ANKARA YILDIRIM BEYAZIT UNIVERSITY

GRADUATE SCHOOL OF NATURAL AND APPLIED SCIENCES

SYSTEMS ENGINEERING METHODOLOGIES IN A TURN-KEY PROJECT DESIGN: A VERMICOMPOST PRODUCTION EXAMPLE

M.Sc. Thesis by

Pelin ÜSTÜNYER

Department of Industrial Engineering

January, 2019

ANKARA

SYSTEMS ENGINEERING METHODOLOGIES IN A TURN-KEY PROJECT DESIGN: A VERMICOMPOST PRODUCTION EXAMPLE

A Thesis Submitted to

The Graduate School of Natural and Applied Sciences of

Ankara Yıldırım Beyazıt University

In Partial Fulfillment of the Requirements for the Degree of Master of Science in Industrial Engineering, Department of Industrial Engineering

by

Pelin ÜSTÜNYER

January, 2019

ANKARA

M.Sc. THESIS EXAMINATION RESULT FORM

We have read the thesis entitled **"SYSTEMS ENGINEERING METHODOLOGIES IN A TURN-KEY PROJECT DESIGN: A VERMICOMPOST PRODUCTION EXAMPLE"** completed by **PELİN ÜSTÜNYER** under the supervision of **PROF. DR. METE GÜNDOĞAN** and we certify that in our opinion it is fully adequate, in scope and in quality, as a thesis for the degree of Master of Science.

Prof. Dr. Mete GÜNDOĞAN

Supervisor

Prof. Dr. Ergün ERASLAN

Jury Member

Assoc. Prof. Dr. Yusuf Tansel İÇ

Jury Member

Prof. Dr. Ergün ERASLAN

Director

Graduate School of Natural and Applied Sciences

I hereby declare that, in this thesis which has been prepared in accordance with the Thesis Writing Manual of Graduate School of Natural and Applied Sciences,

- All data, information, and documents are obtained in the framework of academic and ethical rules,
- All information, documents, and assessments are presented in accordance with scientific ethics and morals,
- All the materials that have been utilized are fully cited and referenced,
- No change has been made on the utilized materials,
- All the works presented are original,

and in any contrary case of above statements, I accept to renounce all my legal rights.

Date: 2019, 28 January **Signature:**

Name & Surname: Pelin ÜSTÜNYER

ACKNOWLEDGMENTS

I would first like to thank Ankara Yıldırım Beyazıt University for providing me all technical opportunities.

I would like to thank my thesis advisor, Prof. Dr. Mete GÜNDOĞAN who always guided me in this research. Whenever I had a question about my thesis or unable to work out a solution, his door was always open to me.

I would also like to thank my family for supporting me at every stage of my life. This thesis would not have been without them.

2019, 28 January **Pelin ÜSTÜNYER**

SYSTEMS ENGINEERING METHODOLOGIES IN A TURN-KEY PROJECT DESIGN: A VERMICOMPOST PRODUCTION EXAMPLE

ABSTRACT

This thesis addresses a turn-key project design for a vermicompost production by using systems engineering techniques. It is also aimed to provide the fundamentals of future systems design studies and different turn-key projects. Due to the gaining importance of organic agriculture, the need for organic fertilizer is increasing. One of the most preferred organic fertilizers is known as vermicompost because of having simple production and high yield. In this thesis, a turn-key project is designed to produce vermicompost by using the Structured Systems Analysis and Design Method (SSADM) in which the proposed system is transformed into interrelated activity diagrams at three levels: 1) departmental level, 2) functional level and 3) user requirements level. Activity diagrams represent all information and materials of the proposed system. Daily working hours and required manpower are determined at the user requirements level. In addition, the cost of SSADM activities and the total cost of the proposed system are calculated.

Keywords: Vermicompost, systems engineering, Structured Systems Analysis and Design Method, manpower planning, activity-based costing.

ANAHTAR TESLİM PROJE TASARIMINDA SİSTEM MÜHENDİSLİĞİ METODOLOJİLERİ: VERMİKOMPOST ÜRETİM ÖRNEĞİ

ÖZ

Bu tez çalışması, vermikompost üretimi için sistem mühendisliği tekniklerinin kullanıldığı bir anahtar teslim proje tasarımıdır. Ayrıca bu tez, gelecekteki sistem tasarımı çalışmalarına ve farklı anahtar teslim projelerine temel oluşturmayı amaçlamaktadır. Organik tarımın önem kazanmasından dolayı organik gübreye olan ihtiyaç da artmaktadır. Vermikompost, üretiminin kolay olması ve yüksek verimi nedeniyle en çok tercih edilen organik gübrelerden biri olarak bilinmektedir. Bu tezde, Yapısal Sistem Analiz ve Tasarım Yöntemi (SSADM) kullanılarak vermikompost üretimi için bir anahtar teslim proje tasarlanmıştır. SSADM'de önerilen sistem, birbiriyle ilişkili faaliyet şemalarına (aktivite diyagramlarına) 3 aşamada dönüştürülür: 1) departman seviyesi, 2) işlevsel (fonksiyonel) seviye ve 3) kullanıcı gereksinimleri seviyesi. Faaliyet şemaları, önerilen sistemin bütün bilgi ve malzemelerini göstermektedir. Günlük çalışma saatleri ve gerekli iş gücü, kullanıcı gereksinimleri seviyesinde belirlenmiştir. Buna ek olarak, SSADM faaliyetlerinin ve önerilen sistemin toplam maliyeti hesaplanmıştır.

Anahtar Kelimeler: Vermikompost, sistem mühendisliği, Yapısal Sistem Analiz ve Tasarım Yöntemi, iş gücü planlama, faaliyet tabanlı maliyet.

CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

Plants need nutrients like other creatures. It is necessary that plants are not deprived of nutrients, to obtain high and sustainable yields. When they could not reach the nutrients they need, they should be fed with fertilizers containing plant nutrients. For having a sustainable agricultural production, fertilization has crucial importance, besides irrigation.

Turkey uses less chemical fertilizer than developed countries; however, producers in Turkey tend to multiply their use of chemical fertilizer within decades. Because chemical fertilizers contain heavy metals, they cause various environmental pollution such as water, soil, and air when used [1].

Organic farming is a controlled agricultural production, with no fertilizer or drug in use, which are harmful to human health and the environment. The use of organic fertilizers is essential for efficient and sustainable farming. Considering environmental pollution and associated health problems, the use of organic fertilizers in agriculture has become a significant issue. Especially, vermicompost is the organic fertilizer amongst them has become very popular in recent years [2].

Vermicompost means worm fertilizer. Various vegetable and animal wastes become fertilizer through the digestive system of the worms. In the production of vermicompost which is a fruitful organic fertilizer in terms of nutrients and microbial activities, Eisenia Andrei and Eisenia Fetida worms are preferred because of their rapid reproduction and survival rate. Eisenia Fetida is the brown color and Eisenia Andrei is red. The environmental requirements, lifetime, and reproduction rates of these two species are very similar but Eisenia Andrei is more frequently preferred because its reproduction rate is slightly higher. However, most of the time, hybridization is performed [2].

In this thesis, a turn-key project is designed for a vermicompost production facility using systems engineering approaches such as system design, manpower planning, and cost calculation. The main product of this facility is vermicompost and its by-product is the worm. After reached a determined worm capacity, the production volume is kept fixed, and increased worms are also sold.

While designing the project, a structured system design is used. With structured methods, it is aimed to create a meaningful whole of the small activities that interact with each other so that the developers and the users can understand easily. Some of the advantages of the structured method are:

- An understandable application and a firm foundation for the next design,
- More efficient use of staff,
- Improved project plan and control, and
- Better quality systems [3].

Structured Systems Analysis and Design Method (SSADM), which is used in this project, became the most preferred structured method with the advantages it created shortly after being introduced in the United Kingdom [3].

SSADM includes the analysis and design of the system as a stage of a system before programming. With SSADM, the system becomes more efficient, flexible, easy to explain and control. For these reasons, SSADM is used in this turn-key project design.

First of all, the boundaries of the whole system are determined with a diagrammatic presentation. The system's three different levels (departmental, functional, and user requirements) are created by using diagrams of SSADM. All materials and information flows in and out of the system are shown with arrows in SSADM. The contents of all arrows are explained.

Besides SSADM, manpower planning is also done. When planning the manpower, the periods required for the works are taken into consideration. The required times for

carrying out the tasks designed for the third (user requirements) level of the SSADM have been estimated. Then a Gantt chart is used to decide the manpower requirement, and the amount of manpower to make the work without interruption in the required time has been determined.

Furthermore, activity-based costing has done for the cost calculations. The costs for each activity at the user requirements level are determined. The sum of these costs gives the cost of the entire system.

The entire system has collected in three titles as investment cost, production cost, and operation and maintenance costs. Then the break-even analysis is used to determine the point of start to profit. Total annual income and expenses, and annual net profits are calculated.

Finally, a visual description of the project is presented by drawing the inside and outside areas of the facility.

In the second chapter of this thesis, a literature review is given. In this chapter, the concepts of the system, systems engineering, SSADM, manpower planning, and activity-based costing are explained. In the third chapter, the required general information about the production process for the proposed turn-key project is given. In the fourth chapter, project design is done with SSADM, manpower planning, and cost calculation. Then a 3-dimensional facility drawing is made. In the fifth and the sixth chapters, results and discussion and further studies are given respectively.

CHAPTER 2

LITERATURE REVIEW

2.1. System and Systems Engineering

There are various definitions of the system. One of the definitions specified in the literature as:

“An open set of complementary, interacting parts with properties, capabilities, and behaviors emerging both from the parts and from their interactions to synthesize a unified whole” [4].

In other words, the system is a set of components that are together and interact with each other for the same purpose. In this respect, a system can be the subsystem of another system or can be divided into smaller components [5].

Figure 2.1 shows the structure of the system. Each system interacts with its surroundings. The system has inputs and outputs. Considering a production facility as in this project, customer needs are the input of this system and the final products are the output of the system. In addition, the system has various constraints and resource requirements such as budget constraints and human resources.

Figure 2.2 shows the major elements of a system.

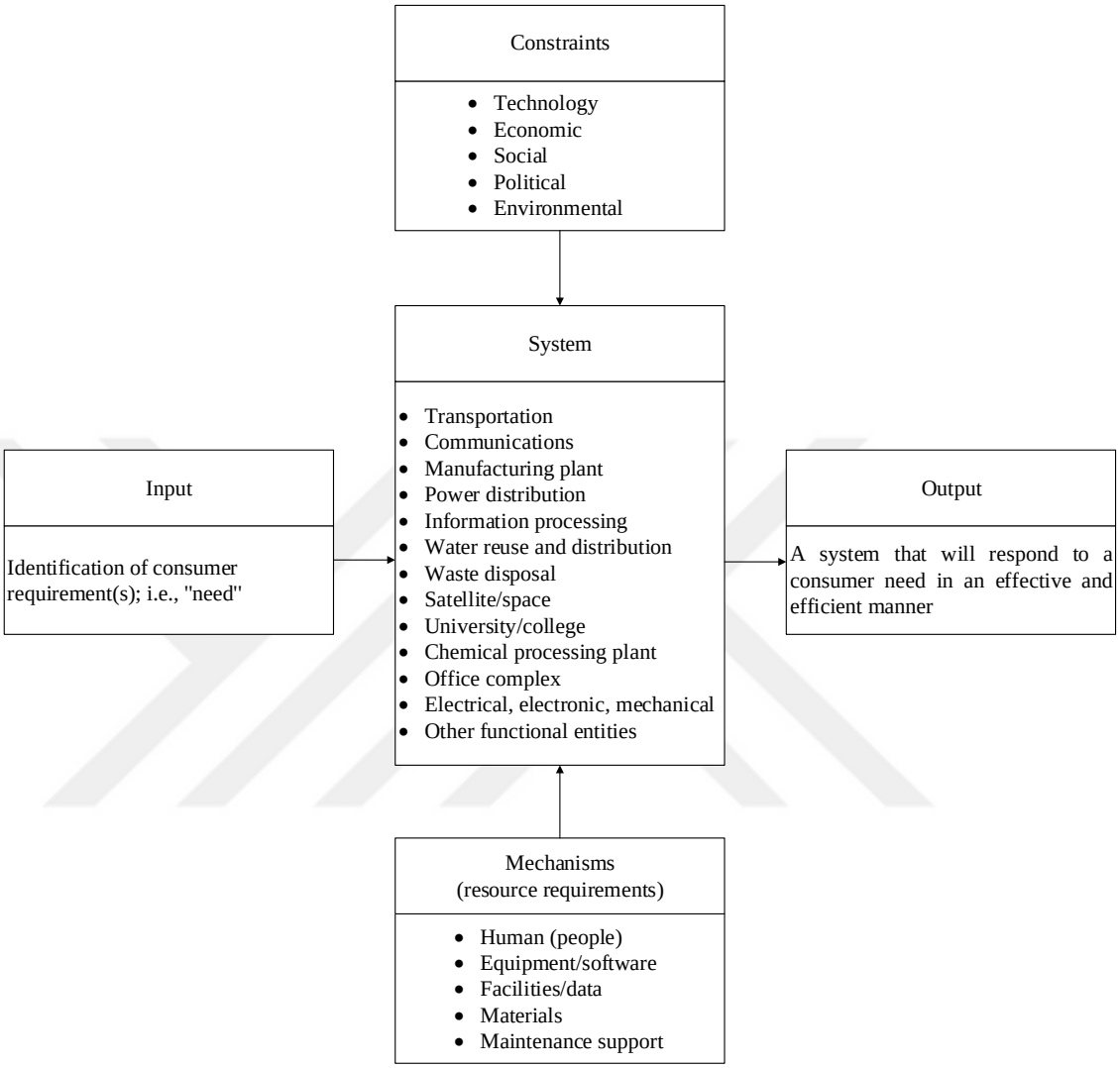

Figure 2.1 The system [6]

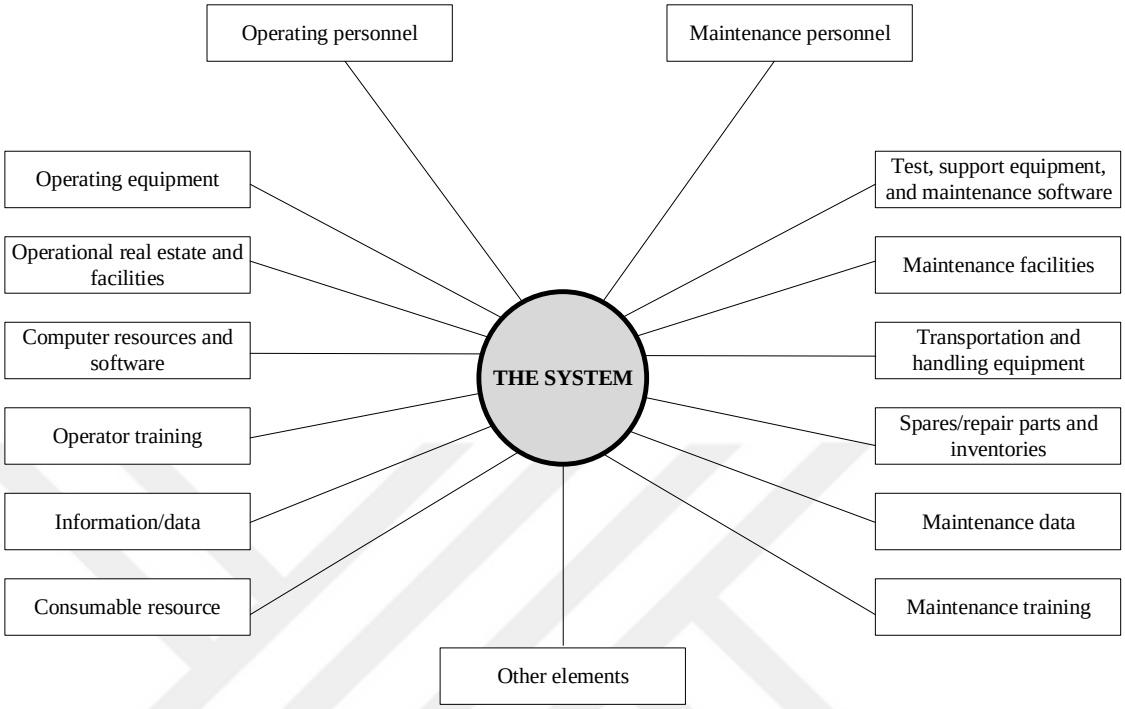

Figure 2.2 Major elements of a system [6]

In the literature, the characteristics of the system are described as follows: Every system has its purpose, interacting components, a hierarchical structure, life cycle, and reliability [5].

The system approach is considered as the best way to understand the complex issues. Also, systems engineering is recognized as the most appropriate method to solve complex problems [4].

"The International Council on Systems Engineering (INCOSE) is a not-for-profit membership organization founded to develop and disseminate the interdisciplinary principles and practices that enable the realization of successful systems" [7].

The aims of INCOSE are systems engineers keeping together, creating a network, and taking advantage of the training programs [7].

> The International Council on Systems Engineering (INCOSE 2012) defines systems engineering as follows:
>
> Systems engineering is an interdisciplinary approach and means to enable the realization of successful systems. It focuses on defining customer needs and required functionality early in the development cycle, documenting requirements, then proceeding with design synthesis and system validation while considering the complete problem:
>
> - Operation
> - Performance
> - Test
> - Manufacturing
> - Cost and schedule
> - Training and support
> - Disposal
>
> Systems engineering integrates all the disciplines and specialty groups into a team effort forming a structured development process that proceeds from concept to production to operation. Systems engineering considers both the business and the technical needs of all customers with the goal of providing a quality product that meets the user needs [5].

Considering the definition of systems engineering, it can be said that the aim of systems engineering is finding solutions to complex problems that can be identified and solvable [4].

In other words, systems engineering aims to find and implement the most suitable solution for solving a problem. In this context, systems engineering analyzes the problem from all angles and explores alternative solutions [4].

2.2. Structured Systems Analysis and Design Method

"SSADM was developed by the United Kingdom government in 1982 for development of information systems by government projects. Since then its use has spread to the commercial market and to other countries" [8].

SSADM assumes that systems are built on a specific data structure. These data are integrated into the appropriate processes with documents in the system design [3]

With SSADM, the system is designed in stages with the help of diagrams. The activity interactions within the diagrams are clearly stated. The inputs and outputs of each diagram are specified. There are also forms and documents required to fulfill the requirements of the system in these inputs and outputs. In summary, the system is organized by three features which are:

- Structures,
- Techniques,
- Documentation [3].

One of the main advantages is that SSADM builds up several different views of the system which are used to cross-check one another. In SSADM, three different views of the system are developed in analysis. These views are closely related to one another and are cross checked extensively for consistency and completeness. The equal weight given to these three techniques and the prescriptive procedures for checking them against one another is a great strength of the SSADM approach. The three views are:

- The underlying structure of the system's data (the Logical Data Structure);
- How data flows into and out of the system and is transformed within the system (Data Flow Diagrams);
- How the system data are changed by events over time (Entity Life Histories).

Another advantage of SSADM over a number of methods is that it combines techniques into a well-established framework, and so, as well as providing the techniques for the analyst, it gives guidance on how and when to use them. Even though SSADM adopts this rather prescriptive

approach, there is still a large amount of flexibility within the method and the method should be tailored to specific project circumstances [3].

The components used in the creation of SSADM are as shown in Figure 2.3. The context boundary indicates the limits of the system. It enables the internal and external environment of the system to be handled separately. Activity boxes form the sub-elements of the system. These are the activities required for the system to function. The activity number is used to specify the number of activity boxes. Material flow and information flow arrows are used to indicate the flow of raw material, stuff, and data. Material and information stores are the areas where materials and data are stored. They may be a physical warehouse or a data storage device such as a computer. A regular storage symbol is used for continuous storage. For external sources such as suppliers and customers, the external resource symbol is used. Also, the symbol of regular external resource is used for continuous resources.

