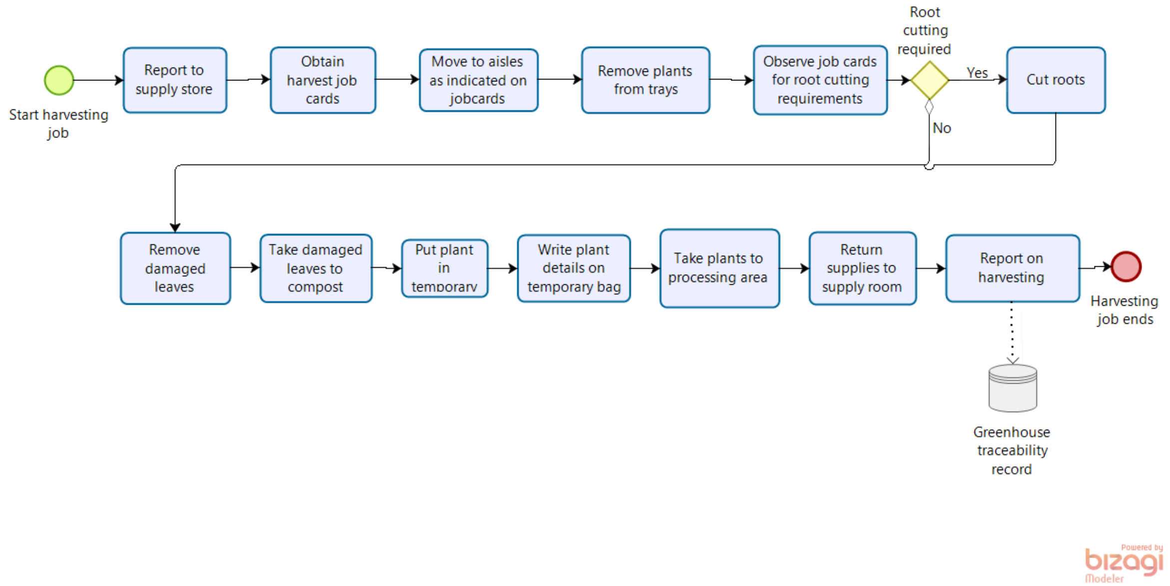


Figure 29 Harvesting

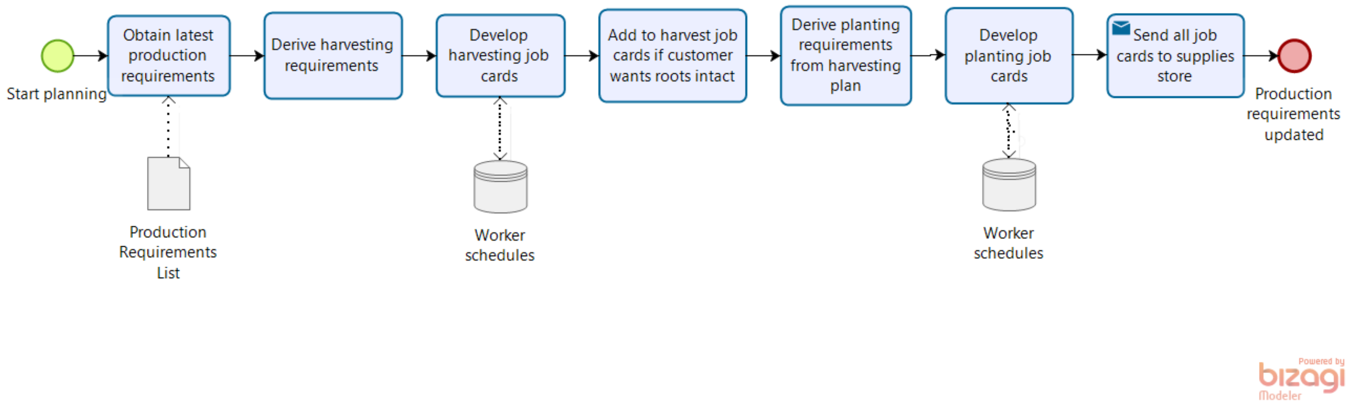


Figure 30 Planting

5.3.2.10 Sub-processes: Washing, labelling and bagging

In Figure 31 the basics of washing is explained. Figure 32 and Figure 33 show the labelling and bagging processes.

