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Investigation of Inventory Record Accuracy in Product-Service System

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ABSTRACT

In this paper we examine Product-Service System (PSS) in manufacturing industries application to inventory control in Malaysian Elaeis Guineensis or known as palm oil industries. We are particularly interested in the record of inventory accuracy for palm oil tree, fresh fruit bunch (FFB) and palm oil. If the inventory is uncontrolled or not accurate, the production will face problems to meet customers demand. We focus not just on inventory activities themselves, but also the key linkages between production, market, supply chain, and oil production. These linkages are examined using generic model using IDEF0 which consists five charts: A0 chart, A1 chart, A2 chart, A3 chart and A4 chart. This paper has provided useful insights into the actual data collection and the preliminary analysis, as well as the contextual and associated information relating to inventory control system. Further research will be to evaluate the generic model development using Technomatix Logistic and Material Flow Simulation Software.

INTRODUCTION

Product-Service System (PSS) is one of the competitive paradigm that generate products, services, actor network and infrastructure to satisfy customer's requirement with lower environmental impact. The application of PSS examines sustainability of performance and growth which results in attract more demands. Inventory control is used to balance organizational objectives to achieve sustainable product, especially on accuracy of inventory record for raw materials and finished goods. The performance of the company can be described by two conditions: high inventory level and low inventory level. High inventory level is good in responsiveness but lower in efficiency vice versa; low inventory level will produce poor responsiveness but high in efficiency. Inventory record accuracy plays a vital role in performance of the company which used to improve responsiveness and flexibility also make a better organizational competitiveness. In addition, effective inventory control record accuracy will gain advantages in term of high efficiencies, high level of customer service and low in cost.

Function-oriented business model (Tukker, 2004) and Integrated Product service Offering (Nilsson and Lindahl, 2016) are the other terms for Product-Service System (PSS) which first formal defined by Goedkoop et al. (1999) as a set of products and services that marketable to satisfy consumer's needs. Tischner et al. (2002) stated PSS consists tangible products and intangible services that implemented to fulfil customer's requirement. Generally, products and services give advantages to fulfil customer requirements but both have different characteristics. "Products" usually is an objective value (tangible item) produced for sale as well as satisfy the customer's requirements (Goedkoop et al., 1999).

The development of PSS by manufacturers is normally to reach business innovation based on the strengths of product come out with element of the services (Kim and Choe, 2017). According to Fernanda et al. (2016), addition of services in PSS development is a solution to improve company's market position as it offers functionalities for user to lower environmental impact. In order to increase customer demand, manufacturers forced to introduce a new solution and the combination of product and services is one of the solutions. Justyna (2015) have studied that PSS is not a possible solution but essential in manufacturing firm to increase profit, customer demand and a good position in market. Not only that, Baines and Lightfoot (2013) claimed that the business innovation of manufacturing company can be achieved because designing a PSS is the main solution in manufacturing servitization. A number of researchers have utilized the servitization and Vandermerwe and Rada (1988) were the first introduced the term of servitization. Servitization is the transformation from products to services with aim to satisfy the customer' requirements. Baines et al. (2009) have grouped the servitization into five concepts that are service marketing, service management, operations management, product-service system (PSS), and service science.

Tukker (2004) have investigated eight types of PSS under three categories that integrate the relationship between product and service in PSS as shown in Figure 2.1. A first major category which is product-oriented services focuses on product market but it still adds some extra services. The subcategories in this category are product related service, and advice and consultancy. For use-oriented services, it not focuses on product market as the product is kept remain with provider and ownership also sometimes a number of users will share it. Product lease, product renting or sharing, and product pooling are the subcategories in use-oriented services. The last category that does not involve the pre-determined product because it aimed to agree on a result by both client and provider is called result-oriented services. It includes three subcategories which are activity management or outsourcing, pay per service unit, functional result.

There are four elements of PSS has been carried out by Ismail et al. (2015). Firstly, Product and Services; the manufacturer will offer to customers a product and options on related services available. Secondly, Product with Service; the manufacturer provides a product and service together. Next is Product and lastly is Service which means that the manufacturer only offers either product or service only.

In early 1871, palm oil had been introduced to Malaya as ornamental plants for landscaping by the British Government. Henri Fauconnier is the one who established the palm oil plantation as he bought palm oil seeds from Sumatera which is the first commercial plantation then planted it in Selangor at his Rantau Panjang Estate to replace unsuccessful coffee plantation. The palm oil plantation in the beginning was quite small in size about a couple hundred hectares each. But now, palm oils become one of the largest plantations in Malaysia (Suhaila, 2012). The largest plantation areas in Malaysia is Sarawak with 1 555 828 hectares followed by the Sabah of 1 546 904 hectares in 2017.