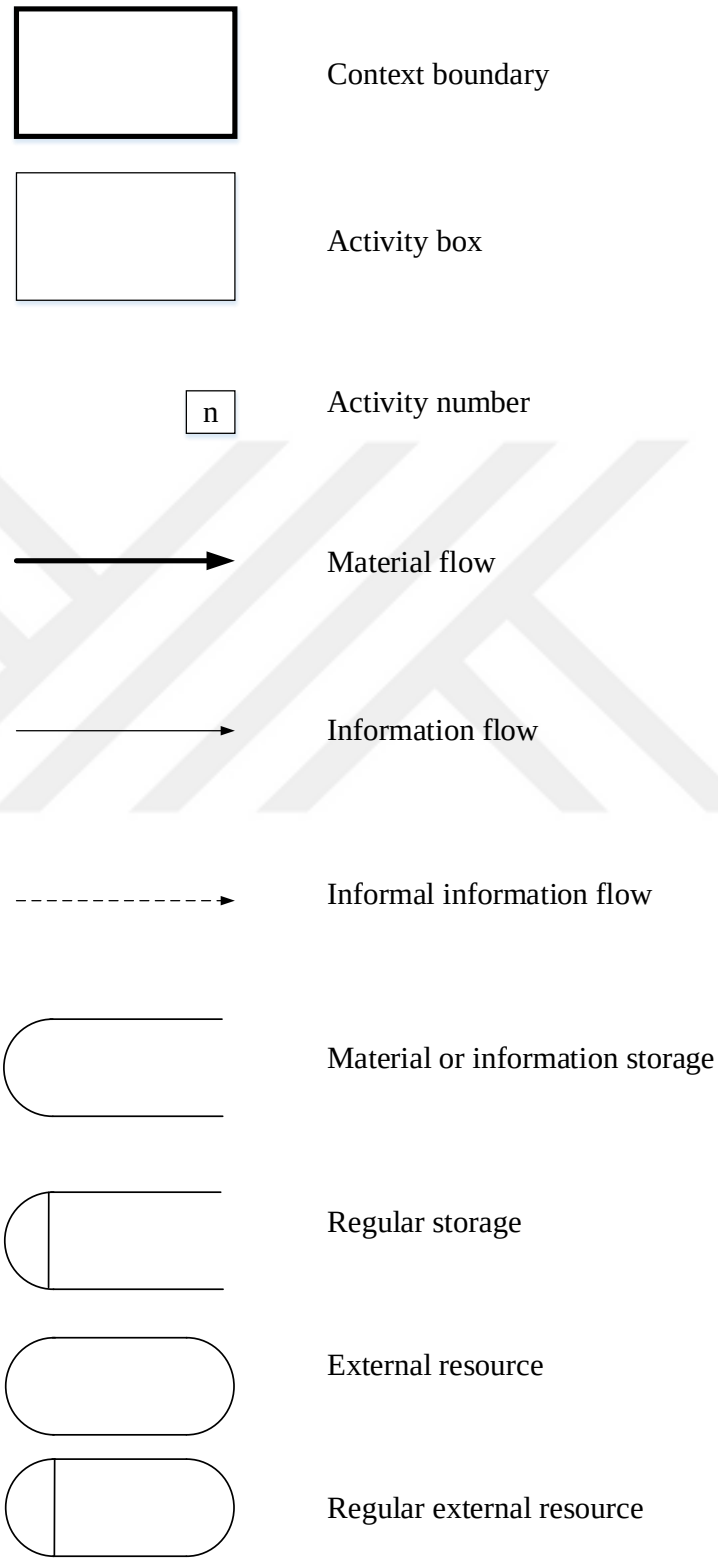

Figure 2.3 Components of SSADM

Figure 2.4 is given for a better understanding of the SSADM structure. The first level (departmental level) is the top level. Its subcomponents are the second level (functional level). Finally, the third level (user requirements level) is the lowest level.

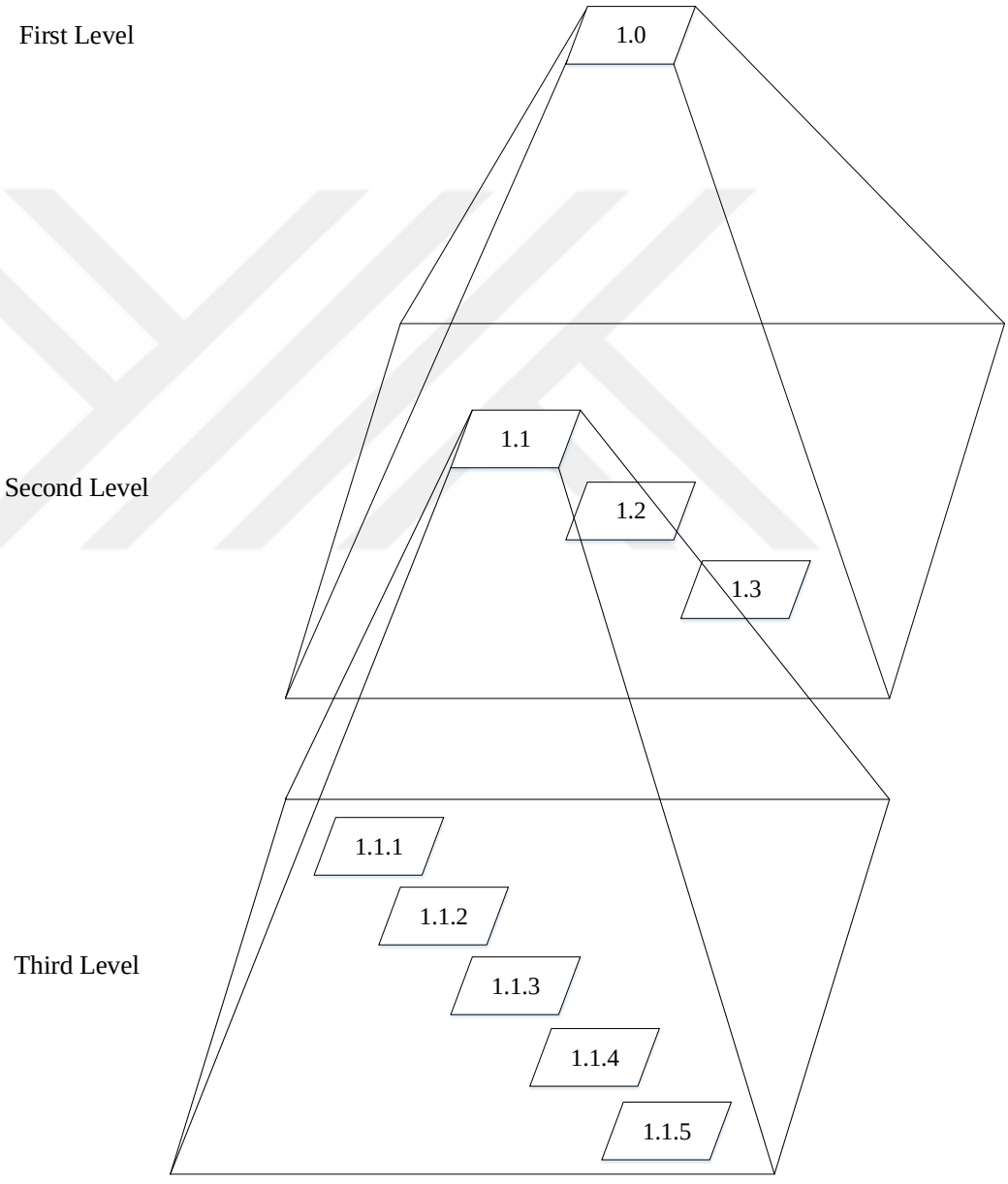

Figure 2.4 SSADM structure [8]

2.3. Manpower Planning

Considering the importance of employees in the competitiveness of companies, manpower planning is an important and complex issue. Manpower planning is one of the most challenging issues for managers. It includes the determination of the number of required employees, recruitments, layoffs, and scheduling according to tasks [9].

In the manpower planning, deterministic and stochastic models are presented in the literature considering various uncertainties such as the economic environment and working life. Hierarchical structures are also important in the manpower planning which is developed to enable certain employees to perform certain tasks in the right places according to their job descriptions. For example, works can be created at three levels for the production systems, the production worker can be in the first level, the supervisor can be a higher level and the manager can be the highest level [10].

Today, there is a wide range of professional degrees and job descriptions are more and more intertwined. The change in the occupational limits has led to the spread of manpower in large areas and in various fields. This has necessitated manpower planning. Manpower planning is a policy for ensuring the necessary labor force [11].

When planning manpower, estimating the necessary manpower is a good way to make decisions. With this method, the difference between the current manpower and the future requirement is put forward [12].

It is a good method that making this estimation and planning based on the required time. In this thesis, manpower planning is made based on the required work times.

2.4. Activity-Based Costing

Activity-based costing (ABC) was proposed in the mid-1980s. It is based on the idea that the costs increase according to activities rather than the production volume. It is the process of determining all activities of the system and assigning costs to these activities. With this method, managers can easily see where significant costs occur and take the necessary measures faster [13]. SSADM user requirements level costs give Cost Breakdown Structure (CBS) given in Figure 2.5.

CBS is used to determine all functions and to show the costs them in the future. This provides functional costing, which can be seen more clearly. Costs in the life cycle are written and collected for each year as shown in Table 2.1 [6]. Therefore, the life cycle cost is achieved.

Life cycle costing is a cost account that includes all costs of the system from the creation stage to the disposal and enough to perform all required operations during the life of the system. In other words, it requires taking into account all the costs of the system in the current state and in the future [6].

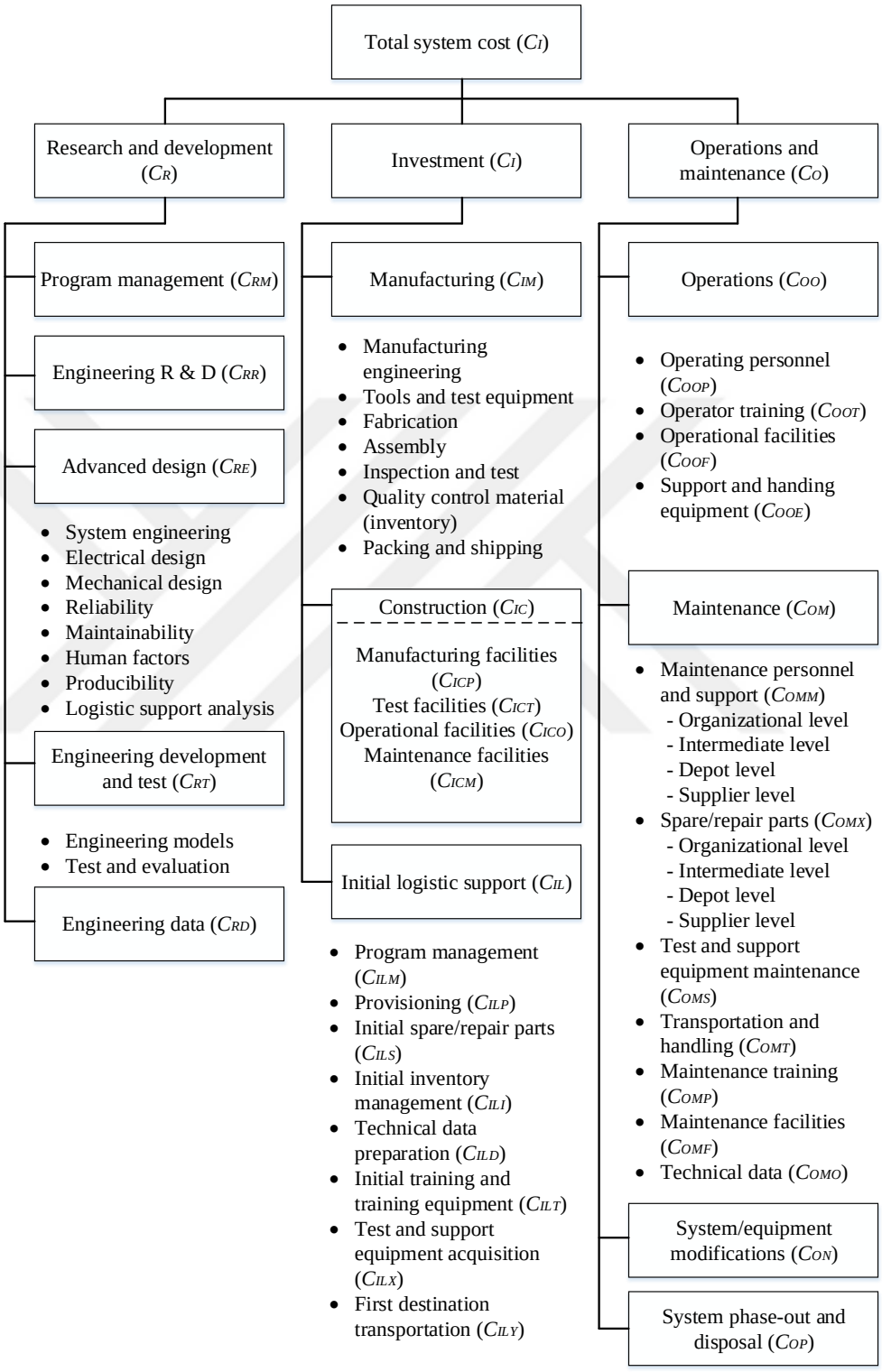

Figure 2.5 Cost breakdown structure (CBS) [6]

Table 2.1 Description of cost categories (partial) [6]

Cost Category	Method of Determination (Quantitive Expression)	Cost Category Description and Justification
Total system cost (C)	$C = C_R + C_I + C_O$ C_R = R and D cost C_I = Investment cost C_O = Operations and maintenance cost	Includes all future costs associated with the acquisition, utilization, and subsequent disposal of system/ equipment.
Research and development (C_R)	$C_R = C_{RM} + C_{RR} + C_{RE} + C_{RT} + C_{RD}$ C_{RM} = Program management cost C_{RR} = Advanced R&D cost C_{RE} = Engineering design cost C_{RT} = Equipment development/ test cost C_{RD} = Engineering data cost	Includes all costs associated with conceptual/feasibility studies, basic research, advanced research and development, engineering design, fabrication and test of engineering prototype models (hardware) and associated documentation. Also covers all related program management functions. These cost are basically nonrecurring.
Investment (C_I)	$C_I = C_{IM} + C_{IC} + C_{IL}$ C_{IM} = System/equipment manufacturing cost C_{IC} = System construction cost C_{IL} = Cost of initial logistic support	Includes all costs associated with the acquisition of systems/equipment (once design and development have been completed). Specifically, this covers manufacturing (recurring and nonrecurring), manufacturing management, system construction, and initial logistic support.
Operations and maintenance (C_O)	$Co = C_{OO} + C_{OM} + C_{ON} + C_{OP}$ C_{OO} = Cost of system/equipment life-cycle operations C_{OM} = Cost of system/equipment life-cycle maintenance C_{ON} = Cost of system/equipment life-cycle modifications C_{OP} = Cost of system/equipment phase-out and disposal	Includes all costs associated with the operation and maintenance support of the system throughout its life cycle subsequent to equipment delivery in the field. Specific categories cover the cost of system operation, maintenance, sustaining logic support, equipment modifications, and system/equipment phase-out and disposal. Costs are generally determined for each year throughout the life cycle.

Table 2.1 (continued) Description of cost categories (partial) [6]

Cost Category	Method of Determination (Quantitive Expression)	Cost Category Description and Justification
Transportation and handling cost (C_{OMT})	$C_{OMT} = [(C_T)(Q_T) + (C_P)(Q_T)]$ C_T = Cost of transportation C_P = Cost of packing Q_T = Quantity of one-way shipments $C_T = [(W)(C_{TS})]$ W = Weight of item (lb) C_{TS} = Shipping cost ($/lb) C_{TS} will, of course, vary with the distance (in miles) of the one-way shipment. $C_P = [(W)(C_{TP})]$ C_{TP} = Packing cost ($/lb) Packing cost and weight will vary depending on whether reuseable containers are employed.	Initial (first destination) transportation and handling costs are covered in C_{ILY}. This category includes all sustaining transportation and handling (or packing and shipping) between organizational, intermediate, depot, and supplier facilities in support of maintenance operations. This includes the return of faulty material items to a higher echelon; the transportation of items to a higher echelon for preventive maintenance (overhaul, calibration); and the shipment of spare/repair parts, personnel, data, etc., from the supplier to forward echelons.
Maintenance training cost (C_{OMP})	$C_{OMP} = [(Q_{SM})(T_T)(C_{TOM})]$ Q_{SM} = Quantity of maintenance students C_{TOM} = Cost of maintenance training ($/ student-week) T_T = Duration of training program(weeks)	Initial maintenance training cost is included in C_{ILT}. This category covers the *formal* training of personnel assigned to maintain the prime equipment, test and Support equipment, and training equipment. Such training is accomplished on a periodic basis throughout the system life-cycle to cover personnel replacements due to attrition. Total costs include instructor time; supervision; student pay and allowances while in school; training facilities (allocation of portion of facility required specifically for formal training); training aids and data; and student transportation as applicable.
Operational facilities cost (C_{OOF})	$C_{OOF} = [(C_{PPE} + C_U)(\%\ \text{Allocation}) \times (N_{OS})]$ C_{PPE} = Cost of operational facility support ($/site) C_U = Cost of utilities ($/site) N_{OS} = Number of operational sites *Alternative Approach* $C_{OOF} = [(C_{PPF})(N_{OS})(S_O)]$ C_{PPF} = Cost of operational facility space ($/square foot/site). Utility cost allocation is included. S_O = Facility space requirements (square feet)	Initial acquisition cost for operational facilities is included in C_{ICO}. This category covers the annual recurring costs associated with the occupancy and maintenance (repair, paint, etc.) of operational facilities throughout the system life cycle. Utility costs are also included. Facility and utility costs are proportionately allocated to each system.

CHAPTER 3

PROJECT DESIGN INITIATION

In this project, a turn-key project for a facility that produces vermicompost is designed.

The facility land is leased and the plant is purchased as prefabricated. The facility's main product is vermicompost and it could be started production with 200000 pieces of worms. These worms can produce 3.6 tons of fertilizer the first time after 6 months. Worms are assumed to double their numbers every 3 months [14].

One pool is purchased for each of the first 6 months. Worms, which are increased from the first month, are placed in the pool purchased in the 4th month. Worms, which are increased from the 2nd month, are placed in the pool purchased in the 5th month. Worms, which are increased from the 3rd month, are placed in the pool purchased in the 6th month. 3.6 tons of fertilizer and 400000 worms are sold each month after the worm count reaches 1200000, and worm count is kept fixed.

In the production process of vermicompost, organic wastes such as tea leaves, paper, vegetable/fruit shells are taken from restaurants, tea houses, and factories and cattle fertilizer is taken from farmers. Then, they are mixed in the garden to get compost with shovels by workers.

For efficient production, compost should consist of 30% domestic wastes, 70% organic wastes [14]. The total compost amount will be 15.12 tons in a month after 6 months. After mixing organic wastes and cattle fertilizer, compost is left to fermentation. This process takes a month.

Fermented compost is placed in trays with the help of a shovel and processed in a heat treatment furnace given in Figure 3.1. The heat treatment furnace ensures that the

hazardous substances in the compost are removed. This process is carried out at 70 degrees for 1 hour.