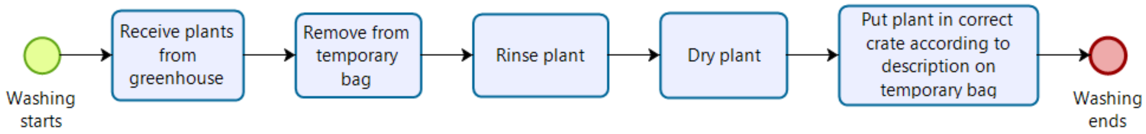


Figure 31 Washing

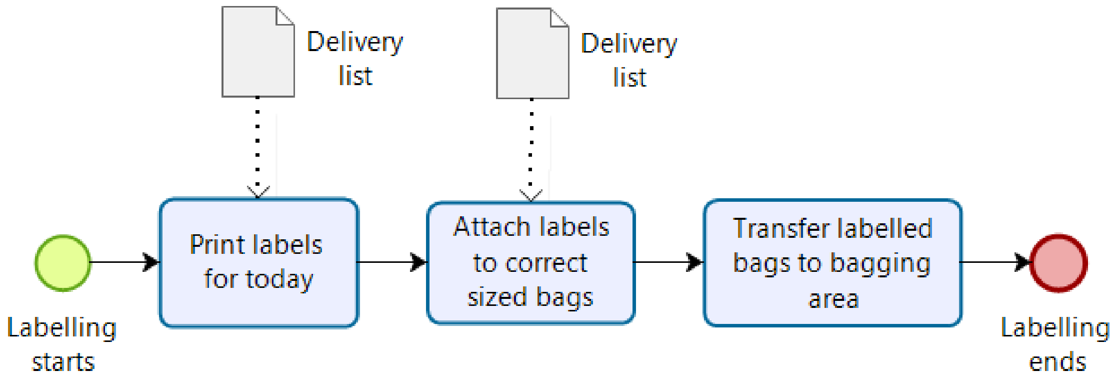


Figure 32 Labelling

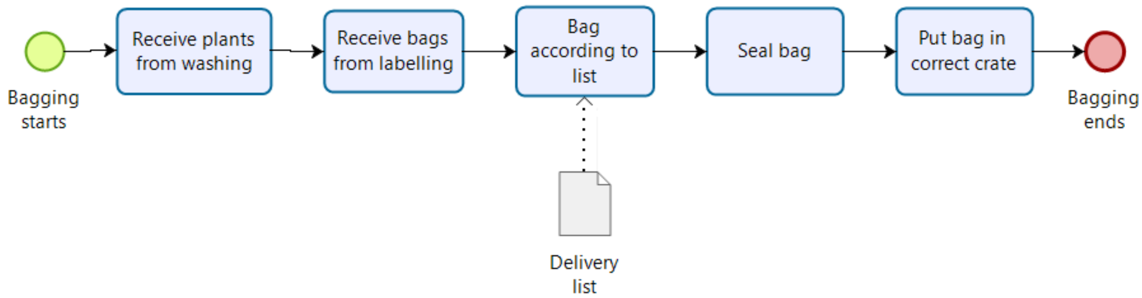


Figure 33 Bagging

5.3.2.11 Sub-process: Order consolidation and loading

The outbound logistics involved in preparing orders and loading products for customer delivery is explained in Figure 34.