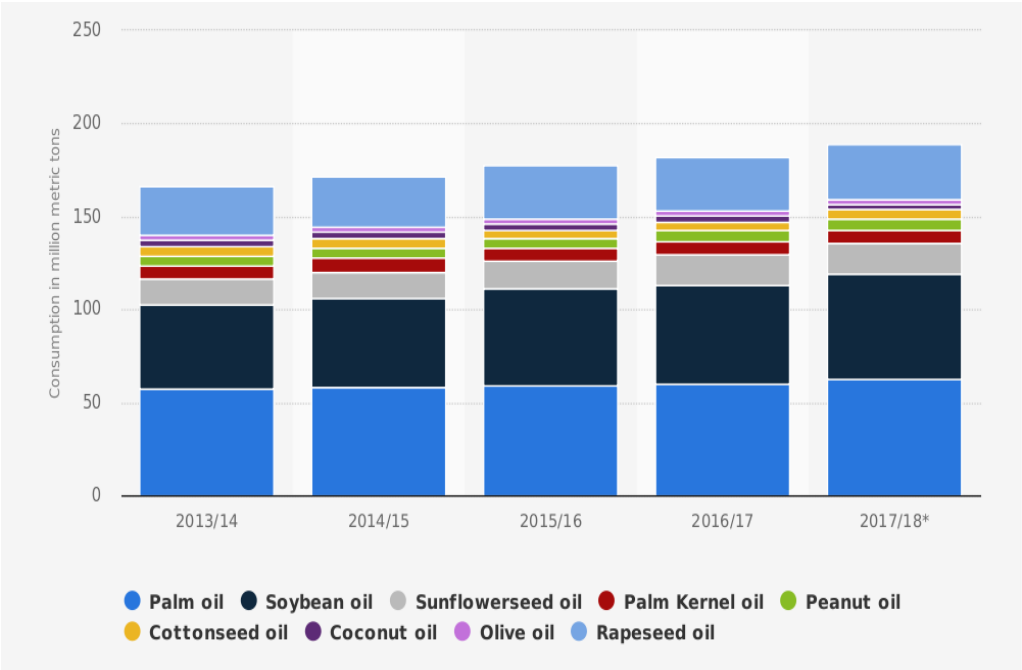

Figure 1.1: Vegetable oils worldwide consumption (Statista, 2018)

The volume of vegetable oils particularly palm oil has been increased year by year as well the global population growth and demand of oils consumption increased as shown in Figure 1.1. Palm oil is the important source of vegetable oils as it has become the highest consumed vegetable oils in the world. The increasing demand of palm oil from 59.97 million metric tons (2016) to 62.92 million metric tons (2017) is one of the reasons why much land was converted to palm oil plantations.

The cultivation of palm oil is a major economic factor especially for Indonesia and Malaysia. Palm oil originally from Africa but now, Indonesia and Malaysia are two major palm oil producing countries. This research focuses on inventory control in Malaysian palm oil industries. Malaysia has an important role to fulfil the global need for oils sustainably as it growing because currently Malaysia is being the one of the largest producers. Figure 1.2 shows the exporters of palm oil.

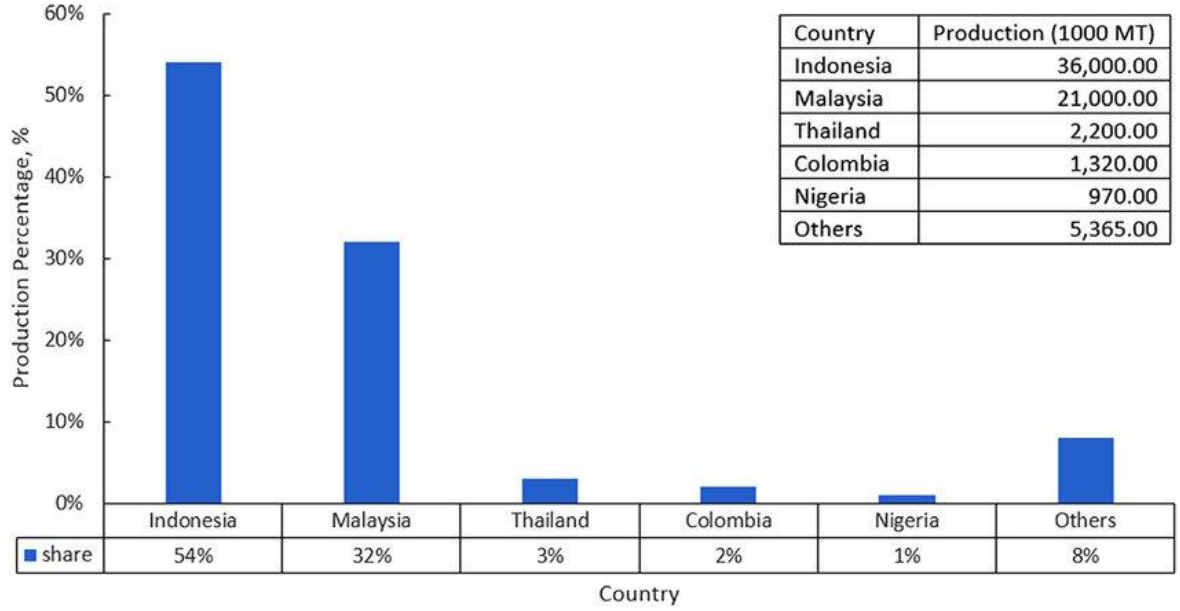

Figure 1.2: World palm oil production for 2017 (Index Mundi, 2017)

There are three types of inventories in palm oil agriculture: palm oil tree, fresh fruit bunch (FFB) and palm oil. Issue in palm oil tree is to optimise the quantity of the trees according to the weather issue especially on hot and dry day; weather will affect the yield of FFB which can cause high in cost. The big current issue in palm oil agriculture is the palm oil. The uniqueness of palm oil in production is it produced FFB into two types of oils: crude palm oil (CPO) and Palm Kernel (PK) which can be used in many productions in food and non-food. From Table 1.1, the expansion of palm oil planted in Malaysia contributes to the production of FFB. From 2016 to 2017, both CPO and PK production are increased where CPO production increased by 6.98% while production of PK increase about 8.32%. But, the performance of FFB yield generally depend on management and agronomic practices. Normally, effective management and good agricultural practices will increase the performance of the FBB yield.