Figure 3.1 Heat treatment furnace [15]

Employees take compost from the furnace and carry them with wheeled buckets to pools given in Figure 3.2. Composts are being poured into pools where worms are. The temperature must be between 10 and 24 degrees, and the humidity must be between 70-80% in this environment [14]. After 6 months, the whole pool is filled with fertilizer and fertilizer is ready to be taken. Workers take the fertilizers from pools and put them to the area which is separated for the drying process. Fertilizer is left for the drying for 3 months.

Figure 3.2 Production pools [16]

After the fertilizers are dried, they are thinned with the fertilizer sifting machine given in Figure 3.3 and packed into sacks. Then sacks are sewed with the sewing device.

Figure 3.3 Fertilizer sifting machine [17]

Fertilizers are sold in plastic packages of 5, 10, and 25 kg. Worms are counted and sold in 10000 and 20000 units. Target markets of the company are farmers, hobby gardens, markets, and greenhouses.

CHAPTER 4

PROJECT DESIGN

The system design is done with the SSADM. Then, manpower planning and the cost of the system are determined. Finally, the drawing of the facility is presented.

4.1. Structured Systems Analysis and Design Method

SSADM for vermicompost production facility is created as shown in this section. Readers should be aware of the repetitions existing from the SSADM nature. For example, an input information line to an activity could be an output of a previous activity. In order to keep schemes integrated, all of the information relating to that scheme has been written beneath the figure. This type of representation will naturally include some repetitions but exhibit a good scheme to understand the system. The inputs and outputs of each scheme are handled as shown in Figure 4.1.

Figure 4.1 Input and output

4.1.1. Vermicompost Production Management System

The boundaries of the whole system are determined by this scheme as shown in Figure 4.2. Vermicompost production management system consists of three departments: Management department, production department, and storage and delivery department. With demand and policies between management and suppliers, raw materials are obtained. Then the production is done. Final products are sent customers from storage and delivery. The flows of all required materials and information are shown in Figure 4.2.

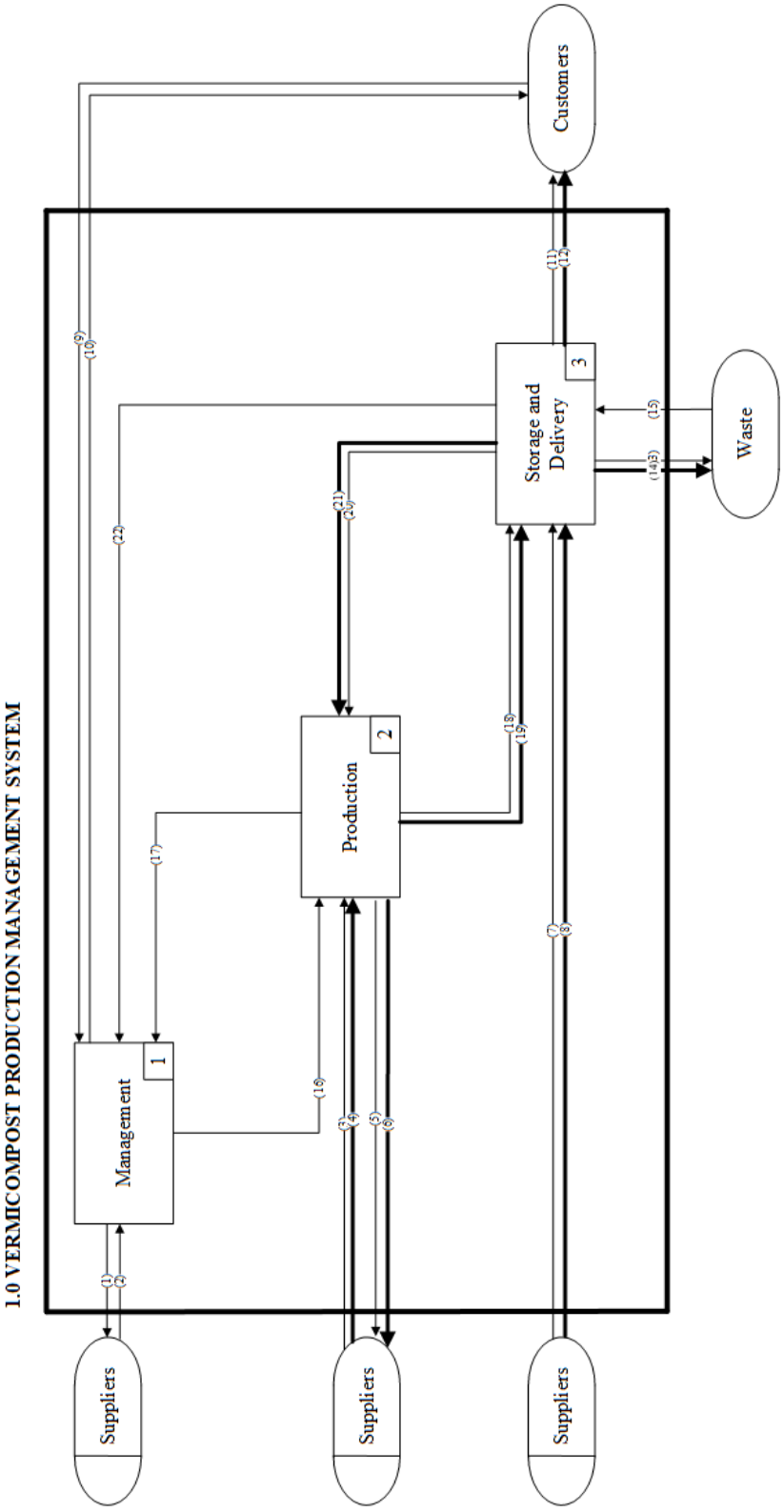

Figure 4.2 Vermicompost production management system

(1) Output – Offer request form, delivery confirmation, and approved offer form from "management" to "suppliers". An offer request form contains the following information:

- Request date,
- Company name,
- Related person name,
- Phone number,
- Fax number,
- Explanation, and
- Material description.

(2) Input – Cattle fertilizer price offer form, office material price offer form, utility bills, and delivery form from "suppliers" to "management". A cattle fertilizer price offer form contains the following information:

- Company name,
- Supplier name,
- Address of supplier,
- Telephone number of supplier,
- Amount of fertilizer,
- Price of fertilizer,
- Type of fertilizer, and
- Information about fertilizer.

An office material price offer form contains the following information:

- Company name,
- Supplier name,
- Quantity of material,
- Type of material, and
- Price of material.

A delivery form contains the following information:

- Order number,
- Order name,
- Company name,
- Supplier name,
- Company address,
- Company telephone,
- Quantity, and
- Price.

(3) Input – Delivery form, purchase detail, and raw material information from "suppliers" to "production". A delivery form contains the following information:

- Order number,
- Order quantity,
- Delivery number,
- Related person name, and
- Explanation.

Raw material information contains the following information:

- Bill number,
- Company name,
- Address-telephone-fax-mail,
- Product,
- Quantity, and
- Explanation.

(4) Input – Raw material of compost from "suppliers" to "production".

(5) Output – Returned raw material form from “production” to “suppliers”. It contains the following information:

- Purchase order number,
- Bill number,
- Company name,
- Address-telephone-fax-mail,
- Product,
- Quantity,
- Reason for return, and
- Explanation.

(6) Output – Returned raw material from “production” to “suppliers”.

(7) Input – Delivery form and purchase detail form from “suppliers” to “storage and delivery”. A delivery form contains the following information:

- Order number,
- Order quantity,
- Delivery number,
- Related person name, and
- Explanation.

(8) Input – Product package materials from “suppliers” to “storage and delivery”.

(9) Input – Request form from “customers” to “management”. It contains the following information

- Company name,
- Product type,
- Product quantity, and
- Payment type.

(10) Output – Offer request form, delivery confirmation, and approved offer form from “management” to “customers”. An offer request form contains the following information:

- Request date,
- Company,
- Related person name,
- Phone number,
- Fax number,
- Explanation, and
- Material description.

(11) Output – Delivery form from “storage and delivery” to “customers”. It contains the following information:

- Company name,
- Customer name,
- Address-telephone-fax-mail of the customer,
- Amount of fertilizer,
- Price of fertilizer,
- Type of fertilizer, and
- Information about fertilizer.

(12) Output – Fertilizer from “storage and delivery” to “customers”.

(13) Output – Information of amount and type of waste from “storage and delivery” to “waste”.

(14) Output – Office and production wastes from “storage and delivery” to “waste”.

(15) Input – Delivery information from “waste” to “storage and delivery”.

4.1.2. Management Department

The boundaries of the management department are determined as shown in Figure 4.3. Management is the department that carries out various activities to ensure the process of efficiently and effectively transforming the resources into the product. The management department consists of five activities: Administration, finance and accounting, technical analysis, human resources, and IT and R&D. Also, there is a data store on management. All related documents are stored here.

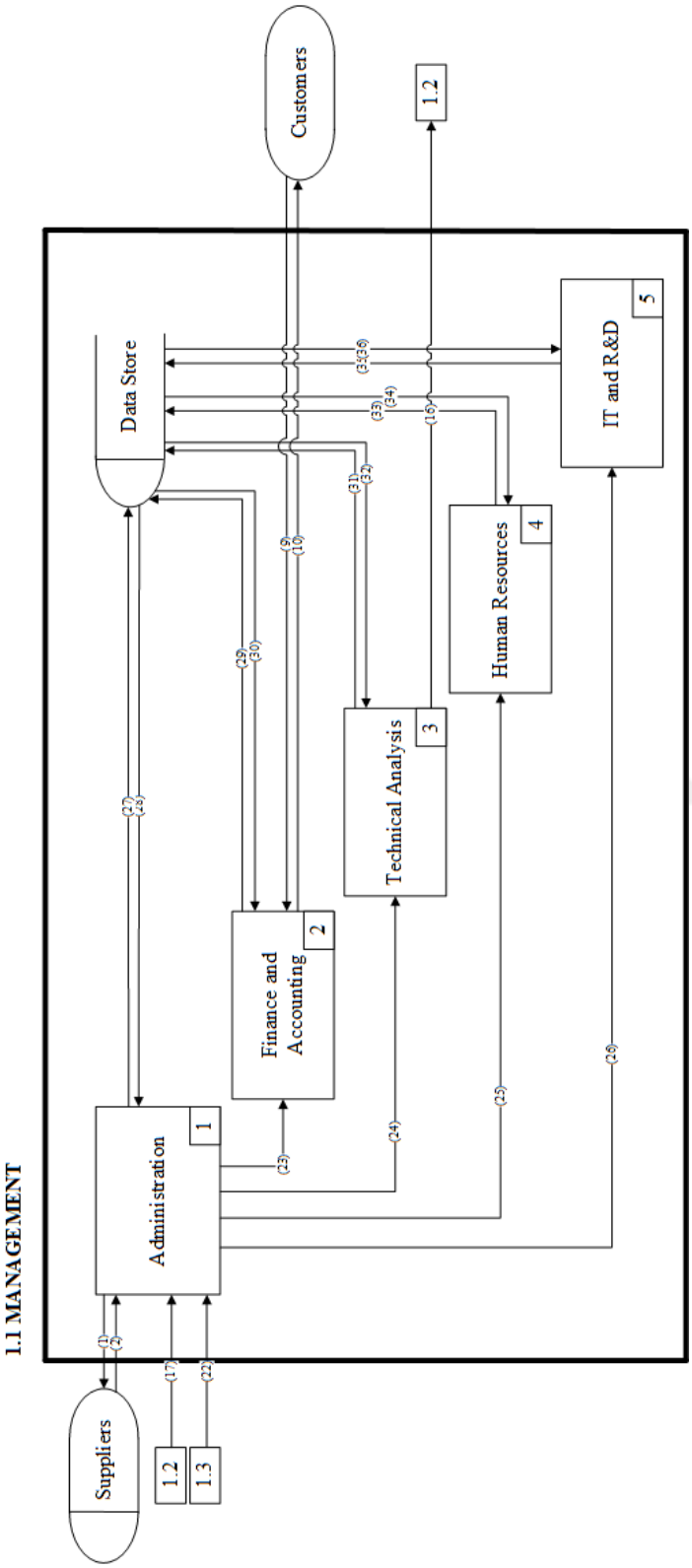

Figure 4.3 Management department

(1) Output – Offer request form, delivery confirmation, and approved offer form from “administration” to “suppliers”. An offer request form contains the following information:

- Request date,
- Company name,
- Related person name,
- Phone number,
- Fax number,
- Explanation, and
- Material description.

(2) Input – Cattle fertilizer price offer form, office material price offer form, utility bills, and delivery form from “suppliers” to “administration”. A cattle fertilizer price offer form contains the following information:

- Company name,
- Supplier name,
- Address of supplier,
- Telephone number of supplier,
- Amount of fertilizer,
- Price of fertilizer,
- Type of fertilizer, and
- Information about fertilizer.

An office material price offer form contains the following information:

- Company name,
- Supplier name,
- Quantity of material,
- Type of material, and

- Price of material.

A delivery form contains the following information:

- Order number,
- Order name,
- Company name,
- Supplier name
- Company address,
- Company telephone,
- Quantity, and
- Price.

(9) Input – Request form from “customers” to “finance and accounting”. It contains the following information:

- Company name,
- Product type,
- Product quantity, and
- Payment type.

(10) Output – Offer request form, delivery confirmation, and approved offer form from “finance and accounting” to “customers”. An offer request form contains the following information:

- Request date,
- Company,
- Related person name,
- Phone number,
- Fax number,
- Explanation, and
- Material description.

(16) Output – Product order, product schedule, order changes, inventory requirement, and maintenance planning from “technical analysis” to “production”.

(17) Input – Product report, inventory report, production demand forecast, operation information, and maintenance requirement from “production” to “administration”. A product report contains the following information:

- Product quantity,
- Product order name, and
- Related person name.

An inventory report contains the following information:

- Name of inventory,
- Inventory number, and
- Unit of inventory.

Operation information contains the following information:

- Operation name,
- Operation code, and
- Operation times.

(22) Input – Final product quantity, fertilizer requirement, and delivery report from “storage and delivery” to “administration”. A delivery report contains the following information:

- Order number,
- Order quantity,
- Order date,
- Delivery number,
- Delivery date,
- Related person name, and

- Explanation.

4.1.2.1. Administration Activities

Administration activities are manager tasks, and they are given in Figure 4.4. The manager makes necessary conversations about raw materials and tools with the supplier, makes the checks and approvals of reports coming from units, provides stability by performing the follow-up of the works that have been done and that need to be done.

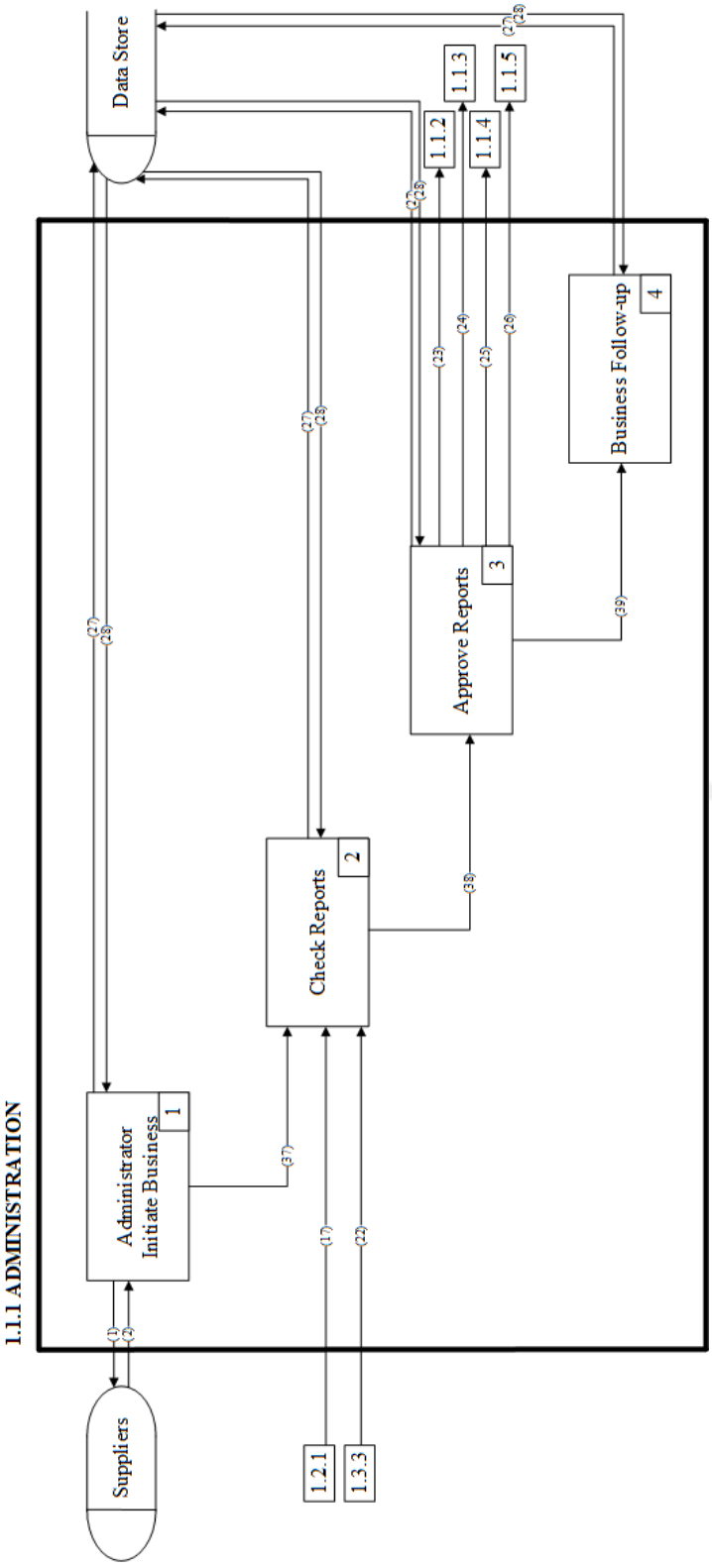

Figure 4.4 Administration activities

(1) Output – Offer request form, delivery confirmation, and approved offer form from "administrator initiate business" to "suppliers". An offer request form contains the following information:

- Request date,
- Company name,
- Related person name,
- Phone number,
- Fax number,
- Explanation, and
- Material description.

(2) Input – Cattle fertilizer price offer form, office material price offer form, utility bills, and delivery form from "suppliers" to "administrator initiate business". A cattle fertilizer price offer form contains the following information:

- Company name,
- Supplier name,
- Address of supplier,
- Telephone number of supplier,
- Amount of fertilizer,
- Price of fertilizer,
- Type of fertilizer, and
- Information about fertilizer.

An office material price offer form contains the following information:

- Company name,
- Supplier name,
- Quantity of material,
- Type of material, and

- Price of material.

A delivery form contains the following information:

- Order number,
- Order name,
- Company name,
- Supplier name,
- Company address,
- Company telephone,
- Quantity, and
- Price.

(17) Input – Product report, inventory report, production demand forecast, operation information, and maintenance requirement from “receiving and control” to “check reports”. A product report contains the following information:

- Product quantity,
- Product order name, and
- Related person name.

An inventory report contains the following information:

- Name of inventory,
- Inventory number, and
- Unit of inventory.

Operation information contains the following information:

- Operation name,
- Operation code, and
- Operation times.

(22) Input – Final product quantity, fertilizer requirement, and delivery report from “delivering” to “check reports”. A delivery report contains the following information:

- Order number,
- Order quantity,
- Order date,
- Delivery number,
- Delivery date,
- Related person name, and
- Explanation.

(23) Output – Approved finance report from “approve reports” to “finance and accounting”. It contains the following information:

- Approve date,
- Report name,
- Report number,
- Report explanation,
- Financial statement period,
- Financial statement date,
- Financial statements title,
- Financial statement, and
- Accounting policies.