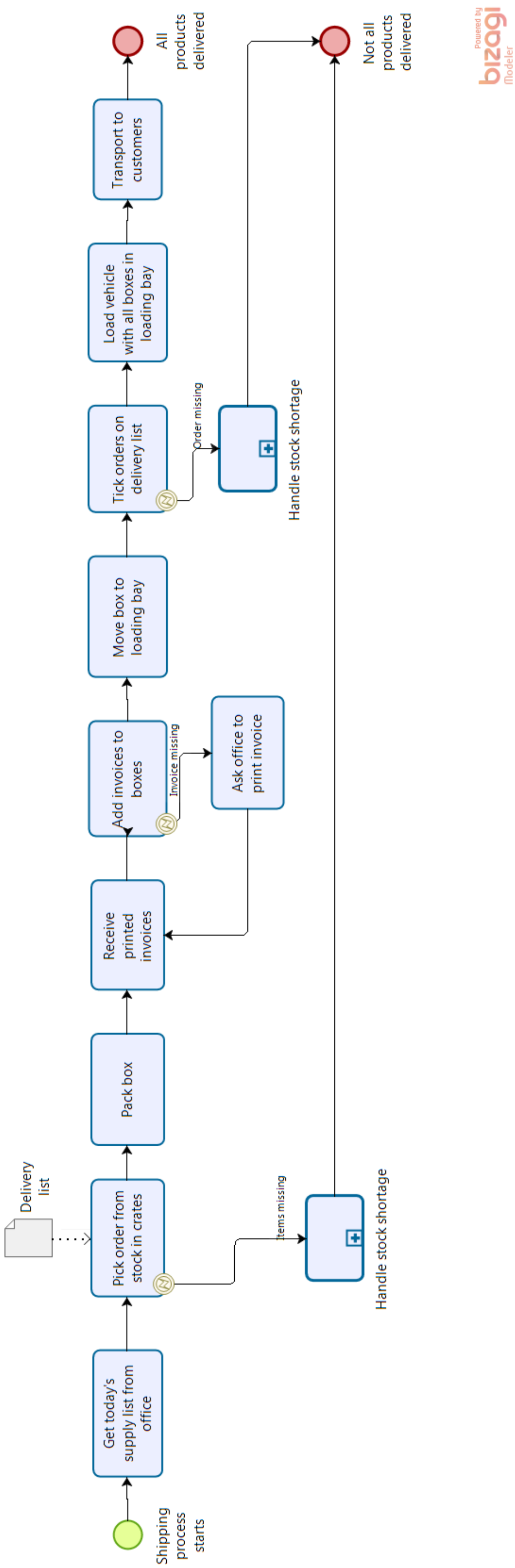


Figure 34 Order consolidation and loading

5.3.2.12 Sub-process: Handling stock shortage

In the case of a stock shortage during the final phases of order loading, the sub-process in Figure 35 will resolve the problem.