Table 1.1: CPO and PK monthly production for 2017 in tons (MPOB)

Months	Crude Palm Oil		Palm Kernel	
	2016	2017	2016	2017
January	1 129 747	1 276 849	276 238	310 182
February	1 042 707	1 258 539	261 442	316 069
March	1 219 449	1 464 021	309 658	374 530
April	1 301 291	1 548 026	326 138	387 306
May	1 364 583	1 654 494	334 628	405 274
June	1 532 613	1 514 255	371 048	370 828
July	1 585 341	1 826 828	367 561	448 172
August	1 701 833	1 810 551	403 245	447 742
September	1 715 085	1 779 918	428 104	441 950
October	1 677 873	2 008 838	400 125	498 966

November	1 574 938	1 942 847	365 729	484 880
December	1 473 717	1 834 165	346 520	465 062
Total	**17 319 177**	**19 919 331**	**4 190 436**	**4 950 961**

Since the production of FFB is increase, risk opportunities might be arising on inventory control especially inventory records accuracy (IRA) issues. In term of palm oil inventory, it is important to meet the demand by holding enough stock at required quantity as it helps to make sure smooth flow from delays in deliveries and stock out situation happens when it is needed to meet current demand. Figure 1.3 shows the palm oil inventories in Malaysia for 2017; it had fluctuated from January to June then increased to December. Issue in inventory can be seen through the trend of closing stock because it is one of method used to measure the market performance of palm oil production where it refers to the amount of inventory has on hand includes raw materials, work-in-progress and finished goods. If the inventory control not effective, the problem of underproduction or overproduction might be happened.

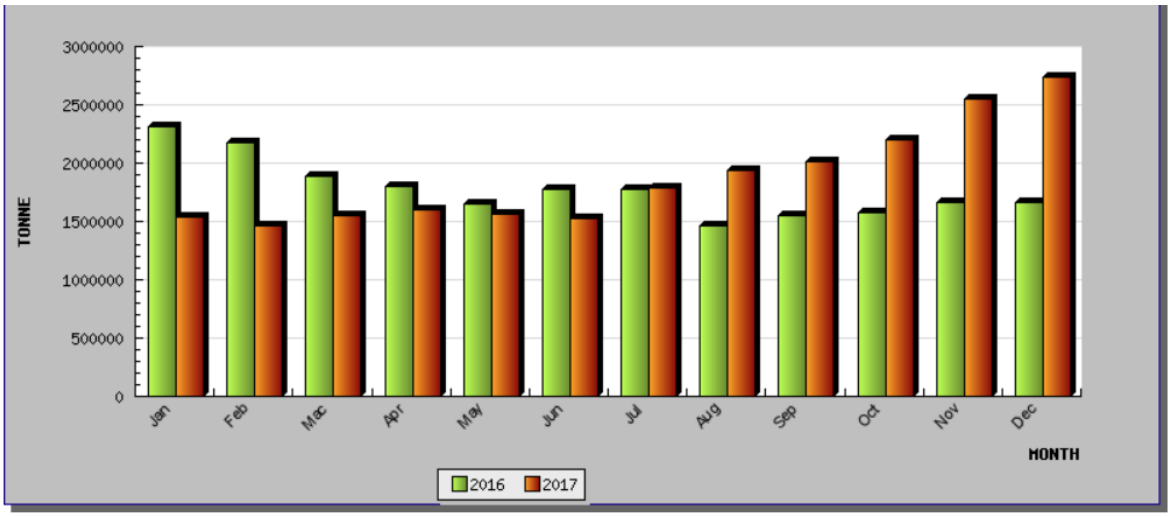

Figure 1.3 Monthly closing stock of palm oil in 2016/2017 (MPOB)

The inventory level of palm oil in Malaysia usually in lower range because buyers in the world bought all the palm oil products so the closing stock was relatively short. Many countries interested with producing and exporting palm oil which create an issue for buyers to choose suppliers. This is a reason why the level of inventory is rising which affect the efficiency of the product distribution and the stockholding period become longer. As palm oil production in Malaysia has grown rapidly, the application of IRA is needed to make sure the exact quantity in the inventory to ease the management of the inventories from raw materials to finished goods. So, this will lead to increase the sustainability of the product then improve the performance of palm oil industry. The aim of this paper is to identify the current challenges and risks as associated with Product-Service System Inventory Control in Palm Oil Industry. The palm oil plantation in Malaysia should be managed responsibly and sustainably because it has become a vital for government institution and other agencies such as Malaysian Palm Oil Board (MPOB), Roundtable on Sustainable Palm Oil (RSPO) and United Nations Framework Convention on Climate Change (UNFCC). Director General of MPOB, Datuk Dr. Ahmad Kushairi Din claimed that the palm oil industry is a backbone of Malaysia economy because it plays a vital responsibility in providing and arising the global population. So, this research may lead the government to maintain the sustainability then promotes sustainable production in line with the strategy of MPOB which are; high income, sustainable development and value addition.