(24) Output – Approved market analysis graphs, forecast reports, demand reports, capacity utilization rates, and risk and money management strategies from “approve reports” to “technical analysis”.

(25) Output – Recruitment order from “approve reports” to “human resources”. It contains the following information:

- Number of people to hire,

- Task definition, and
- Special conditions.

(26) Output – Approved research and development offer form from “approve reports” to “IT and R&D”.

(27) Output – Controlled and approved reports by the administrator from “administration” to “data store”.

(28) Input – Finance report from “finance and accounting” to “check reports”. It contains the following information:

- Report name,
- Report number,
- Report explanation,
- Financial statement period,
- Financial statement date,
- Financial statements title,
- Financial statement, and
- Accounting policies.

Market analysis graphs, forecast reports, demand reports, capacity utilization rates, and risk and money management strategies from “technical analysis” to “check reports”.

Performance evaluation form from “human resources” to “check reports”. It contains the following information:

- Personnel name surname,
- Task,
- Professional knowledge,
- Communication skills,
- Work discipline, and

- Opinion of the supervisor.

Research and development offer form from “IT and R&D” to “check reports”.

Initiation of Business

The manager starts working. The initiation of business activity includes report controls and the exchange of information with the suppliers.

Checking of Reports

The manager makes controls of reports that come from other departments.

Confirmation of Reports

Confirmation activity includes approval of checked reports and returning them to departments.

Following-up the Business

Examination of completed works, determining the work to be done, determining the work processes, and determining the working time.

4.1.2.2. Finance and Accounting Activities

On finance and accounting activities, purchase requirements of materials are determined and the administration is informed. Then, the necessary accounting works are made. These works include calculating the rights, wages, premiums, and bonuses of the employees arising from overtime, recording the start and exit dates of the employees and recording cash and real estate of the facility. Product advertisements are conducted with a website. Finally, the required conversations with the customer are carried out, and the quantity of the sold products is determined. Then, the technical analysis department is informed. The finance and accounting activities scheme is given in Figure 4.5.

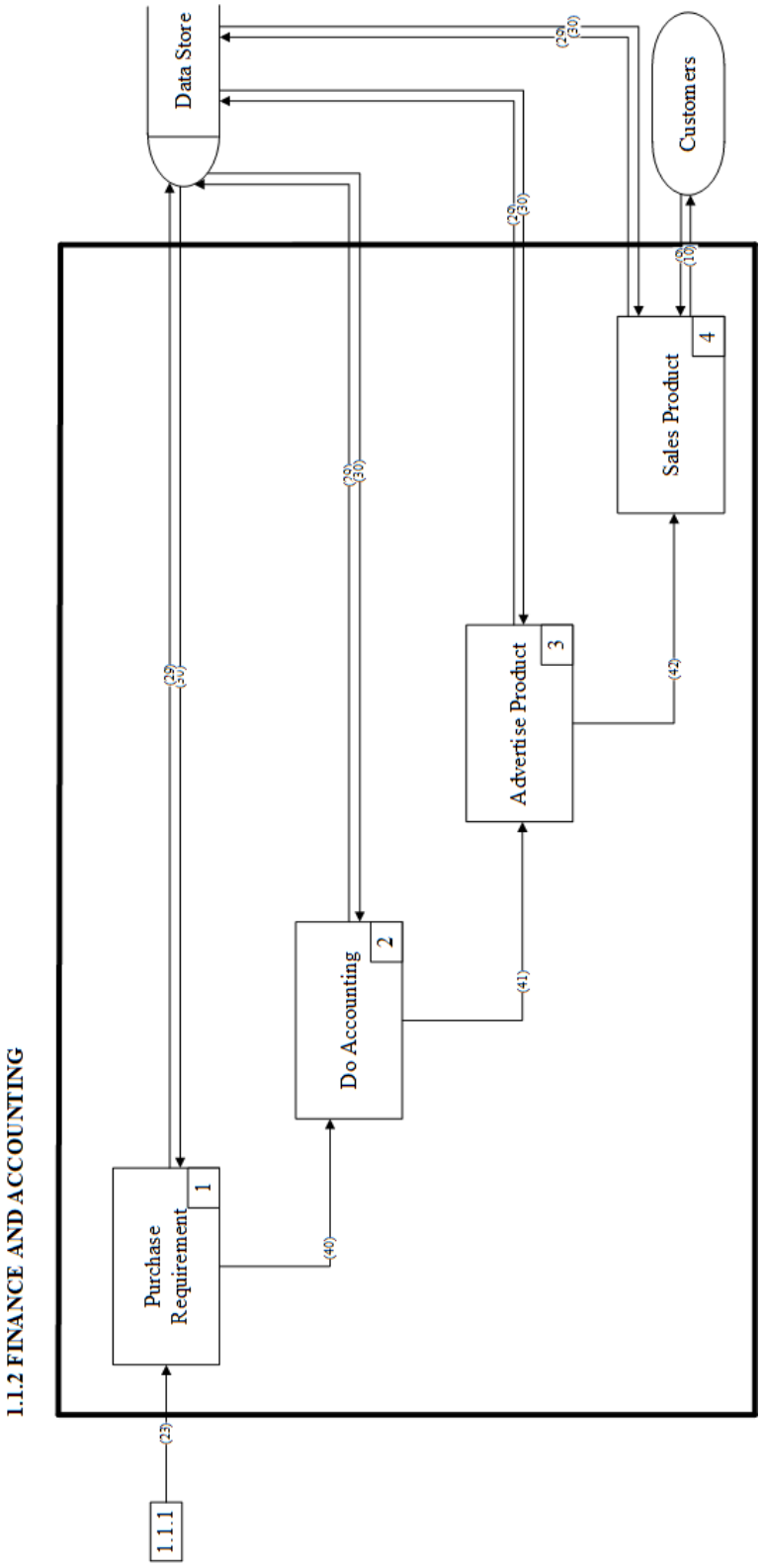

Figure 4.5 Finance and accounting activities

(9) Input – Request form from “customers” to “sales product”. It contains the following information

- Company name,
- Product type,
- Product quantity, and
- Payment type.

(10) Output – Offer request form, delivery confirmation, and approved offer form from “sales product” to “customers”. An offer request form contains the following information:

- Request date,
- Company,
- Related person name,
- Phone number,
- Fax number,
- Explanation, and
- Material description.

(23) Input – Finance report from “administration” to “purchase requirement”. It contains the following information:

- Approve date,
- Report name,
- Report number,
- Report explanation,
- Financial statement period,
- Financial statement date,
- Financial statements title,
- Financial statement, and

- Accounting policies.

(29) Output – Quantity and type of sold products from “sales product” to “technical analysis”.

Rights, wages, premiums, and bonuses of the employees arising from overtime, records of start and exit dates of the employees from “do accounting” to “human resources”.

Approved finance report from “do accounting” to “administration”. It contains the following information:

- Approve date,
- Report name,
- Report number,
- Report explanation,
- Financial statement period,
- Financial statement date,
- Financial statements title,
- Financial statement, and
- Accounting policies.

(30) Input – Quantity and type of required materials from “technical analysis” to “purchase requirement”.

Determination of the Need to Purchase

It is checked whether the required materials are in the inventory. If there are no materials in the inventory, orders are prepared for deficient materials and the management is informed.

Accounting

This is the activity in which accounting operations of the products and facility employees are made.

Making the Product Advertisement

In accordance with customer expectations, advertisements of products are prepared and they are published on the website.

Making the Product Sales

This activity is where product sales are carried out by communicating with the customers and keeps the information about the products sold.

4.1.2.3. Technical Analysis Activities

The technical analysis activities scheme is given in Figure 4.6. These are the activities where the evaluations are made with the perspective of engineering. It is examined whether production is technically possible.

Necessary raw material quantities and production plans are prepared. Work orders are created according to the tasks of the employees for the works to be done. Quality control standards are determined and maintenance activities are carried out.

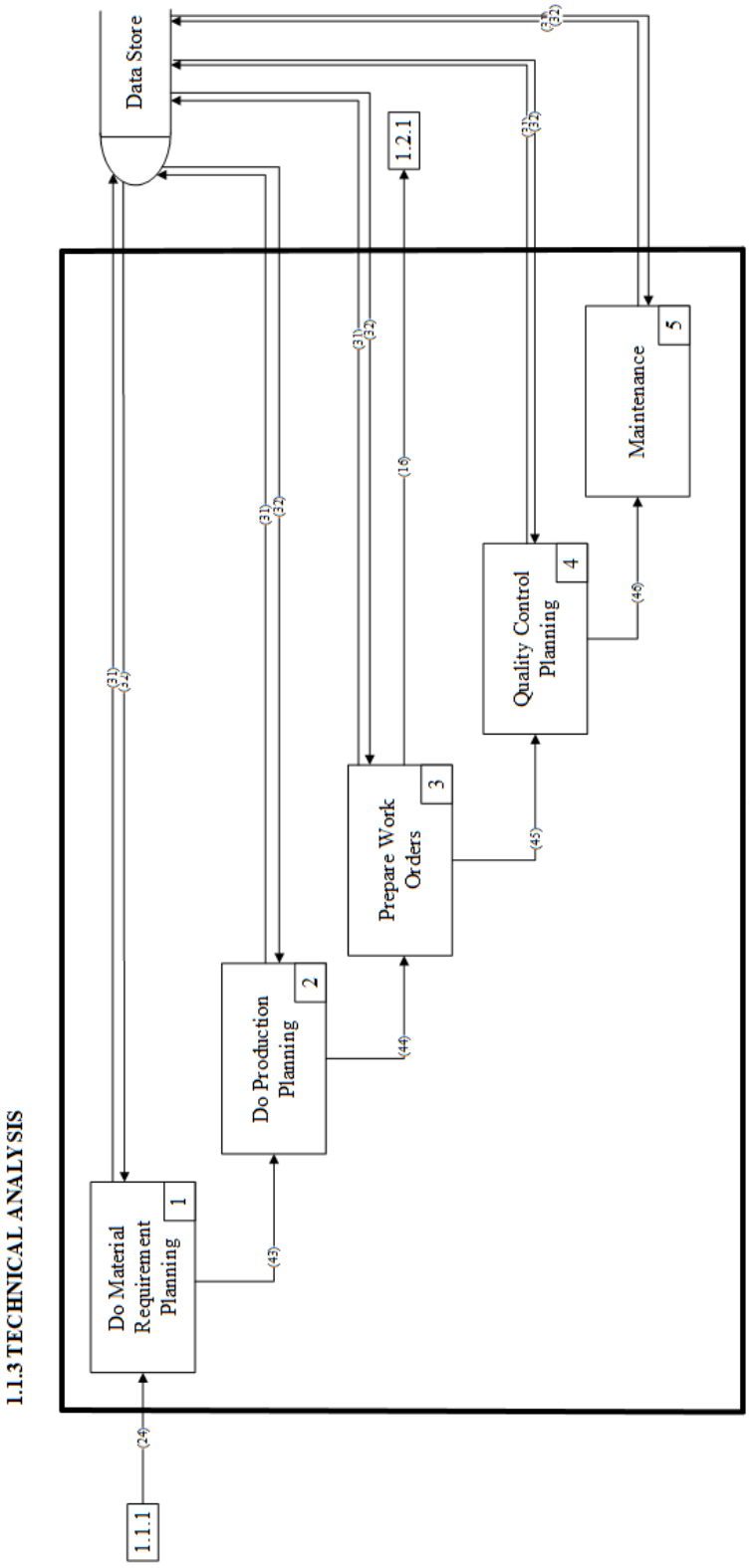

Figure 4.6 Technical analysis activities

(16) Output – Product order, product schedule, order changes, inventory requirement, and maintenance planning from “prepare work orders” to “receiving and control”.

(24) Input – Approved market analysis graphs, forecast reports, demand reports, capacity utilization rates, and risk and money management strategies from “administration” to “do material requirement planning”.

(31) Output – Market analysis graphs, forecast reports, demand reports, capacity utilization rates, and risk and money management strategies from “do production planning” to “administration”.

Knowledge of required quality control systems from “quality control planning” to “IT & R&D”.

Quantity and type of required materials from “do material requirement planning” to “finance and accounting”.

Work order from “prepare work orders” to “human resources”. It contains the following information:

- Document number,
- Document date,
- Estimated date of work completion,
- Code of work,
- The name of the work,
- Person giving the work order,
- Responsible for job, and
- Explanation.

An example of a work order as Figure 4.7.

WORK ORDER	
Document Number	
Document Date	
Code of Work	
Page Number	
Work Completion Date: …../…../20…	
Work Completed Date: …../…../20…	
Variance:	
NO	**The name of works execute**
1	
2	
3	
4	
5	
Work order initiator	
Work complete	
EXPLANATION	

Figure 4.7 Work order

(32) Input – Approved market analysis graphs, forecast reports, demand reports, capacity utilization rates, and risk and money management strategies from "administration" to "do production planning".

Quantity and type of sold products from "finance and accounting" to "do material requirement planning".

Knowledge of newly hired employees from "human resources" to "prepare work orders". It contains the following information:

- Name – surname,

- ID number,
- Starting date,
- Job/profession,
- Department, and
- Daily and weekly working time.

Material Requirement Planning

To determine the number of raw materials and materials required by considering the products to be manufactured and sold.

Production Planning

Preparing job schedules for production at a certain time, in desired quality, cost and amount.

Preparation of Work Orders

It is the preparation of work orders and sending them to the employees according to production plans and their profession.

Quality Control Planning

Quality targets are defined to improve the quality of the products and to provide that the products without errors are delivered to customers. Control stages are prepared and applied to measure whether each delivery is at the expected quality level.

Maintenance

Planning and implementation of activities to provide that the machinery, equipment, and buildings of the facility are continuously operational.

4.1.2.4. Human Resources Activities

Human resources deal with processes related to facility employees. These activities include the recruitment, training, performance evaluation, and warning or rewarding of the worker as given in Figure 4.8.

First of all, the number of worker requirement is announced on the website. Then, with face to face interviews, the workers who are believed suitable for the job are recruited. Training is given to the employees. A performance evaluation form is filled in regularly. Performance evaluation results are reported to the management. Workers are informed according to working performance.

If $t_{114.2} = 0$, info 47 goes from 144.1 to 144.3.

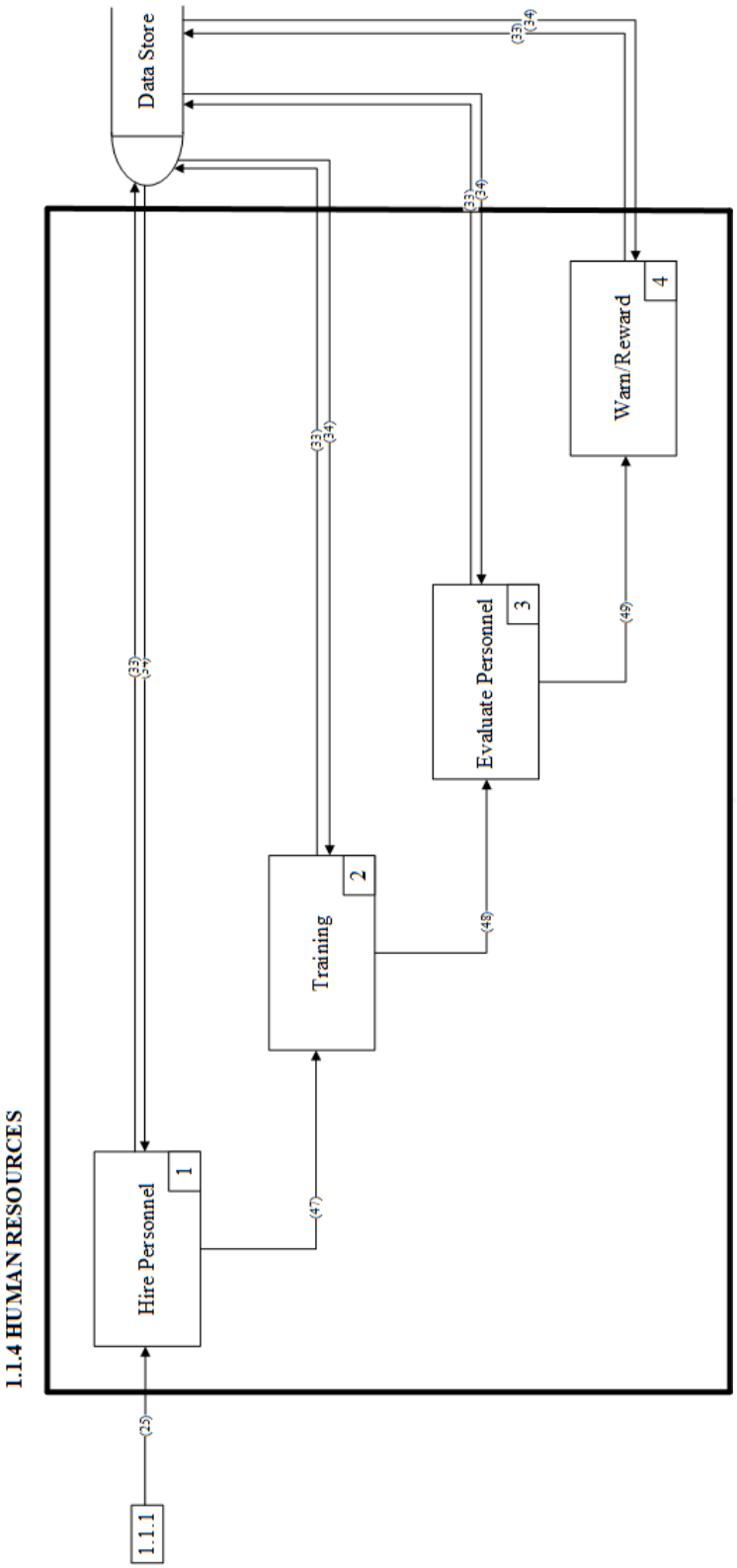

Figure 4.8 Human resources activities

(25) Input – Recruitment order from “administration” to “hire personnel”. It contains the following information:

- Number of people to hire,
- Task definition, and
- Special conditions.

(33) Output – Performance evaluation form from “evaluate personnel” to “administration”. It contains the following information:

- Personnel name surname,
- Task,
- Professional knowledge,
- Communication skills,
- Work discipline, and
- Opinion of the supervisor.

Knowledge of newly hired employees from “hire personnel” to “technical analysis”. It contains the following information:

- Name – surname,
- ID number,
- Starting date,
- Job/profession,
- Department, and
- Daily and weekly working time.

(34) Input – Rights, wages, premiums and bonuses of the employees arising from overtime, and records of start and exit dates of the employees from “finance and accounting” to “hire personnel”.

Work order from “technical analysis” to “hire personnel”. It contains the following information:

- Document number,
- Document date,
- Estimated date of work completion,
- Code of work,
- The name of the work,
- Person giving the work order,
- Responsible for job, and
- Explanation.

Hiring of Personnel

The number of required employees is determined and they are recruited with interviews.

Training of Personnel

Employees are provided with training to fulfill the requirements of the job.

Evaluating of Personnel

The performances of the employees are evaluated through standard forms.

Warning/Rewarding of Personnel

Necessary warnings are made to employees who have negative performance results. Employees who have positive performance results are awarded such as transfer, bonus or verbal appreciation.

4.1.2.5. IT and R&D Activities

IT and R&D Activities are given in Figure 4.9. These activities include the development of a new system, service, product, software, process to reduce costs and increase productivity. They enable us to identify problems in the field of information and technology and to search for solutions to problems.