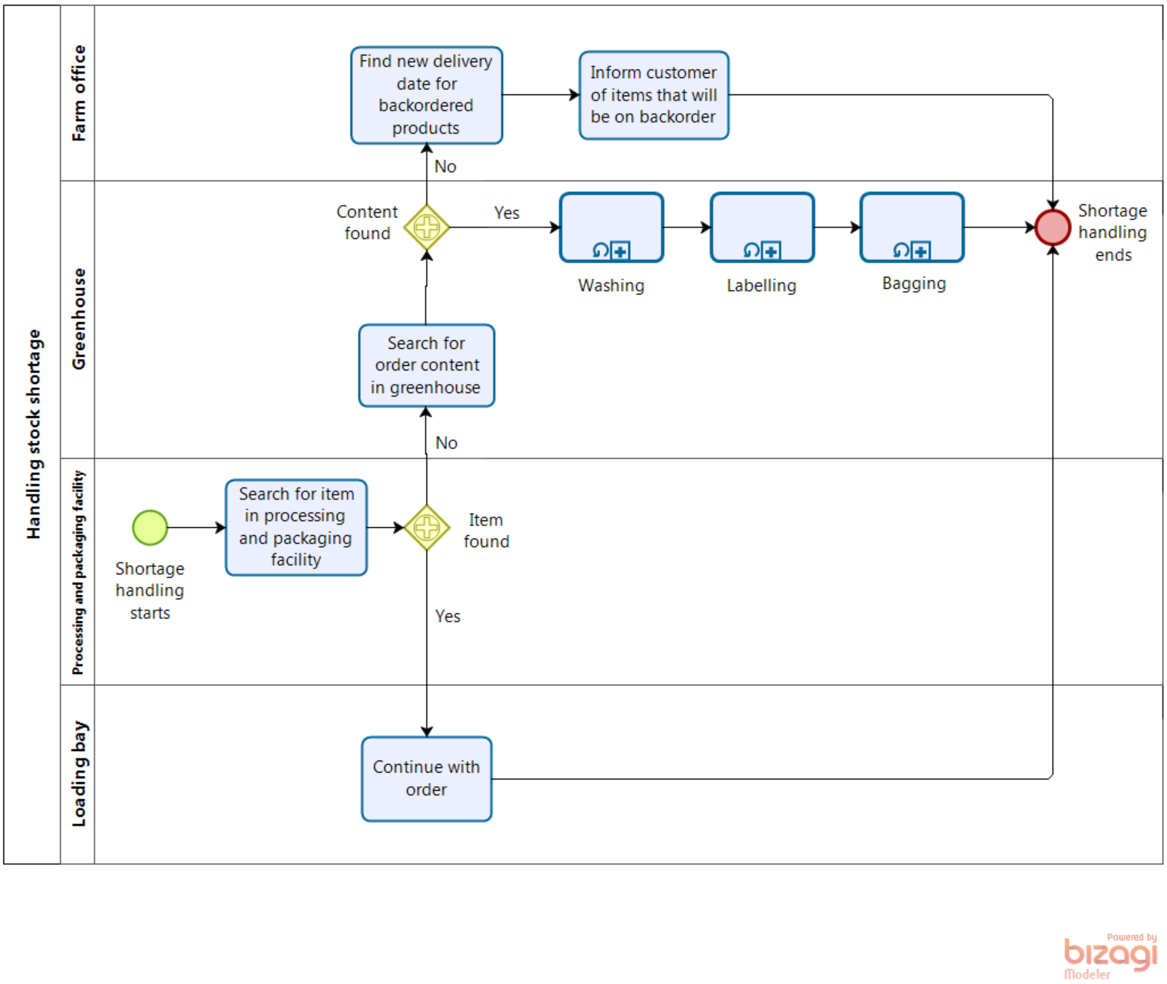


Figure 35 Handling stock shortage

5.3.2.13 Complete traceability record

Record-keeping of maintenance activities is enforced by the reusable sub-process illustrated in Figure 36.

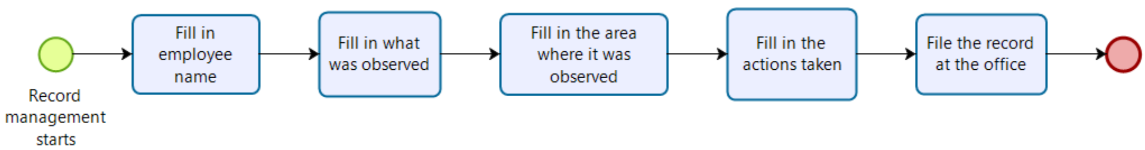


Figure 36 Complete traceability record

5.3.2.14 Sub-process: Recycling Management

To comply with UF's requirement of being environmentally sustainable in all the business' operations management and handling of recyclable materials is enforced by using the sub-process illustrated in Figure 37 .