METHODOLOGY

Research has been done in two stages: (1) current palm oil PSS inventory were investigated; (2) developed a generic model. For this project, Company A has been selected for the case study. Company A is one of the palm oil companies in Malaysia. This company engage and supply of the palm oil. This company is based in Petaling Jaya but the plantation and factory for the data collection is located in Pahang.

The methodology of IDEF0 based on function modelling of processes and generaly description. During 1970, Softech, Inc developed Structured Analysis and Design (SADT) to overcome the defects of the modelling and analysis method . Then, it is selected as language to construct the methodology of Integrated Computer-Aided Manufacturing (ICAM) which particularly used for development and creation of new product of aircrafts and spacecrafts within US Air Force Program. This attempt has developed IDEF0 and widely used in industry and the methodology become used in project areas which includes system definition, project management and integration. Now, standard is the main point for general functional desciption also modelling various business processes currently implemented in organizations which produce various type of products and services. IDEF0 is not used for every project as the merits of IDEF0 usage should be considered on case by case. It usually used to create a functional model that displays the system structure and its function. IDEF0 consists of 5 elements as described in Figure 1.4 that connects each other where described in Table 1.2

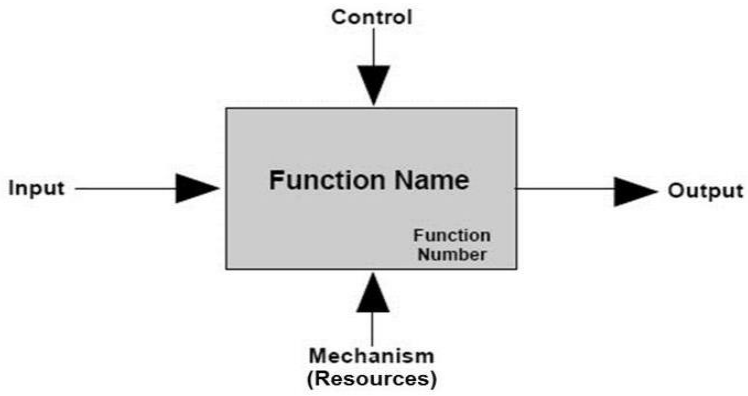

Figure 1.4 IDEF0 elements

Table 1.2: Description of IDEF0 elements

Elements	**Descriptions**
Function Name	Acivity, process, operation or transformation
Input	What is needed: data, object, material
Control	Condition, derictives or guideline that managing the function
Mechanism	Long-term resources needed to undertake relevant work
Output	What it produced; data. object, material

Finished goods with inefficient manufacturing operations and poor capacity control can affect the profitability of manufacturing company. One of the solution to manage the countless factors that contributes in low productivity and efficiency is Technomatix Logistic and Material Flow Simulation as well as to determine the optimal arrangement of new system, establish WIP inventory level, set a schedule of the production and many more. Thus, this software using discrete event simulation and statistical analysis which helps to minizime the operation of the inventory by reducing safety stock and inventory assets. Inventory control and planning in manufacturing company is important to determine the exact quantity when to produce or purchase. The decision can be done by deciding the current inventory position which measures the capability stocks to meet future demand moreover gives a inventory balances and future planned documents to control the inventory by simulate forecasting.

RESULTS AND DISCUSSION

Figure 1.5 shows the structure that developed by using IDEF0 which indicates four main stages in palm oil agriculture; seedling, planting, harvesting and processing. For seedling section, seeds as raw material will be kept in nursery for 12 months start with pre-nursery (4 months) and then transfer to main nursery (6 months). The seeds was ordered and kept batch by batch to ease the planting activities. The seeds need resources of sunlight, water and fertilizer to grow up. From Figure 1.6, seeds was germinated

in pre-nursery after it start to sprout and the germinated seeds will transfer to main nursery for young palm planting. Then, sapling is produced. All the process in seedling section are managed by quality control and IRA to make sure the quantity of inventory in this section is accurate and if inaccuracy happen, it will impact the cost of inventory. Counting and culling activities are used in sprouting stage to know the exact value of the inventory in this section. The sapling form seedling section will be used in planting section in order to produced the plam oil trees. The cycle time of palm oil tree is 25-30 years per palm oil tree. The replanting process is needed when the trees reaches its cycle time. Figure 1.7 shows the sapling will go through cultivating, manuring and weeding to produce high quality of palm oil trees. For cultivating, the first step before planting the sapling is chipping then followed by road construction. For manuring and weeding, it is controlled by the programme for each stage where the programme is measured by the lab test to specify the amount of fertilizer used in manuring and quantity of herbicide in weeding needed for every tree per batch.