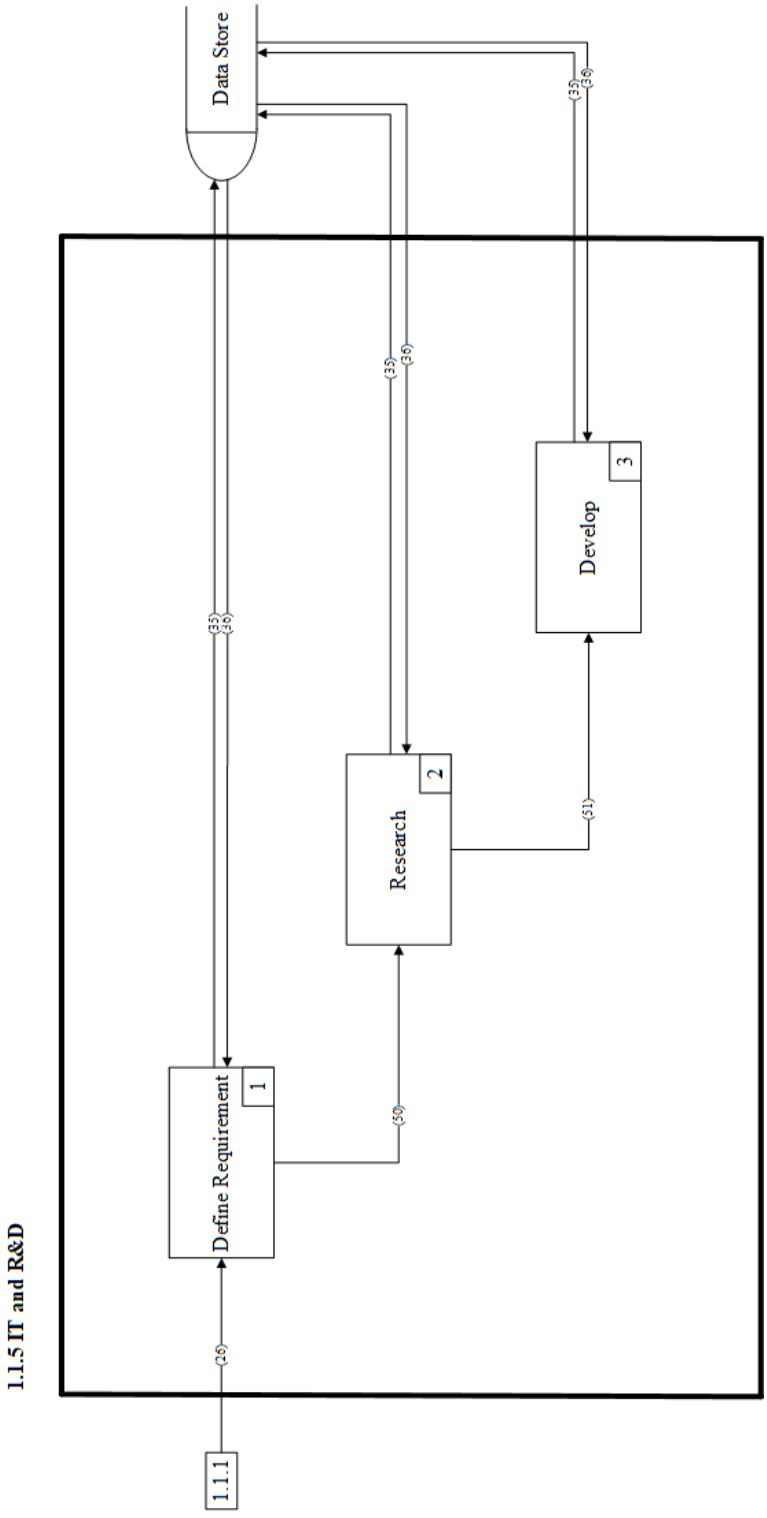

Figure 4.9 IT and R&D activities

(26) Input – Approved research and development offer form from “administration” to “define requirement”.

(35) Output – Research and development offer form from “develop” to “administration”.

(36) Input – Knowledge of required quality control systems from “technical analysis” to “define requirement”.

Approved research and development offer form from “administration” to “define requirement”.

Definition of Required Work

Identifying needs research and development activities and IT investments.

Realization of Research

Finding appropriate solutions by doing research.

Realization of Development

Implementing the found solutions, informing the management and getting feedback.

4.1.3. Production Department

The production department is the department where vermicompost is produced. After the conversations with the supplier, the raw materials are received. If there are any defective raw materials, they are stored and they are returned. If there are not defective raw materials, the production process starts in accordance with the work orders coming from the technical analysis. Firstly, compost is prepared as worm foods. Then fertilization and drying take place and the products are sent to the store for packaging. The production department is given in Figure 4.10.

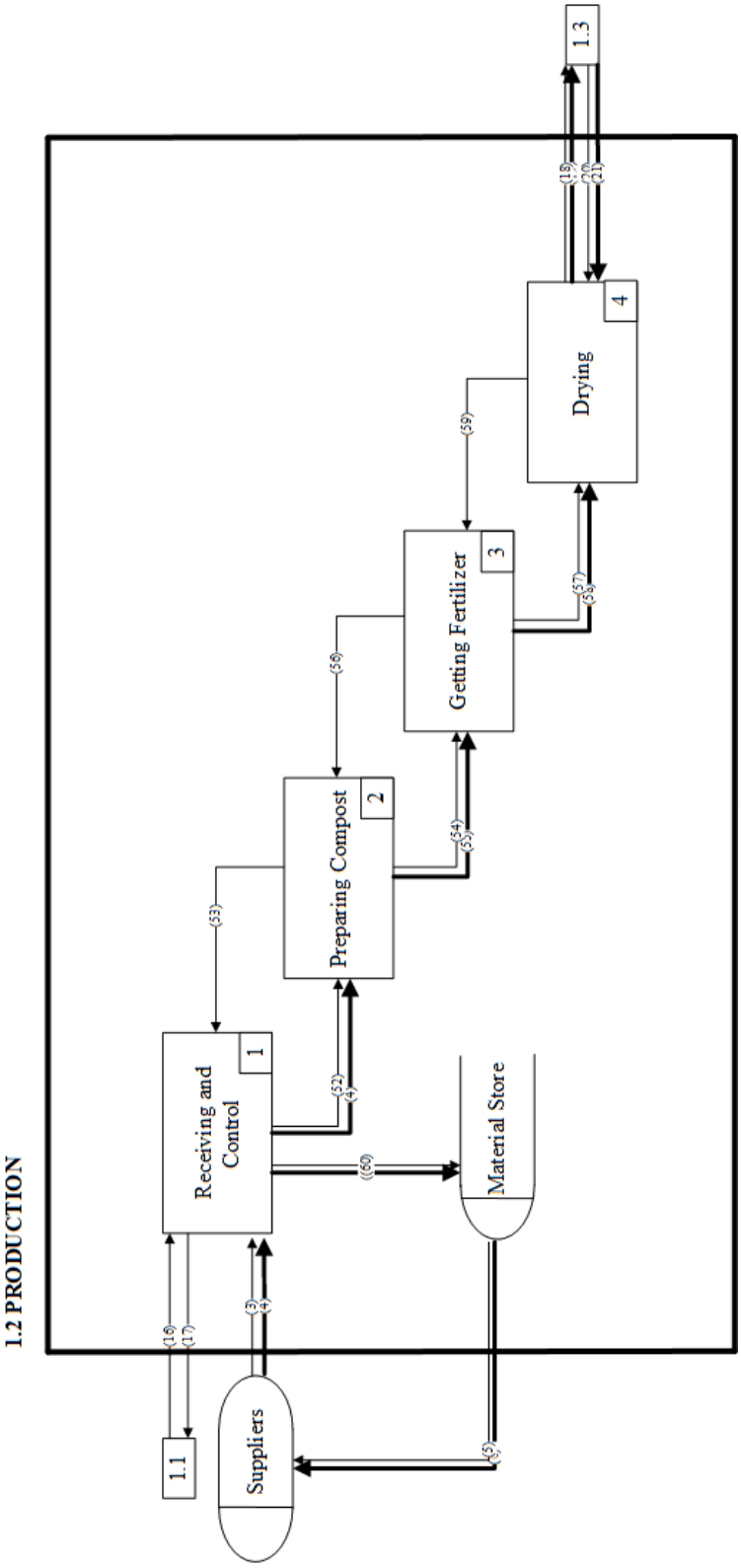

Figure 4.10 Production department

(3) Input – Delivery form, purchase detail, and raw material information from "suppliers" to "receiving and control". A delivery form contains the following information:

- Order number,
- Order quantity,
- Delivery number,
- Related person name, and
- Explanation.

Raw material information contains the following information:

- Bill number,
- Company name,
- Address-telephone-fax-mail,
- Product,
- Quantity, and
- Explanation.

(4) Input – Raw material of compost from "suppliers" to "receiving and control".

(5) Output – Returned raw material form from "material store" to "suppliers". It contains the following information:

- Purchase order number,
- Bill number,
- Company name,
- Address-telephone-fax-mail,
- Product,
- Quantity,
- Reason for return, and
- Explanation.

(6) Output – Returned raw material from “material store” to “suppliers”.

(16) Input – Product order, product schedule, order changes, inventory requirement, and maintenance planning from “management” to “receiving and control”.

(17) Output – Product report, inventory report, production demand forecast, operation information, and maintenance requirement from “receiving and control” to “management”. A product report contains the following information:

- Product quantity,
- Product order name, and
- Related person name.

An inventory report contains the following information:

- Name of inventory,
- Inventory number, and
- Unit of inventory.

Operation information contains the following information:

- Operation name,
- Operation code, and
- Operation times.

(18) Output – Fertilizer report from “drying” to “storage and delivery”. It contains the following information:

- Product number,
- Related person name,
- Product quantity, and
- Amount of waste.

(19) Output – Fertilizer from “drying” to “storage and delivery”.

(20) Input – Final product quantity and fertilizer requirement from “storage and delivery” to “drying”.

(21) Input – Returned fertilizer from “storage and delivery” to “drying”.

4.1.3.1. Receiving and Control Activities

Receiving and control activities are given in Figure 4.11. These activities include receiving, checking, and approving the materials coming from the supplier and sending them to the compost preparing area.

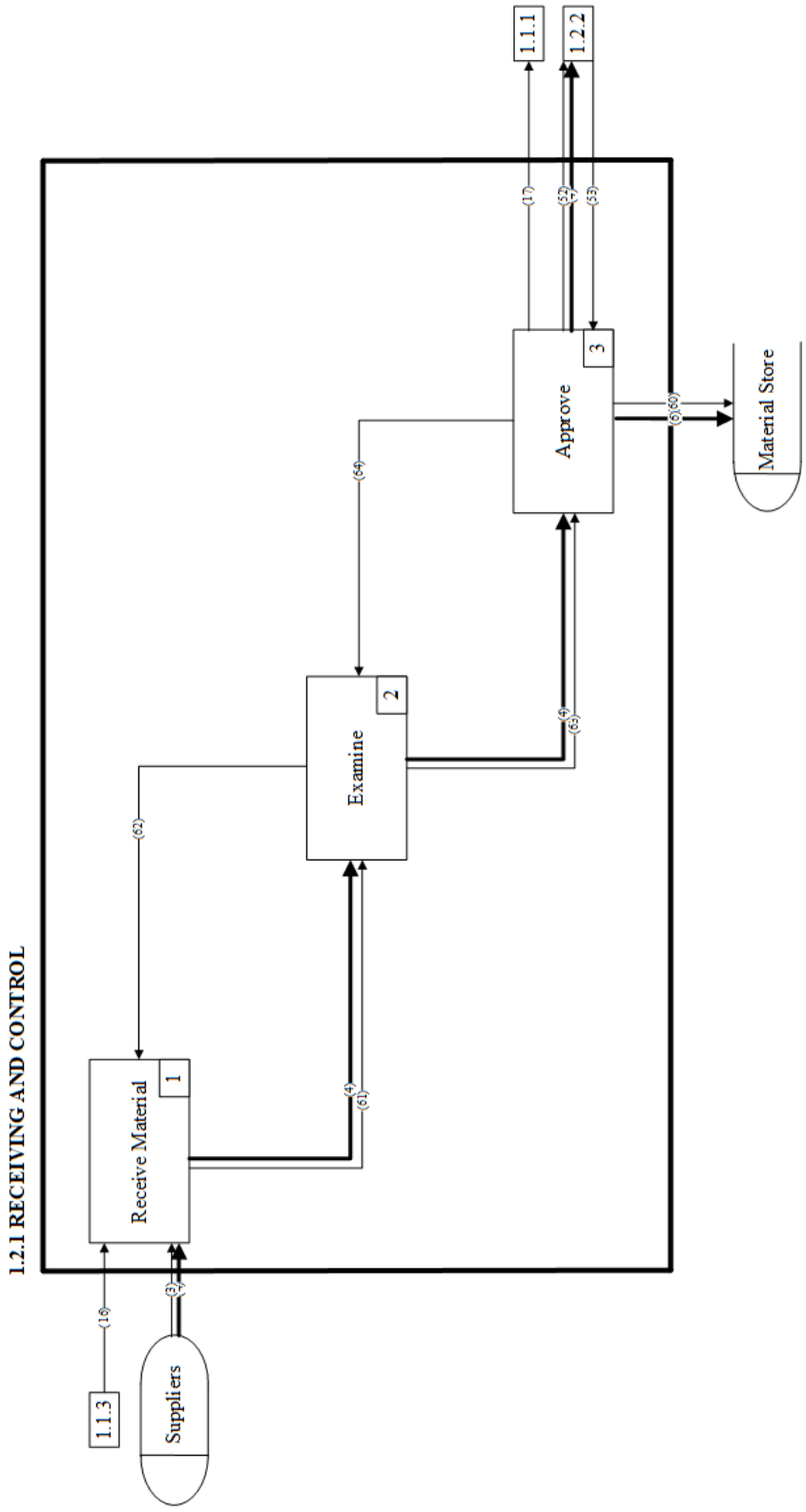

Figure 4.11 Receiving and control activities

(3) Input – Delivery form, purchase detail, and raw material information from "suppliers" to "receive material". A delivery form contains the following information:

- Order number,
- Order quantity,
- Delivery number,
- Related person name, and
- Explanation.

Raw material information contains the following information:

- Bill number,
- Company name,
- Address-telephone-fax-mail,
- Product,
- Quantity, and
- Explanation.

(4) Input – Raw material of compost from "suppliers" to "receive material".

(4) Output – Raw material of compost from "approve" to "preparing compost".

(6) Output – Returned raw material from "approve" to "material store".

(16) Input – Product order, product schedule, order changes, inventory requirement, and maintenance planning from "technical analysis" to "receive material".

(17) Output – Product report, inventory report, production demand forecast, operation information, and maintenance requirement from "approve" to "administration". A product report contains the following information:

- Product quantity,
- Product order name, and

- Related person name.

An inventory report contains the following information:

- Name of inventory,
- Inventory number, and
- Unit of inventory.

Operation information contains the following information:

- Operation name,
- Operation code, and
- Operation times.

(52) Output – Quantity and type of sent raw materials from “approve” to “preparing compost”.

(53) Input – Quantity and type of required raw materials for preparing compost from “preparing compost” to “approve”.

(60) Output – Returned raw material form from “approve” to “material store”. It contains the following information:

- Purchase order number,
- Bill number,
- Company name,
- Address-telephone-fax-mail,
- Product,
- Quantity,
- Reason for return, and
- Explanation.

Receiving Material from Supplier

It is the activity of receiving raw materials from the supplier.

Examination

It is the activity of the examination of raw materials.

Approval of material

If there isn't any problem of raw material, it is confirmed and sent to the compost preparation area. Raw materials are returned if there are problems.

4.1.3.2. Preparing Compost Activities

Activities for preparing compost are given in Figure 4.12. These activities include the preparation of raw materials as compost for worms. First of all, the raw materials are mixed. The obtained compost is laid on a separate area for ventilation. During the ventilation operation, it is reversed at regular intervals. Heating is then carried out and compost is sent to the production pools.

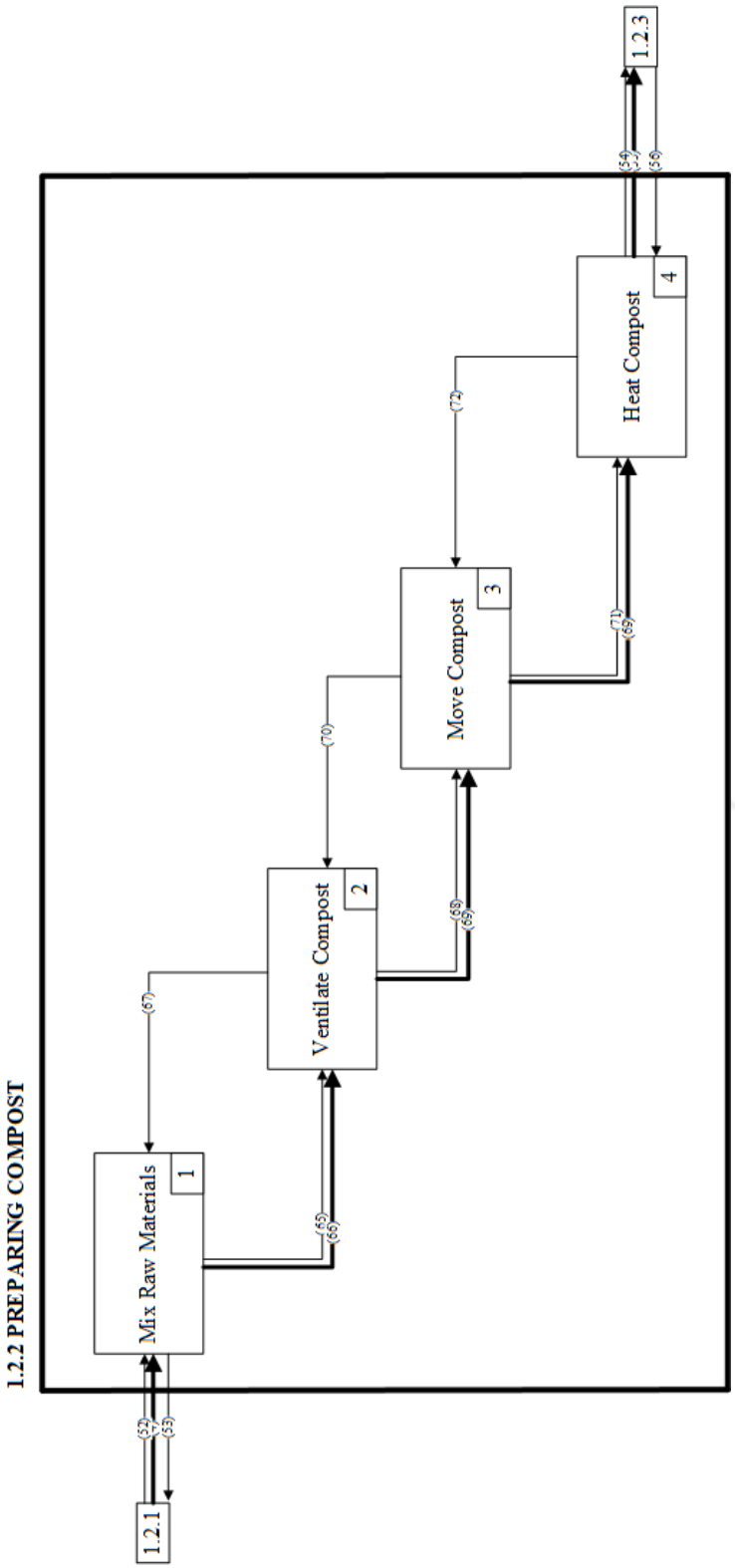

Figure 4.12 Preparing compost activities

(4) Input – Raw material of compost from “receiving and control” to “mix raw materials”.

(52) Input – Quantity and type of sent raw materials from “receiving and control” to “mix raw materials”.