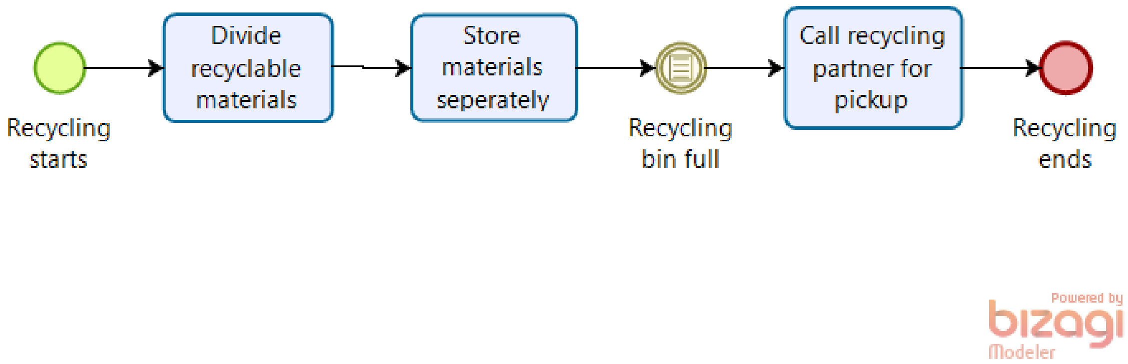


Figure 37 Recycling management

5.3.2.15 Sub-process: Transplanting

Transplanting of germinated seeds is another important process on the farm