Since the palm oil will produced the FFB, harvesting section is the process to collect the FFB. It consists of policy and delivery time schedule which is the FFB must be delivered not more than 24 hours. Harvesting equipments used are palm chisel and pole. After the fruit is collected, the ripe fruit will be graded as shown in Figure 1.8 and the knowledge of the grader is needed to make sure the quality of the FFB. After the FFB is collected, it will delivered to factory for processing stage. In processing secion as in Figure 1.9, the FFB should be weighing first to measure the weight of the FFB that controlled by the policy and IRA. There are five types of mills are used to produce palm oil which are indexing mill, conventional mill, continuous sterilizer mill, compact modular mill concept and vertical sterilizer mill system. The types of mills also can affect the quality of the palm oil and the first process in the palm oil mill usually is separating. The FFB will be separated by using thresher to separate fruitlet from sterilized fruit bunches. Next, the fruitlets is digested by using digester machine in order to loosen mesocarp from nuts and break up the oil cells and press machine is used to extract oil out of the digested mesh. Then, production line is divided into two; palm kernel operation and crude palm oil operation. Palm kernel operation used nut to produce palm kernel, shell and shredded fibre while crude palm oil operation will produced crude palm oil. The other finished goods other than nut and oil are empty bunch and mesocarp fibre that usually used for power generating. The palm kernel inventories are stored in kernel bunker while bunk storage tank is used to store crude palm oil.