(53) Output – Quantity and type of required raw materials for preparing compost from “mix raw materials” to “receiving and control”.

(54) Output – Amount of compost from “heat compost” to “getting fertilizer”.

(55) Output – Compost from “heat compost” to “getting fertilizer”.

(56) Input – Required amount of compost from “getting fertilizer” to “heat compost”.

Mixing of Raw Materials

This activity is the process of mixing raw materials with shovels.

Ventilating of Compost

This activity is laying of the mixture for the ventilating process.

Moving of Compost

This activity is regular reversing of the compost on the ground.

Heating of Compost

This activity is heating the compost in the furnace and sending it to the production pool.

4.1.3.3. Getting Fertilizer Activities

Getting fertilizer activities are given in Figure 4.13. Heated compost on the furnace is sent to production pools. After the fertilization process, the fertilizer is separated from the pool and sent to the drying area.

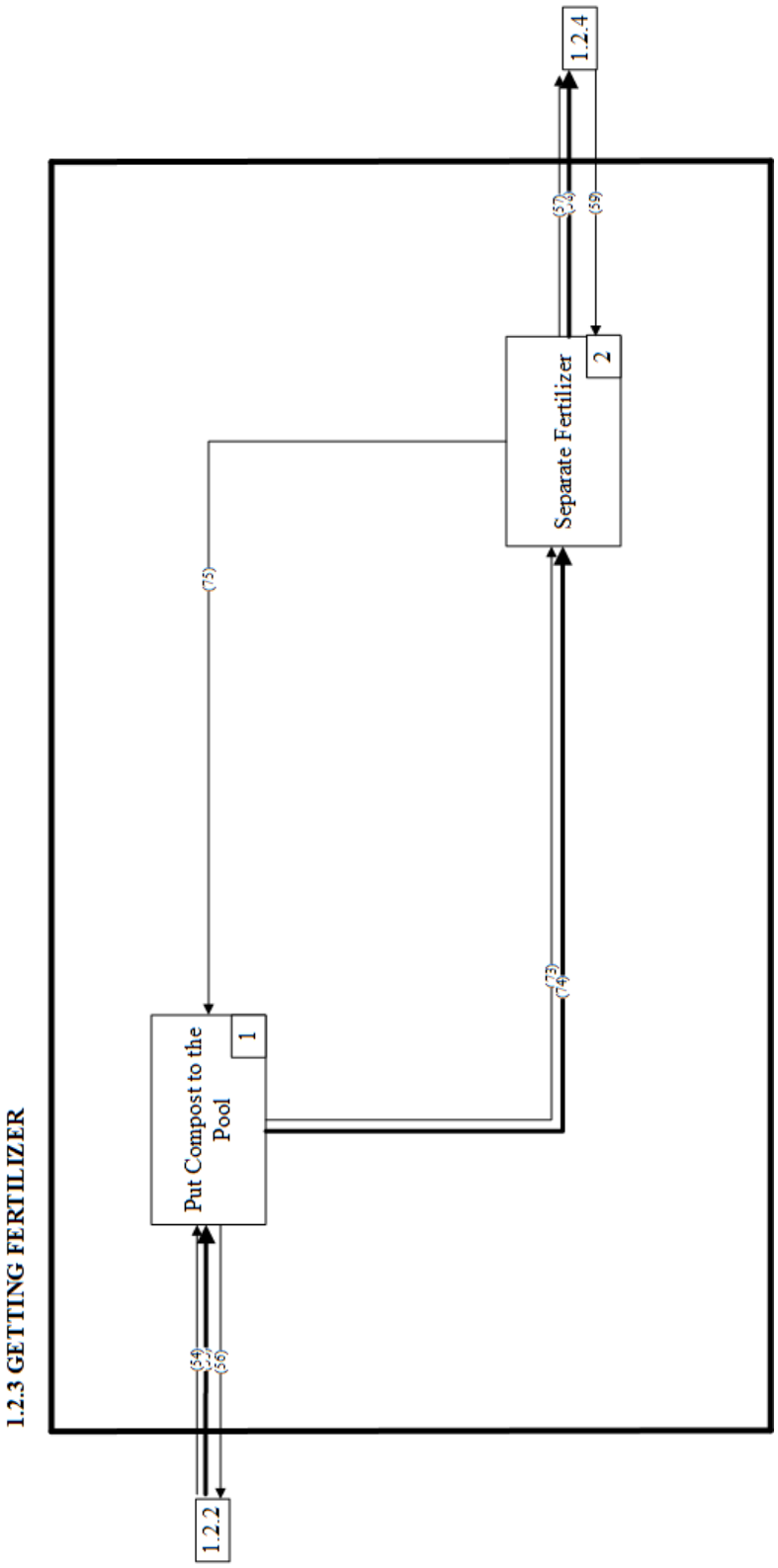

Figure 4.13 Getting fertilizer activities

(54) Input – Amount of compost from “preparing compost” to “put compost to the pool”.

(55) Input – Compost from “preparing compost” to “put compost to the pool”.

(56) Output – Required amount of compost from “put compost to the pool” to “preparing compost”.

(57) Output – Amount of fertilizer information from “separate fertilizer” to “drying”.

(58) Output – Fertilizer from “separate fertilizer” to “drying”.

(59) Input – Amount of dried fertilizer information from “drying” to “separate fertilizer”.

Putting Compost to the Pool

Prepared compost is placed on production pools.

Separating of Fertilizer

The resulting fertilizers are separated from the pool and sent to the drying area.

4.1.3.4. Drying Activities

Drying activities are given in Figure 4.14. Drying is carried out to get the fertilizer ready for packaging. The fertilizers are placed in the drying area. Then, they are sieved and sent to the storage area.

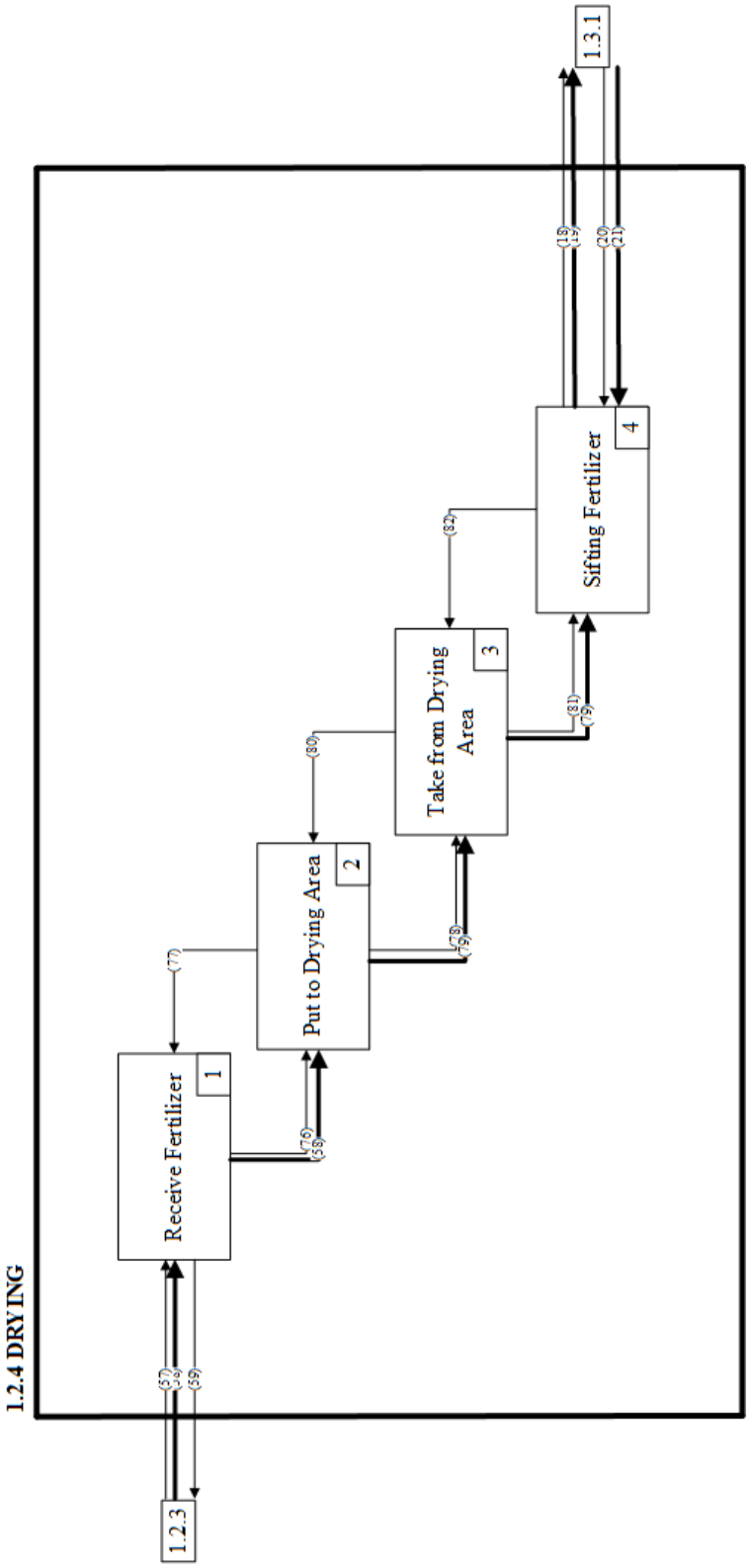

Figure 4.14 Drying activities

(18) Output – Fertilizer report from “sifting fertilizer” to “receiving product”. It contains the following information:

- Product number,
- Related person name,
- Product quantity, and
- Amount of waste.

(19) Output – Fertilizer from “sifting fertilizer” to “receiving product”.

(20) Input – Final product quantity and fertilizer requirement from “receiving product” to “sifting fertilizer”.

(21) Input – Returned fertilizer from “receiving product” to “sifting fertilizer”.

(57) Input – Amount of fertilizer information from “getting fertilizer” to “receive fertilizer”.

(58) Input – Fertilizer from “getting fertilizer” to “receive fertilizer”.

(59) Output – Amount of dried fertilizer information from “receive fertilizer” to “getting fertilizer”.

Receiving Fertilizer

It is the activity of taking wet fertilizer to drying area for the drying process.

Putting Fertilizer to Drying Area

Accepted fertilizers are laid in the drying area.

Taking Fertilizer from Drying Area

The dried fertilizers are taken and put to the sifting machine.

Sifting Fertilizer

The sifting process is carried out with a machine. Then, fertilizers are sent to the storage.

4.1.4. Storage and Delivery Department

The storage and delivery department is given in Figure 4.15. This department includes the packaging and storage and delivery of the products which are ready for sale. Dried fertilizers are taken from the production department, checked, packaged with packages came from the supplier, and delivered to the customer.

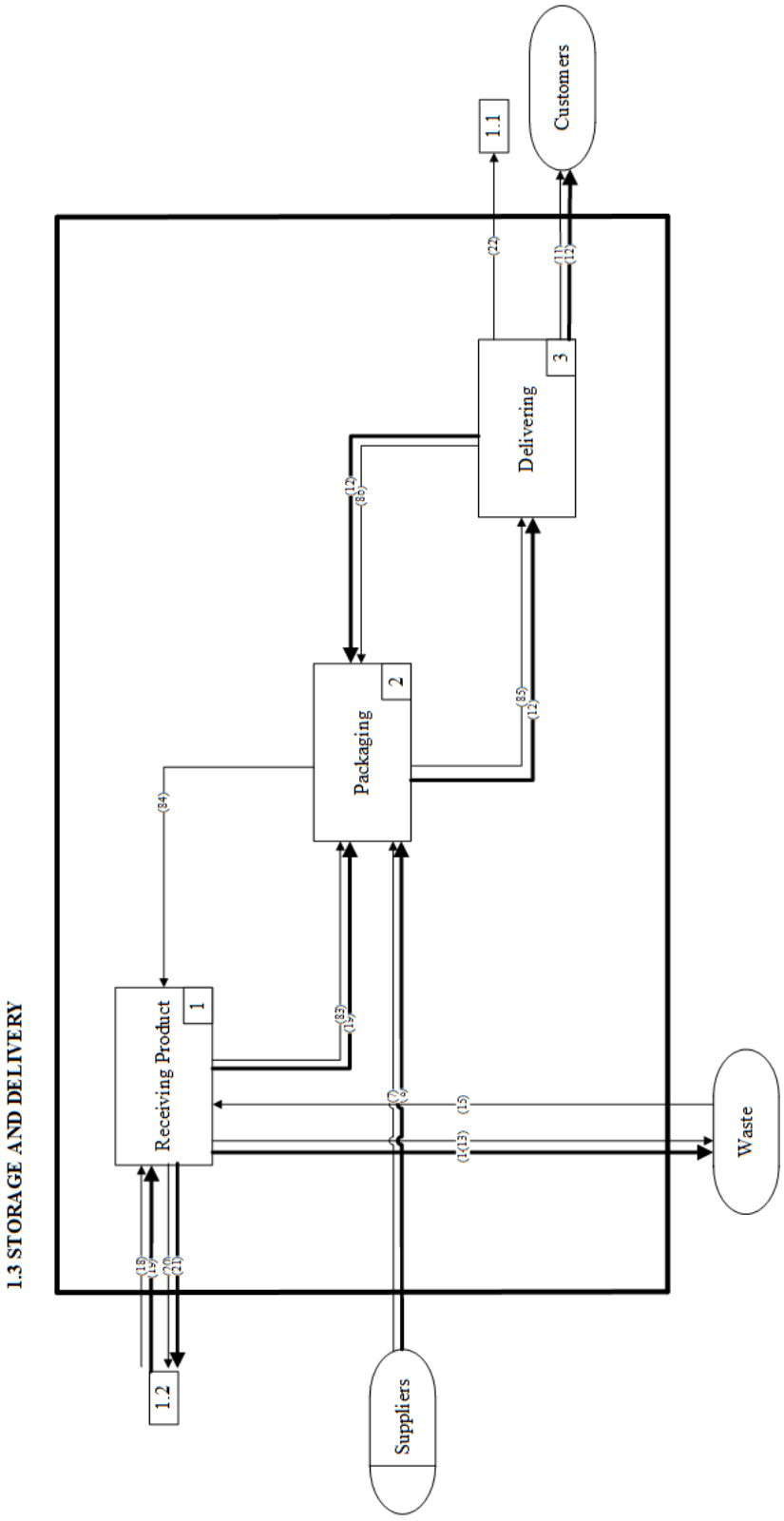

Figure 4.15 Storage and delivery department

(7) Input – Delivery form and purchase detail form from “suppliers” to “packaging”. A delivery form contains the following information:

- Order number,
- Order quantity,
- Delivery number,
- Related person name, and
- Explanation.

(8) Input – Product package materials from “suppliers” to “packaging”.

(11) Output – Delivery form from “delivering” to “customers”. It contains the following information:

- Company name,
- Customer name,
- Address-telephone-fax-mail of the customer,
- Amount of fertilizer,
- Price of fertilizer,
- Type of fertilizer, and
- Information about fertilizer.

(12) Output – Fertilizer from “delivering” to “customers”.

(13) Output – Information of amount and type of waste from “receiving product” to “waste”.

(14) Output – Office and production wastes from “receiving product” to “waste”.

(15) Input – Delivery information from “waste” to “receiving product”.

(18) Input – Fertilizer report from “production” to “receiving product”. It contains the following information:

- Product number,
- Related person name,
- Product quantity, and
- Amount of waste.

(19) Input – Fertilizer from “production” to “receiving product”.

(20) Output – Final product quantity and fertilizer requirement from “receiving product” to “production”.

(21) Output – Returned fertilizer from “receiving product” to “production”.

(22) Output – Final product quantity, fertilizer requirement, and delivery report from “delivering” to “management”. A delivery report contains the following information:

- Order number,
- Order quantity,
- Order date,
- Delivery number,
- Delivery date,
- Related person name, and
- Explanation.

4.1.4.1. Receiving Product Activities

Receiving product activities are given in Figure 4.16. These activities include receive and take action (approve/reject). Receiving fertilizer which came from production is done. If the fertilizer has high quality, it is sent to the packaging area. If fertilizer is defective, it is sent to the waste or drying area.

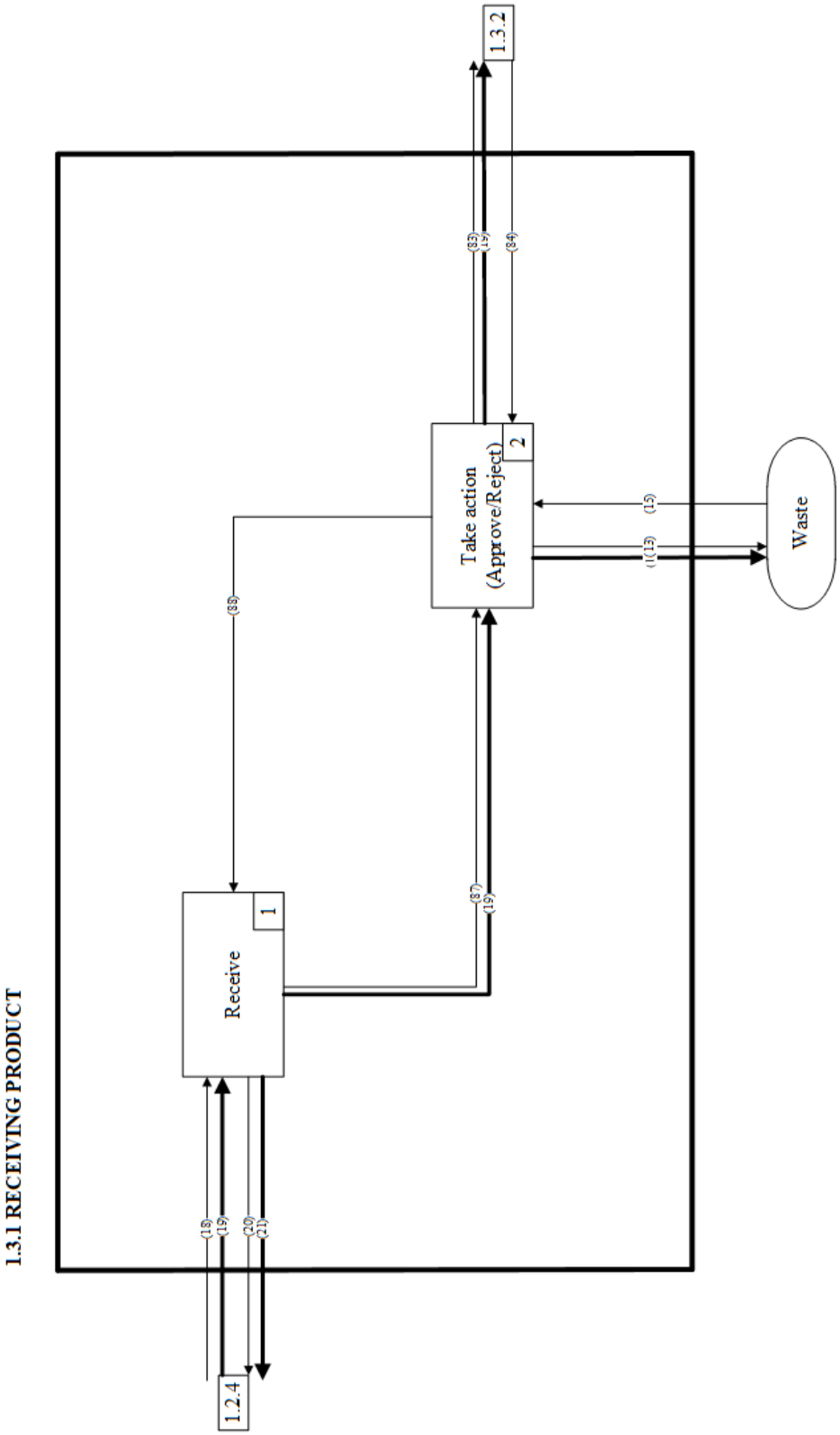

Figure 4.16 Receiving product activities

(13) Output – Information of amount and type of waste from “take action (approve/reject)” to “waste”.