developed from literature studies about how plants should be handled. The process is shown in Figure 38.

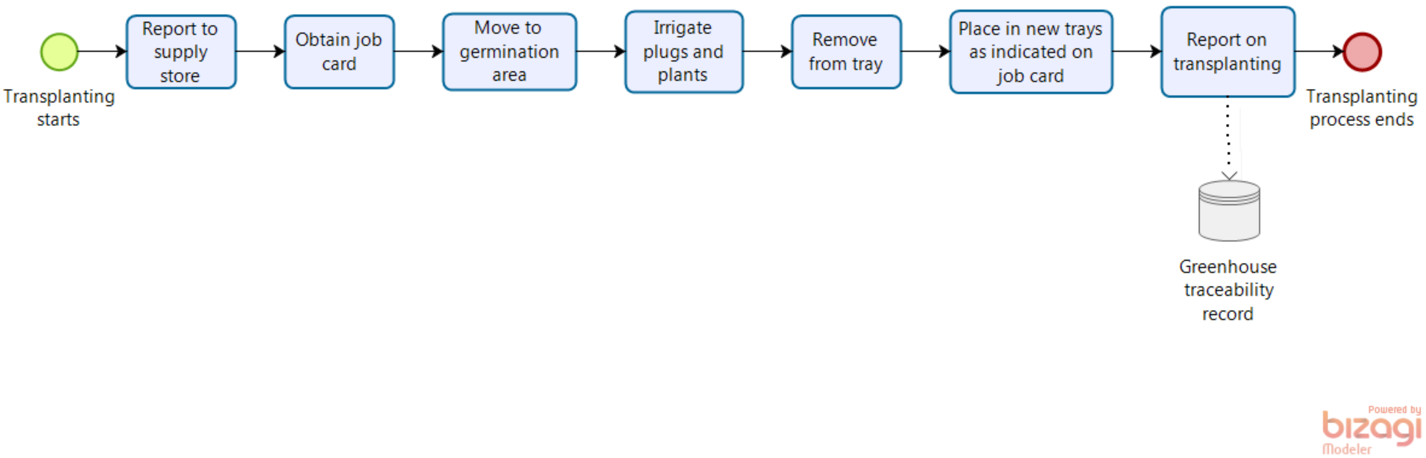
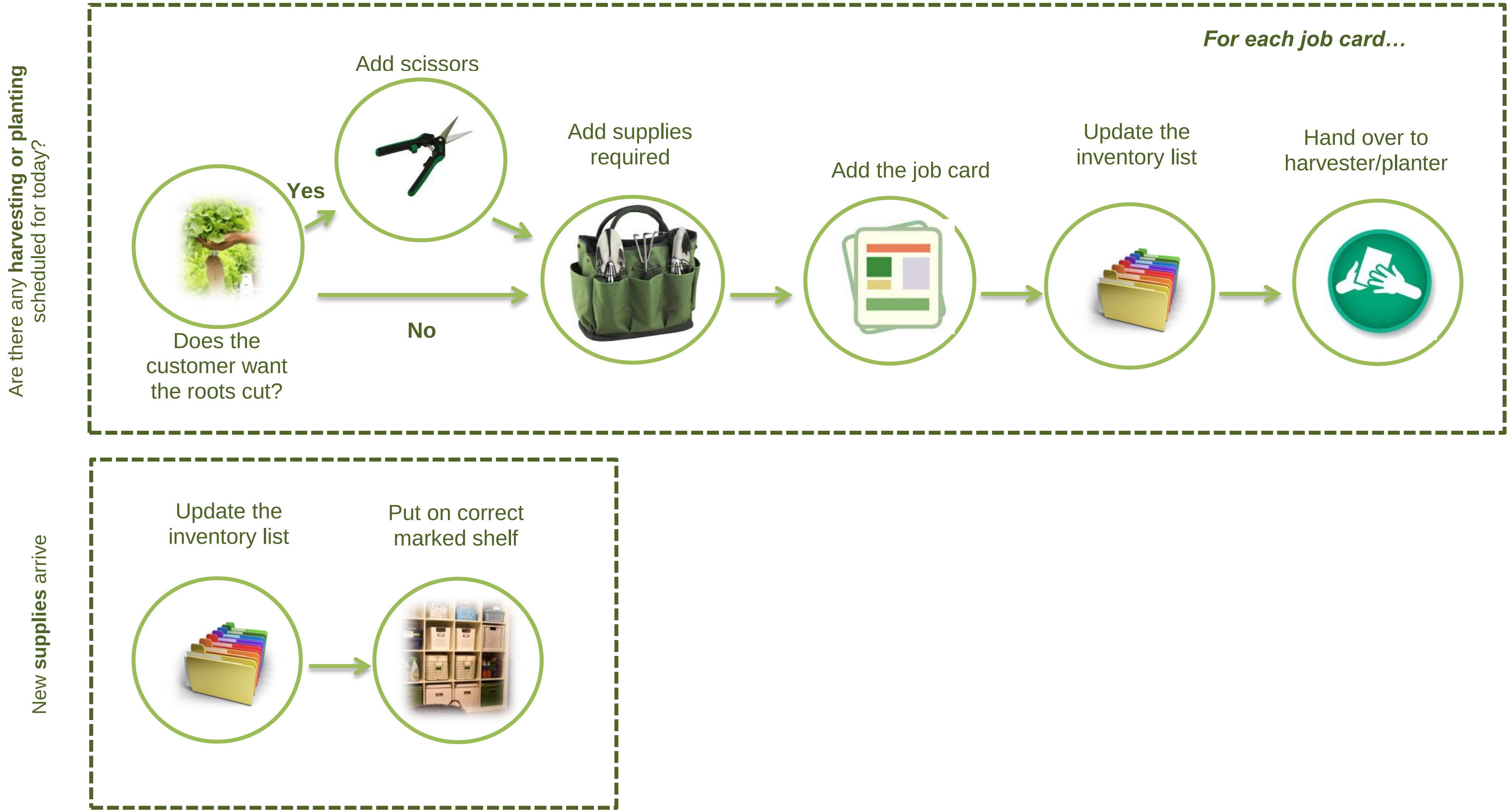