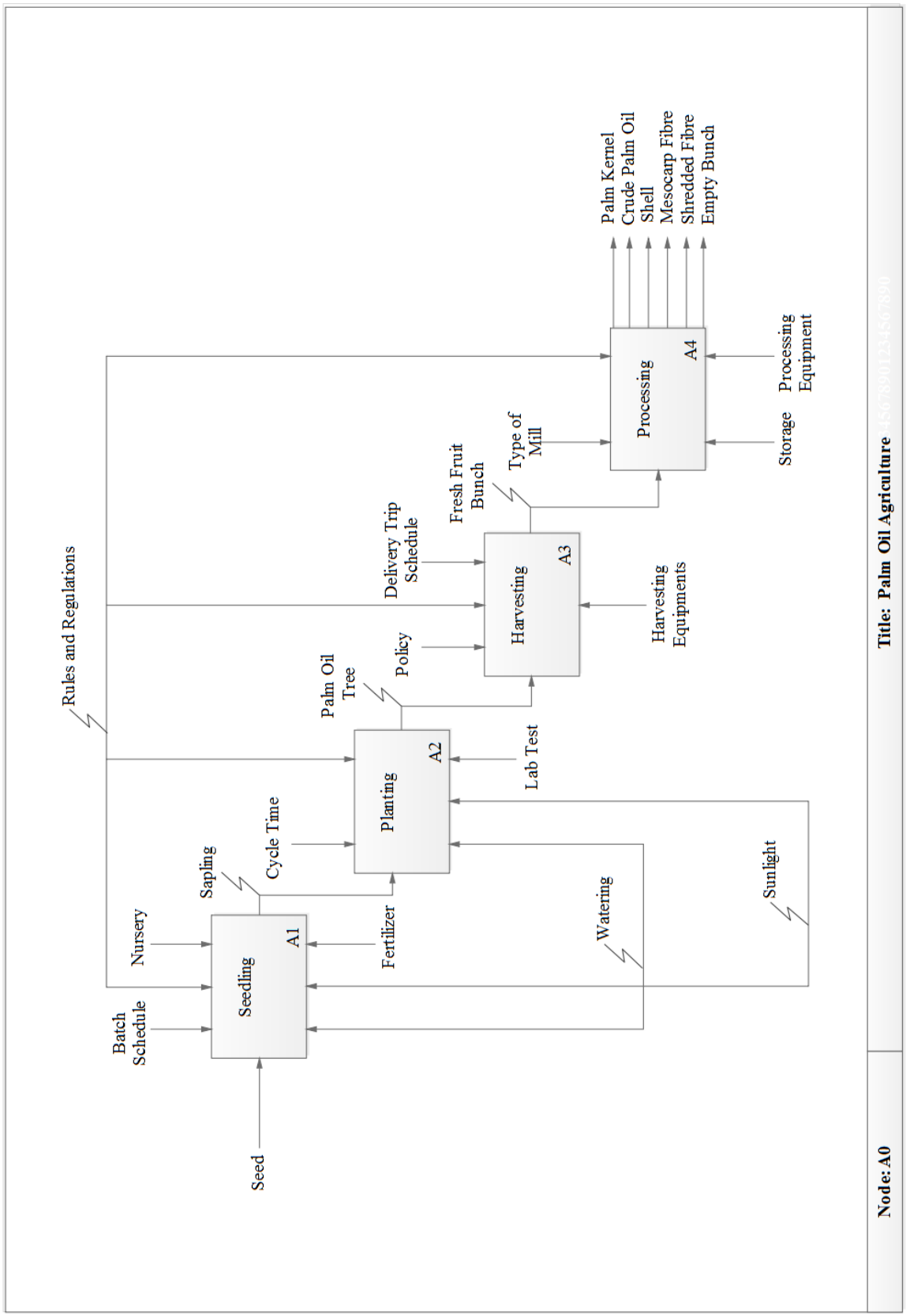

Figure 1.5 Palm Oil Agriculture

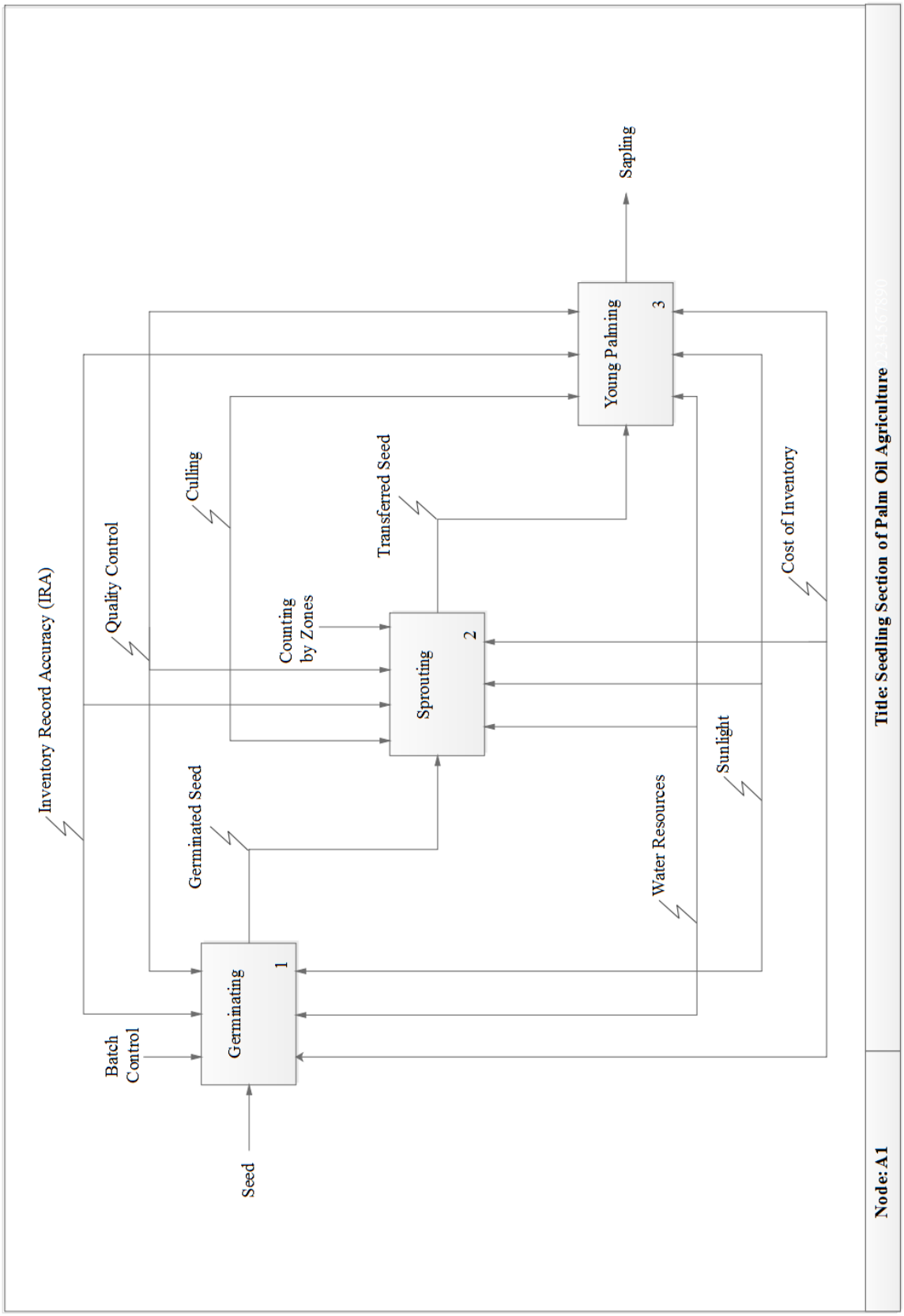

Figure 1.6 Seedling section

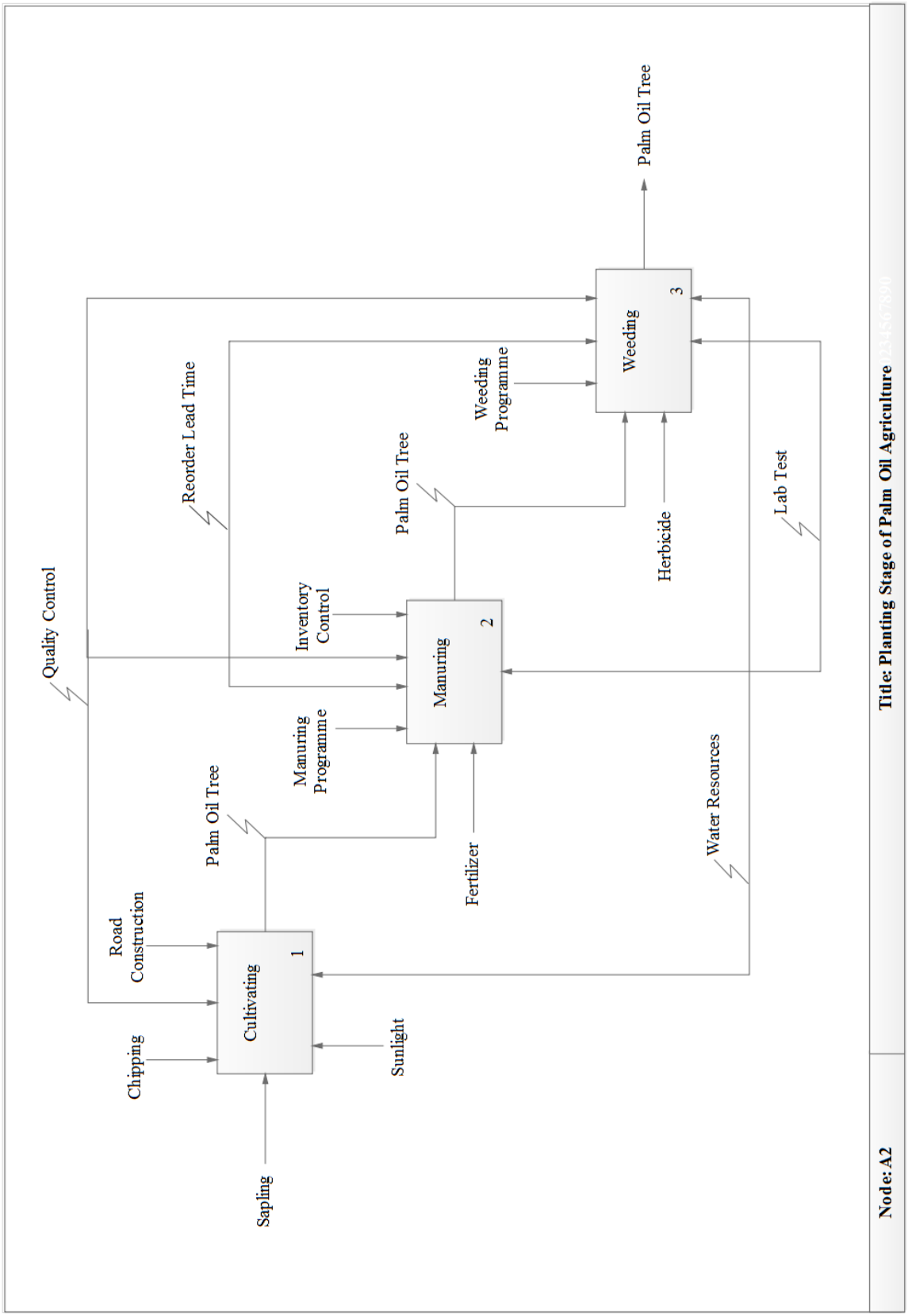

Figure 1.7 Planting section

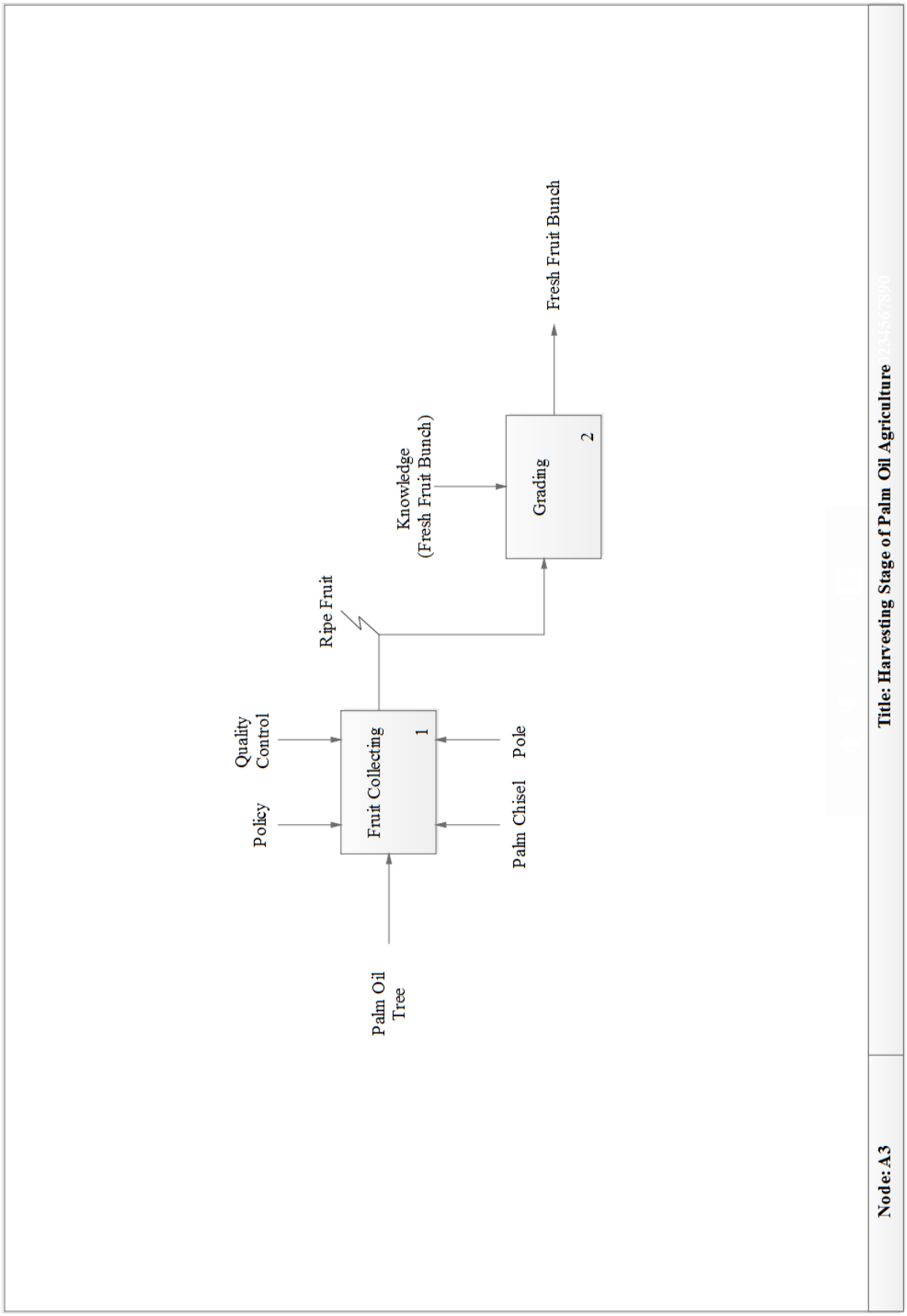

Figure 1.8 Harvesting section

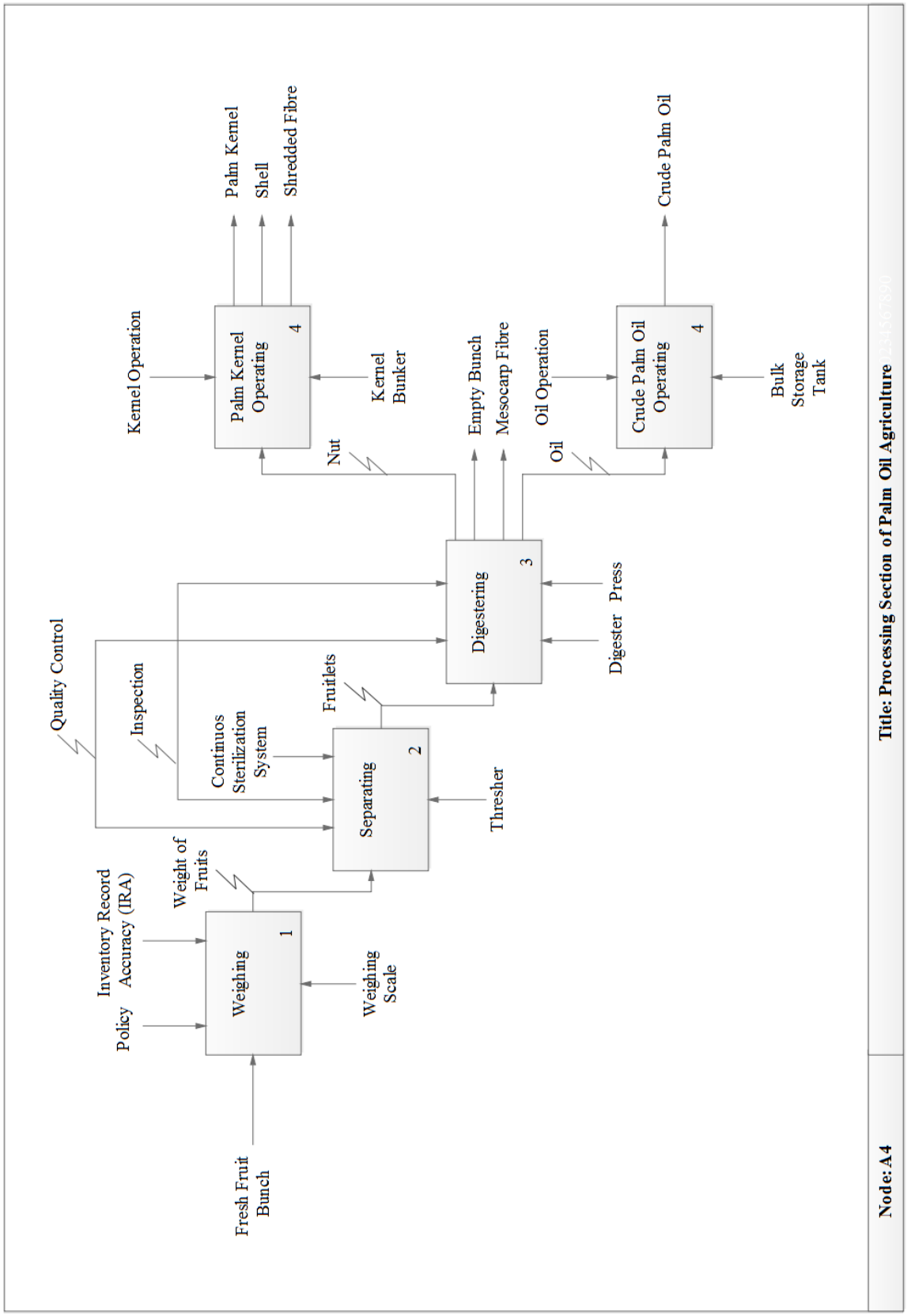

Figure 1.9 Processing section

CONCLUSION

In sum, this paper is in essence a preliminary discussion of an example of PSS in a palm oil agriculture, with a focus on inventory control accuracy record. This generic model using IDEF0 has shown

that the inventory control of PSS is a complex business process as opportunities on innovation and market development also increase the inventory efficiency. Further research will be needed to verify that the generic model proposed is applicable in alternative scenarios and validate the developed generic model in this case study. For the company, this research can provide a better management in inventory control on how to ensure the accuracy of the inventory records. From this research, a company can implement new strategies based on risks opportunities of inventory control as preparations to overcome issues and challenges that might be happened in palm oil production in order to make sure the industry of palm oil will remain resilient in the future.

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