(14) Output – Office and production wastes from “take action (approve/reject)” to “waste”.

(15) Input – Delivery information from “waste” to “take action (approve/reject)”.

(18) Input – Fertilizer report from “drying” to “receive”. It contains the following information:

- Product number,
- Related person name,
- Product quantity, and
- Amount of waste.

(19) Input – Fertilizer from “drying” to “receive”.

(19) Output – Fertilizer from “take action (approve/reject)” to “packaging”.

(20) Output – Final product quantity and fertilizer requirement from “receive” to “drying”

(21) Output – Returned fertilizer from “receive” to “drying”.

(83) Output – Approved product information from “take action (approve/reject)” to “packaging”.

(84) Input – Quantity of packaged product information from “packaging” to “take action (approve/reject)”.

Receiving

This activity is the control process of the products which are ready for packaging. If the fertilizer is not dry, it is sent back to drying. If it is dry, it is sent to take action (approve/reject) for decide to send it to waste or packaging.

Confirmation/Rejection

If fertilizer has high quality, it is sent to packaging, but if it is damaged, it is sent to waste.

4.1.4.2. Packaging Activities

Packaging activities are given in Figure 4.17. These activities are; identify product, control product, and packaging according to product type. Products coming from "receiving and control" are checked according to product types. Packaging materials come from the supplier. The packaged products are stored on the finish goods storage. Then packaged products are sent to delivering from finish goods storage.

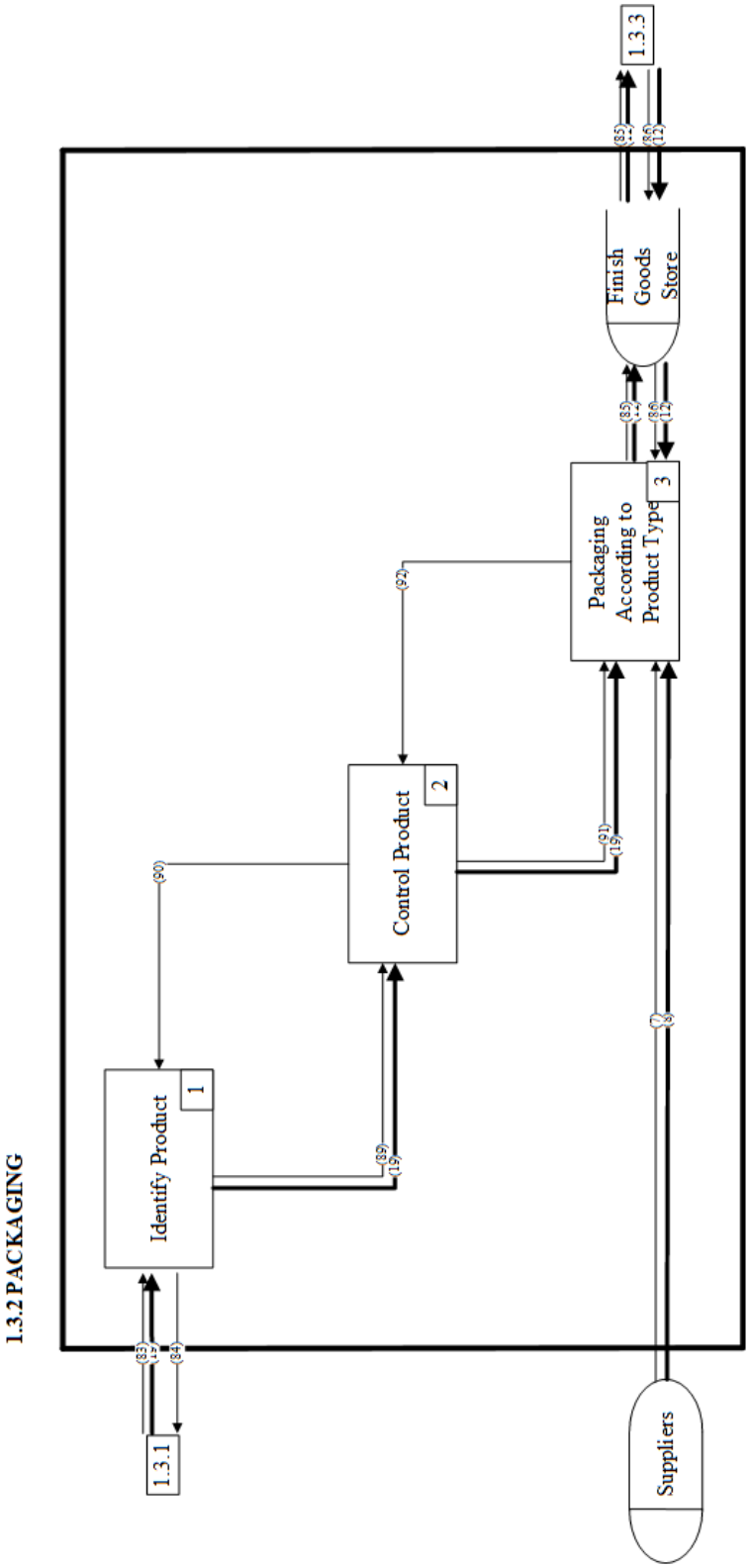

Figure 4.17 Packaging activities

(7) Input – Delivery form and purchase detail form from “suppliers” to “packaging according to product type”. A delivery form contains the following information:

- Order number,
- Order quantity,
- Delivery number,
- Related person name, and
- Explanation.

(8) Input – Product package materials from “suppliers” to “packaging according to product type”.

(12) Output – Fertilizer from “finish goods store” to “delivering”.

(12) Input – Returned fertilizer from “delivering” to “finish goods store”.

(19) Input – Fertilizer from “receiving product” to “identify product”.

(83) Input – Approved product information from “receiving product” to “identify product”.

(84) Output – Quantity of packaged product information from “identify product” to “receiving product”.

(85) Output – Quantity and size of fertilizer package from “finish goods store” to “delivering”.

(86) Input – Quantity and size of sold fertilizer packages from “delivering” to “finish goods store”.

Product Identification

It is determined the products which came from receiving product are whether vermicompost or worm.

Controlling of Product

The final check of the product is done.

Packaging According to Product Type

Worms are packed with boxes, vermicompost is packed with sacks. The sacks are sewn.

4.1.4.3. Delivering Activities

Delivering activities are given in Figure 4.18. Packages came from the packaging department are checked. If there is no problem, they are loaded to vehicles and final products are delivered to the customers. Administration and finance and accounting are informed.

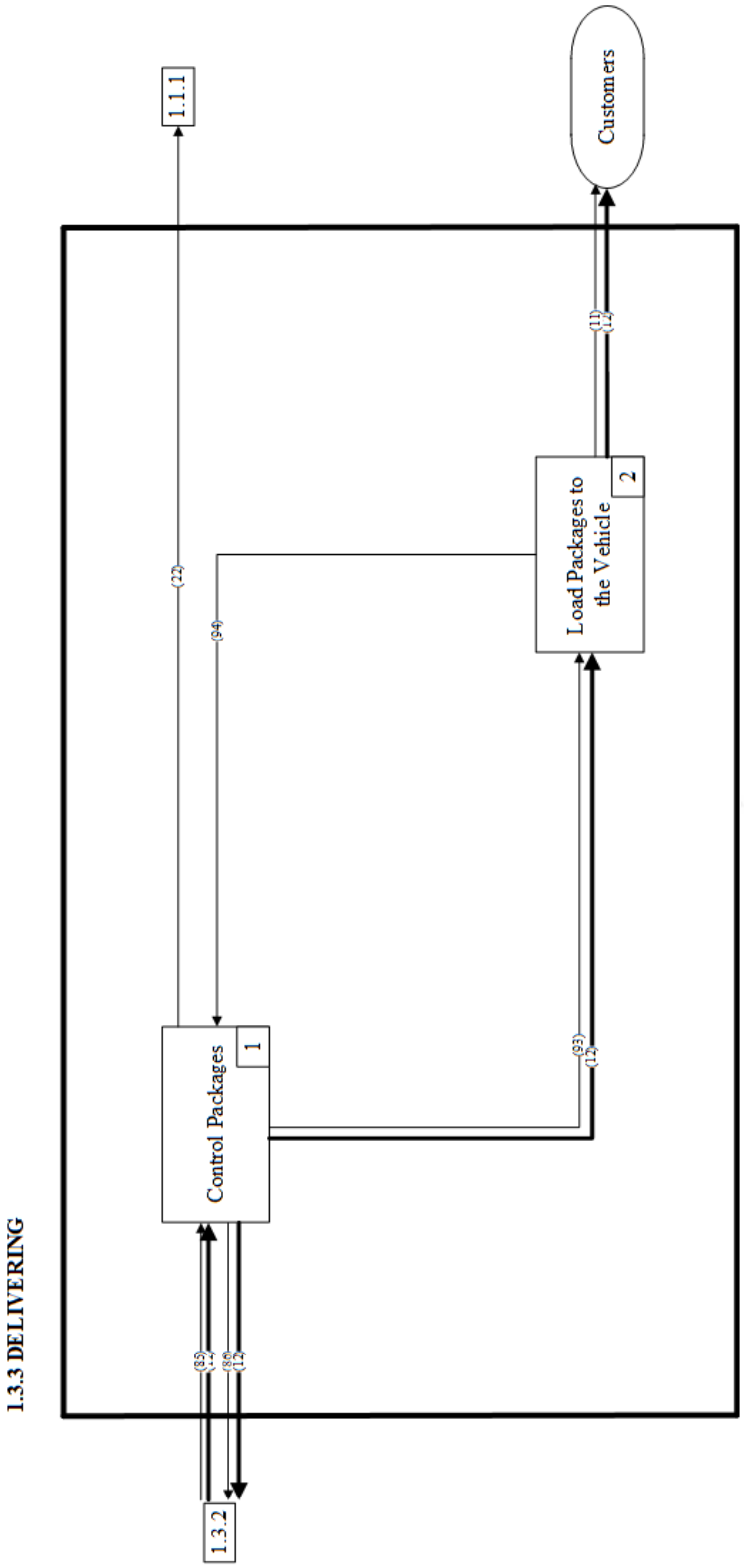

Figure 4.18 Delivering activities

(11) Output – Delivery form from “load packages to the vehicle” to “customers”. It contains the following information:

- Company name,
- Customer name,
- Address-telephone-fax-mail of the customer,
- Amount of fertilizer,
- Price of fertilizer,
- Type of fertilizer, and
- Information about fertilizer.

(12) Input – Fertilizer from “packaging” to “control packages”.

(12) Output – Returned fertilizer from “control packages” to “packaging”.

(12) Output – Fertilizer from “load packages to the vehicle” to “customers”.

(22) Output – Final product quantity, fertilizer requirement, and delivery report from “control packages” to “administration”. A delivery report contains the following information:

- Order number,
- Order quantity,
- Order date,
- Delivery number,
- Delivery date,
- Related person name, and
- Explanation.

(85) Input – Quantity and size of fertilizer package from “packaging” to “control packages”.

(86) Output – Quantity and size of sold fertilizer packages from “control packages” to “packaging”.

Controlling of Packages

The final checks are made before the packages are sent to the customer.

Loading Packages to the Vehicle

Final products are sent to the customer by loading the vehicle.

A Functional Flow Block Diagram (FFBD) example for loading packages to the vehicle is shown in Figure 4.19. "Such FFBDs are developed primarily for the purposes of structuring and transitioning system requirements into functional terms" [6].

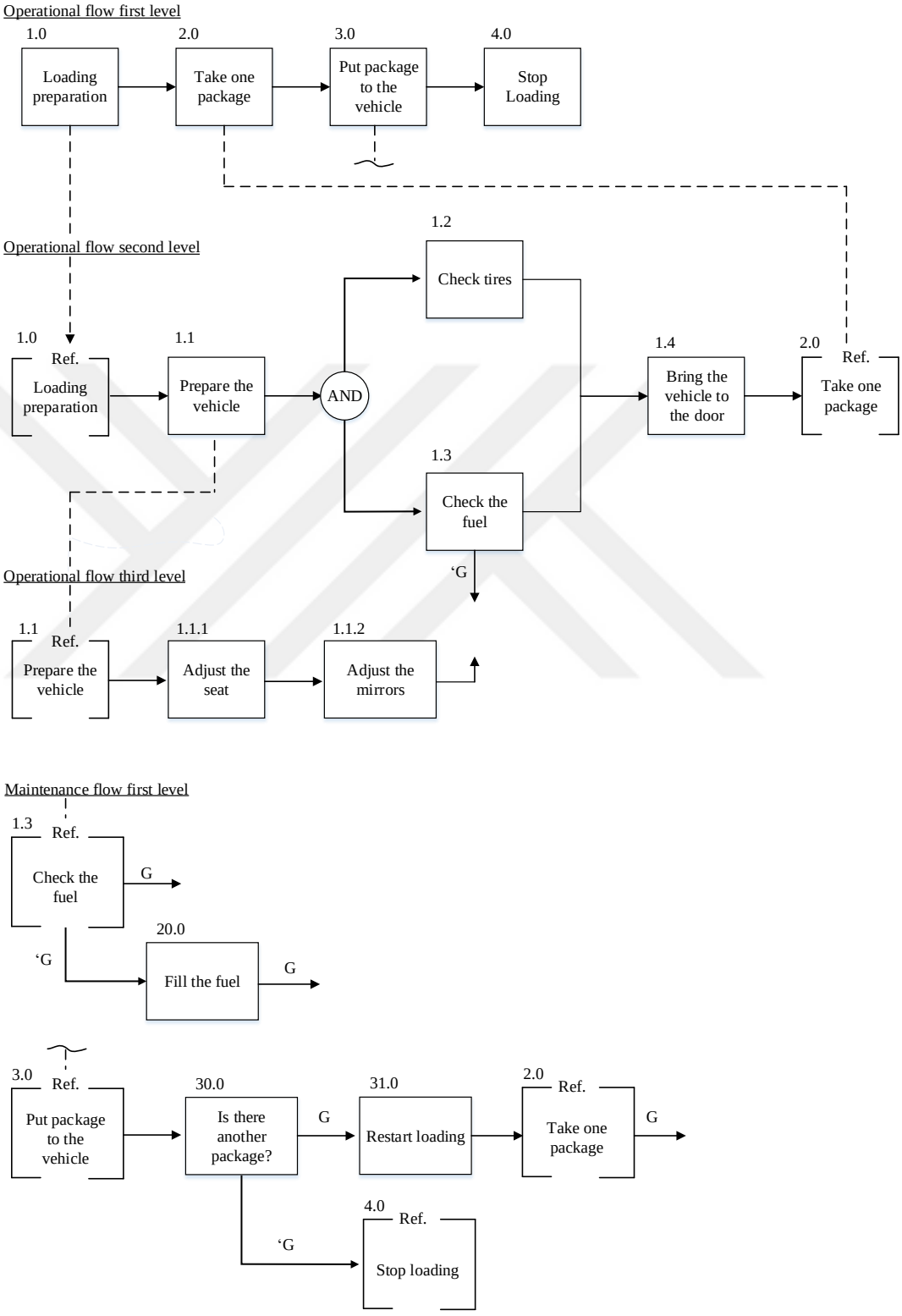

Figure 4.19 FFBD example

4.2. Manpower Planning of the System

When planning manpower, the number of workers required by the works and the level of required knowledge and skills are taken into consideration. In this project, manpower planning is done based on SSADM activities.

Employees grouped side by side as white-collar employees, blue-collar employees, and the manager as shown in Table 4.1. Jobs are written on lines as the tasks at the user requirements level from SSADM. Then, the required time for the relevant staff to work is determined according to each task. Because not all of the works are done every day, the average time for some jobs is taken into account.

The Gantt chart is created as shown in Figure 4.20. If it does not exceed 8 hours per day, the amount of manpower calculation is done. According to the Gantt chart, 2 white-collar workers, 2 blue-collar workers, and 1 manager are sufficient for a 1200000 worm-capacity facility.

Table 4.1 Daily work times

	Manager	White-collar 1	White-collar 2	Blue-collar 1	Blue-collar 2
	Time is given in minutes				
Administrator Initiate Business	60	-	-	-	-
Check Reports	150	-	-	-	-
Approve Reports	30	-	-	-	-
Business Follow-up	180	-	-	-	-
Purchase Requirement	-	60	-	-	-
Do Accounting	-	120	-	-	-
Advertise Product	-	60	-	-	-
Sales Product	-	120	-	-	-
Do Mat. Requirement Planning	-	-	75	-	-
Do Production Planning	-	-	75	-	-
Prepare Work Orders	-	-	75	-	-
Quality Control Planning	-	-	75	-	-
Maintenance	-	-	60	-	-
Hire Personnel	-	15	-	-	-
Training	-	15	-	-	-
Evaluate Personnel	-	20	-	-	-
Warn/Reward	-	10	-	-	-
Define Requirement	-	-	20	-	-
Research	-	-	20	-	-
Develop	-	-	20	-	-
Receive Material	-	-	-	20	20
Examine	-	-	-	20	20
Approve	-	-	-	20	-
Mix Raw Materials	-	-	-	30	30
Ventilate Compost	-	-	-	25	25
Move Compost	-	-	-	15	15
Heat Compost	-	-	-	15	15
Put Compost to the Pool	-	-	-	20	20
Separate Fertilizer	-	-	-	30	30
Receive Fertilizer	-	-	-	30	30
Put to Drying Area	-	-	-	25	25
Take from Drying Area	-	-	-	30	30
Sifting Fertilizer	-	-	-	30	30
Receive	-	-	-	30	30
Take action (Approve/Reject)	-	-	-	10	10
Identify Product	-	-	-	20	-
Control Product	-	-	-	-	10
Packaging According to Prod. Type	-	-	-	30	30
Control Packages	-	-	-	-	30
Load Packages to the Vehicle	-	-	-	20	20

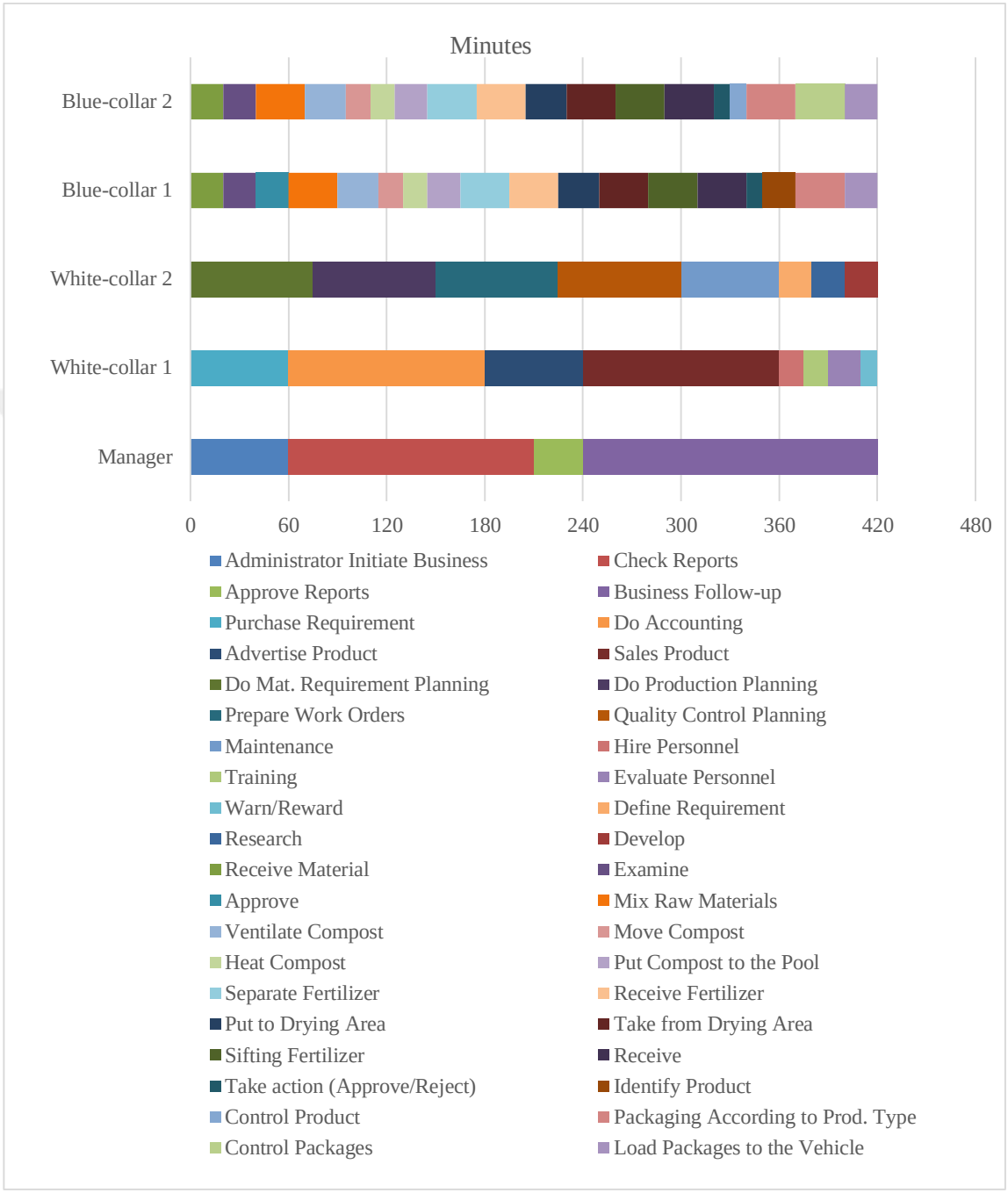

Figure 4.20 Gantt chart for manpower planning

4.3. System Cost

The prices which are assumed in this section are the average ones taken from different resources.