Figure 38 Transplanting

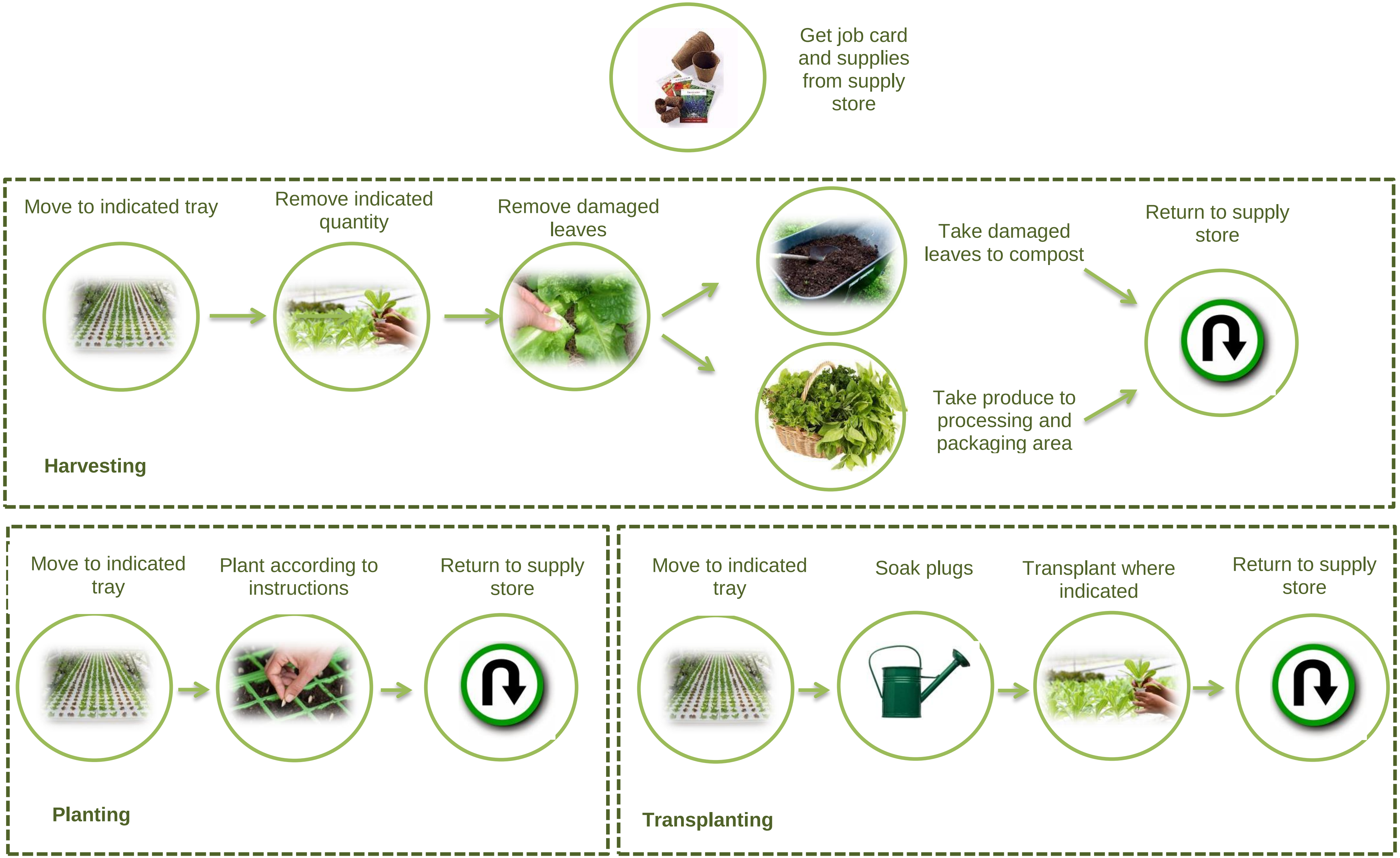
5.4 Story boards

The developed business processes were then used to guide the first steps of training material development. As proved by the literature study visual training is most effective for employees working in a new environment. The developed story boards show the activities that will take place in the supplies store, greenhouse and final steps before delivery. This is the area were the most training will be required, as it will be manned by previously disadvantaged farmers. Its implementation feedback will be used for advanced training systems for future farms.

Supply store



Greenhouse


Get job card and supplies from supply store
Move to indicated tray
Remove indicated quantity
Remove damaged leaves
Take damaged leaves to compost
Return to supply store
Take produce to processing and packaging area
Harvesting
Move to indicated tray
Plant according to instructions
Return to supply store
Planting
Move to indicated tray
Soak plugs
Transplant where indicated
Return to supply store
Transplanting

Outbound operations

Are any deliveries being made today?

5.5 Resource requirements

The human resource requirements listed here can be derived from the above solution and can be used to assist with future development at UF.

- A farm manager with technical knowledge of hydroponics that can also manage supply store;
- Multi-skilled staff members for planting, harvesting, maintenance, processing & packaging functions and order preparation; and
- An administrative assistant.

The following space requirements can be derived from the above solution:

- Supply store;
- Greenhouse with separate germination area;
- Farm office;
- Processing and packaging room;
- Receiving bay; and
- Loading bay.

6 Solution validation

6.1 Validation against initial requirements

Table 7 validates the solutions provided in Chapter 5 against the initial objectives and requirements of the project.

Table 7 Validation

Requirement	Comment
Business Function Requirements	
Inbound logistics, outbound logistics and operations must form part of process design	These three sections were the main starting point for process design.
Production of 3000 lettuce heads per week	The designed processes allow for any production rate that the greenhouse can handle as core functions can be performed in parallel by multiple staff members if required.
Variety of products produced	The documents in the processes allow for the final combination of orders irrespective of the variety included.
Harvesting, processing, packaging and delivery to the customer of all produce must happen on the day of harvest	The process is designed in such a way that only today's deliveries are harvested today. The process forces the harvested produce through the processing and packaging facility and onto the delivery vehicle on the same day.
Investigate Woolworths regulations	This project reported that regulations are not available before a formal pitch to Woolworths. The project will bring UF in contact with Woolworths and Fresh2Go senior managers for future negotiations.
All available technologies must be considered	A balance between technology and manual job creation has been achieved.
Company's environmentally friendly approach kept in mind	The process limits the use of paper, uses nutrients responsibly and includes a recycling initiative.
Emphasis on empowerment	Job descriptions and training material will achieve empowerment.
Feasibility Study Requirements	
Include the economic considerations	Economic factors were identified and a template for the net present value method was developed.
Clearly indicate the benefits	All alternatives were clearly discussed to indicate their consequences.
Develop a generic approach	The AHP can easily be adapted in an MS Excel document for other farms with different needs or situations.

Use a feasibility study approach that are understandable and can easily be followed by any relevant stakeholders.	AHP delivers an easy to understand hierarchy.
Business Process Models and Training	
Understandable and easy to follow for a non-technical farm worker as well as management	BPMN is easy to follow and understand.
Advanced maps as well as easy to understand maps	The BPMN maps are more advanced while the training flow diagrams are easier to understand.
Include all human activities	All human activities are included in processes.
Include documentation	All document flow is clearly indicated in BPMN diagrams.
Only allow quality products to go through to customer	The functions of maintenance, inspection and greenhouse control implement this.
Adaptable and maintainable	The process allows for different situations at different farms (e.g. local farmer input in supplier selection). The AHP is an easily adjustable MS Excel document which means the decision can be made for again for new farms with different or the same alternatives and criteria.

6.2 General remarks

The developed method in this project proved to be an excellent approach for Business Process Design where there are no processes yet. Its well-structured approach guided both the company and the modeller through the different phases and ensured that all aspects of the farm's operations are included. A challenge experienced during the project was the method's dependability on constant involvement and feedback that was expected from the company. The implementation of this project on UF's pilot farm is out of the scope of this project but will generate valuable feedback for possible future research before new farms are developed.

7 Conclusion

It can be concluded that urban farming is definitely one of the emerging industries worldwide as well as in South Africa. Urbanization, the decreasing state of traditional rural farming areas and the consumer's new way of thinking makes urban farming an exciting and modern – but also essential – approach to food production. If the Urban Farms Company does not make use of this opportunity to start commercial urban farming in South Africa, a competitor definitely will.

Literature presents many tools to address the needs for this project with multi-criteria decision making and Business Process Design (BPD) and modelling at its core. The Analytic Hierarchy Process presents an easy to understand decision making tool that definitely assisted UF in its viewpoint of the processing and packaging facility. The importance of business process modelling is highlighted in this document. As the competitive environment is continuously changing, the business that understands its own activities and processes the best will be the one that provides the best customer service. The use of business process modelling for training is mentioned in literature but this project puts emphasis on this and proves that business process models can easily be adapted into efficient training tools.

Several possibilities exist for future work using this project as starting point. Many authors in literature see BPD as the first step towards the development of a database or information system and it will certainly also add value to UF's operations. Another opportunity for an industrial engineer or supply chain manager is to expand the design of UF's supply chain to include the logistics of the transportation of fresh produce. An opportunity also exists for a graphic artist to improve the story boards and expand on the training material.

Although this project is not a complete guide for UF to start their operations, it most certainly provides the company with an essential starting point. Important decisions have been made and the company is provided with direction for the successful final decision making and development of their business.

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