In calculating the cost, the system is handled in three stages: investment cost, production cost, and operations and maintenance cost. SSADM activity costs give CBS.

When calculating the investment cost, the costs of the equipment that must be purchased or leased, the cost of advertising for the first recruitment, the cost of supplier activity, and land and construction costs are collected.

The required equipment cost is determined. In the initial investment, the heat treatment furnace is purchased because the compost must undergo heat treatment before given to the worms. The cost of the heat treatment machine is 45000 TL for 3600 kg of vermicompost production per month. Sifting machine and a sewing device are purchased in the 9th month because the first pool is filled with vermicompost in the 6th month and this vermicompost dries in 3 months. Sifting machine's price is 3750 TL and the sewing device's price is 400 TL. Production pools and measuring devices are purchased every month from the initial investment to the end of the 5th month. The production volume is kept fixed from the 6th month and no more pools and measuring device are purchased. The production pool's price is 12500 TL for 200000 worms. Wheeled boxes also should be purchased at the beginning because of compost and vermicompost are able to transport with them. Three shovels requirement is determined and the cost of them is 90 TL. A table is required to perform worm counting. The price of the table is 1000 TL. Nylon cover and gloves should be purchased at regular intervals considering the depreciation. Initially, 30000 TL is invested in office materials. In the following months, it is assumed that 100 TL is spent per month for office expenses.

For transportation, car rental is 1200 TL per month. The human factor cost is 400 TL in the beginning and the 6th month. This cost is for announcements on the internet for recruitment. Land and construction costs include land rent costs as 1000 TL per month,

the regulation cost as 1000 TL for once, draw well construction cost as 10000 TL for once, and purchase of prefabricated plant cost as 150000 TL.

In order to calculate production costs, raw materials cost, logistics support cost, and packaging cost are totaled up. Compost is purchased as raw materials all months. For the first 3 months, worms are also purchased until their number reaches 1200000. The price of a worm is 0.10 TL. In the first 3 months, 200000 worms are purchased and the worm cost is 20000 TL per month. Worm number increases and the need for compost multiplies for the first 6 months. In the following months, the price of compost remains fixed as 420 TL. Logistics support cost consists of supplier activity cost which is 300 TL per month and transportation and distribution costs which are 500 TL per month after the 9th month. The packaging cost is accepted as 870 TL per month after the 9th month.

Finally, in the calculation of operation and maintenance costs, system operation cost and maintenance support cost are considered. System operation cost consists of personnel cost, training cost, facilities cost, advertisement cost, and financial cost. During the first 6 months, there are one manager, one blue-collar worker, and one white-collar worker. The manager's salary is 6000 TL, white-collar's salary is 3300 TL, and blue-collar's salary is 2300 TL. The personnel cost is 11600 TL for the first 6 months. After the beginning of vermicompost sales, one blue-collar worker and one white-collar worker could be hired. Thus, personnel costs could be increased to 17200 TL per month. The training cost for 2 recruitments is considered as 200 TL. Facilities and advertisement costs are calculated per month. 130000 TL as KOSGEB support and 450000 TL as bank loan are taken [18]. Depreciation expenses of the machines are calculated for each year as 9956 TL. The depreciation rate is taken as 0,20 for the 5-year depreciation account. Maintenance support cost is also calculated.

Then the total cost and total revenue are calculated according to the present value of money. The net profit for each year after taxes is determined.

The initial cost for every step is given in Table 4.2.

Table 4.2 Initial cost

	Beginning
Investment Cost (CI)	**252213,50**
a) Equipment Cost (Cıe)	89513,50
1) Base Machine and Equipments	89513,50
1.1 Heat Treatment Machine	45000,00
1.2 Sifting Machine	0,00
1.3 Sewing Device	0,00
1.4 Production Pool	12500,00
1.5 Wheeled Boxes	760,00
1.6 Shovel	90,00
1.7 Table (for Counting)	1000,00
1.8 Nylon Cover	46,00
1.9 Gloves	12,50
1.10 Measuring Device	105,00
1.11 Office Materials	30000,00
2) Vehicle Cost	0,00
2.1 Vehicle Purchased	0,00
2.2 Vehicle Rented	0,00
b) Human Factor Cost (C1h)	400,00
c) Supplier Activity Cost (Cıs)	300,00
d) Land and Construction Costs (Cıc)	162000,00
1) Land	1000,00
1.1 Land Purchase	0,00
1.2 Land Rent	1000,00
2) Land Regulation and Preparation	11000,00
2.1 Regulation	1000,00
2.2 Draw Well	10000,00
3) Main Factory Buildings and Facilities	150000,00
Production Cost (Cp)	**0,00**
a) Raw materials Cost (Cpr)	0,00
1) Compost Purchase	0,00
2) Worm Purchase	0,00
b) Logistics Support Cost (Cpl)	0,00
1) Supplier Activity	0,00
2) Transportation & distribution	0,00
c) Packaging Cost (Cpp)	0,00
Operation & Maintenance Costs (Co)	-570000,00
a) System Operation Cost (Cos)	-570000,00
1) Personnel	0,00
2) Training	0,00
3) Facilities	0,00
4) Advertisement	0,00
5) Financial	-570000,00
5.1 KOSGEB	-120000,00
5.2 Bank Loan	-450000,00
6) Depreciation	0,00
b) Maintenance Support Cost (Com)	0,00
1) Spare/repair parts	0,00
2) Maintenance machine	0,00
3) Maintenance facilities	0,00
TOTAL	**-317786,50**
Present value of money for cost (12% rate)	**-317786,50**
Revenue	0,00

According to the cost items given in Table 4.2, the total revenue and cost for five years are given in Table 4.3.

Table 4.3 Annual income statement

	Year 1	Year 2	Year 3	Year 4	Year 5
Revenue	288600,00	755328,00	845967,36	947483,44	1061181,46
Cost	523801,10	569867,85	638251,99	714842,23	800623,30
Profit	-235201,10	185460,15	207715,37	232641,21	260558,16
Tax	24155,83	61201,85	68546,07	76771,60	85984,19
Net Profit After Tax	-259356,93	-135098,63	4070,67	159940,28	334514,25
	-	-	+	+	+

The break-even point is found as the 36th month in the yellow box in Table 4.3. To the break-even point, 97200 kg of fertilizer is produced and sold, 12600000 worms are produced and 12000000 worms are sold.

The break-even point is shown in Figure 4.21. Revenue, initial cost, and total cost are shown as green, purple, and red lines, respectively.

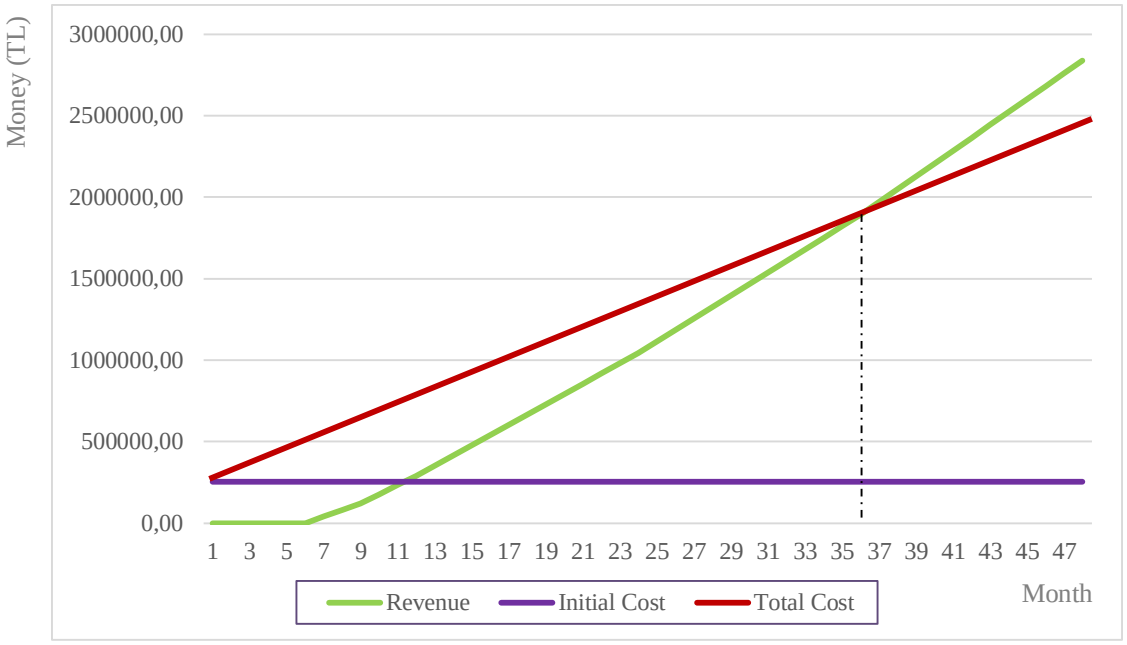

Figure 4.21 Break-even point

4.4. Drawing of the Facility Initial Layout

In this project, the facility is purchased as prefabricated because of its reasonable price and its feasibility than the regular one. This facility is built on an acre of land. The area of the building is 750 square meters and the outer area is 250 square meters.

The 3-dimensional visualization of the facility is drawn using the SketchUp program. The inner and outer areas from various angles are as shown in Figure 4.22 - 4.29.

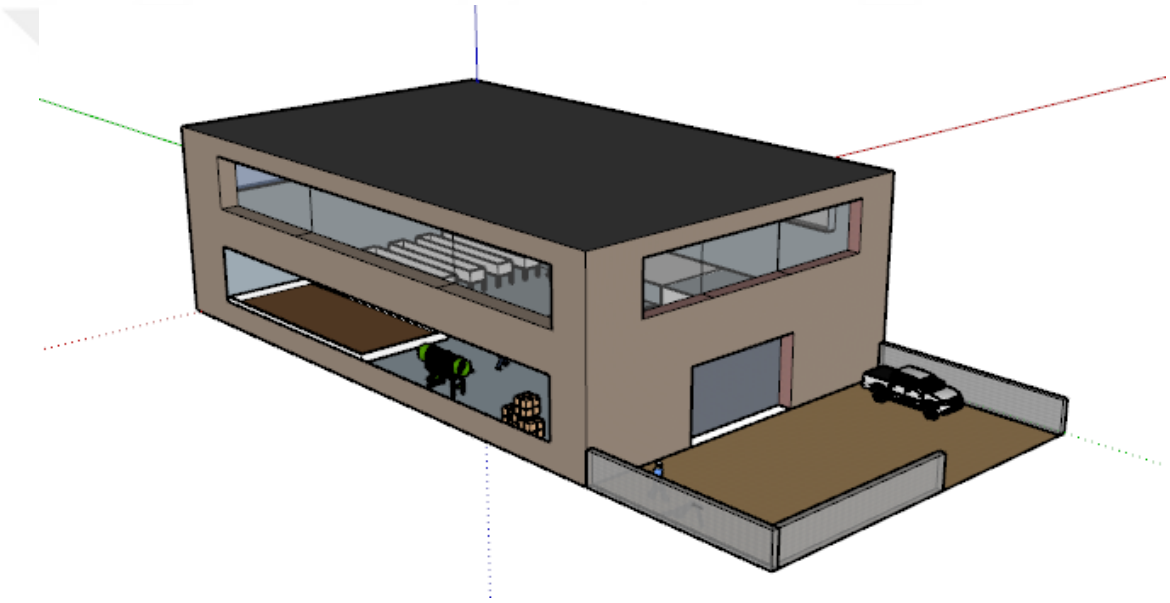

Figure 4.22 Drawing of the facility - 1

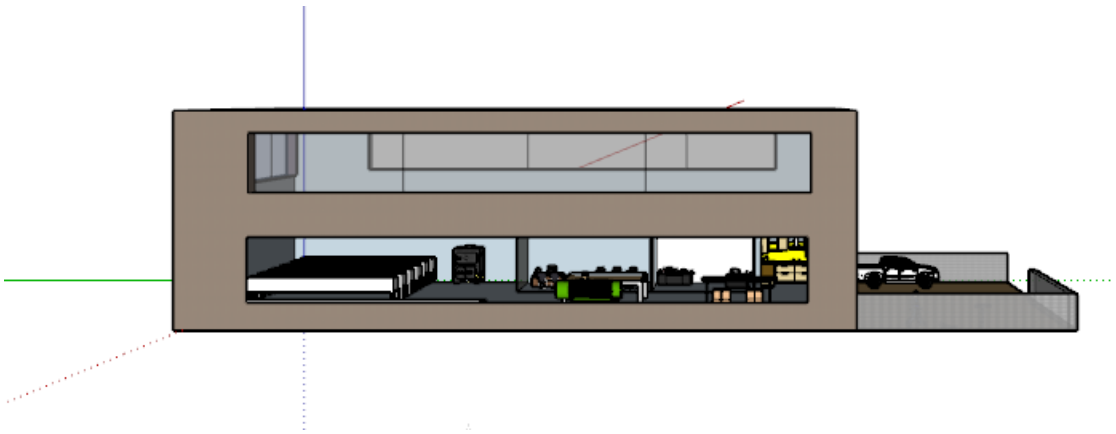

Figure 4.23 Drawing of the facility - 2

Figure 4.24 Drawing of the facility - 3

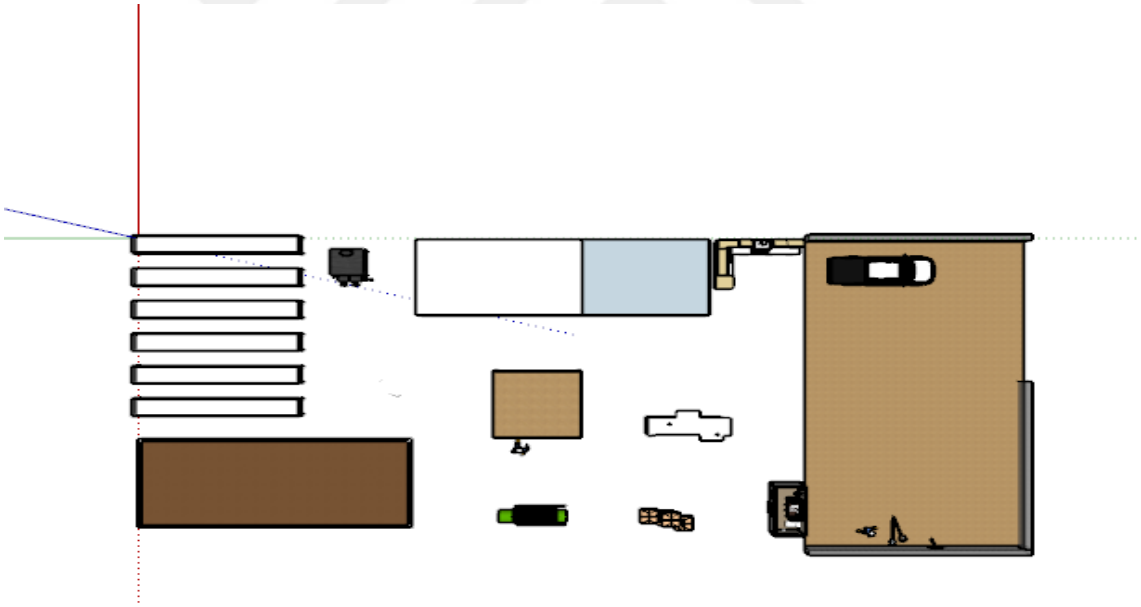

Figure 4.25 Drawing of the facility - 4

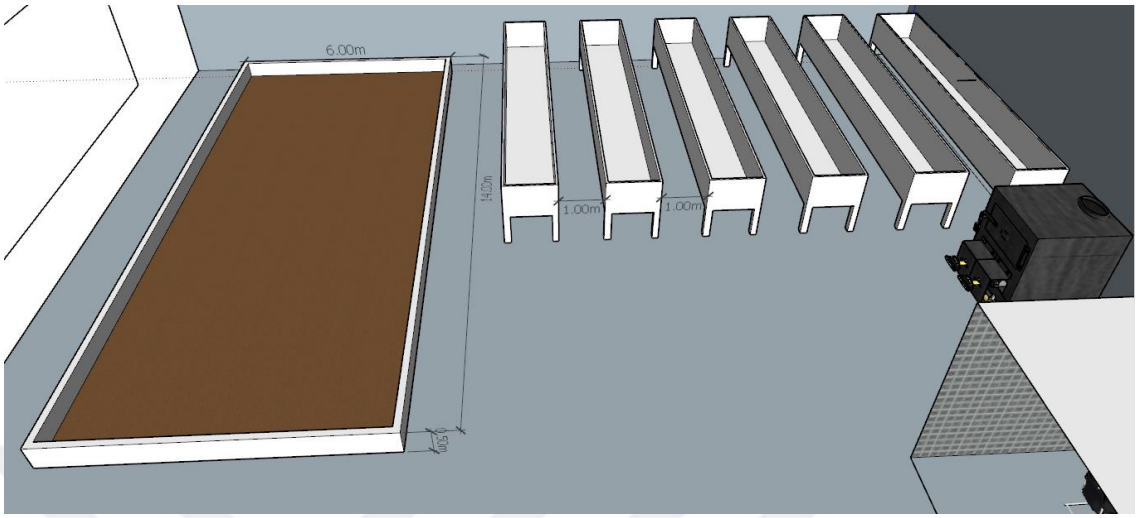

Figure 4.26 Drawing of the facility - 5

Figure 4.27 Drawing of the facility - 6

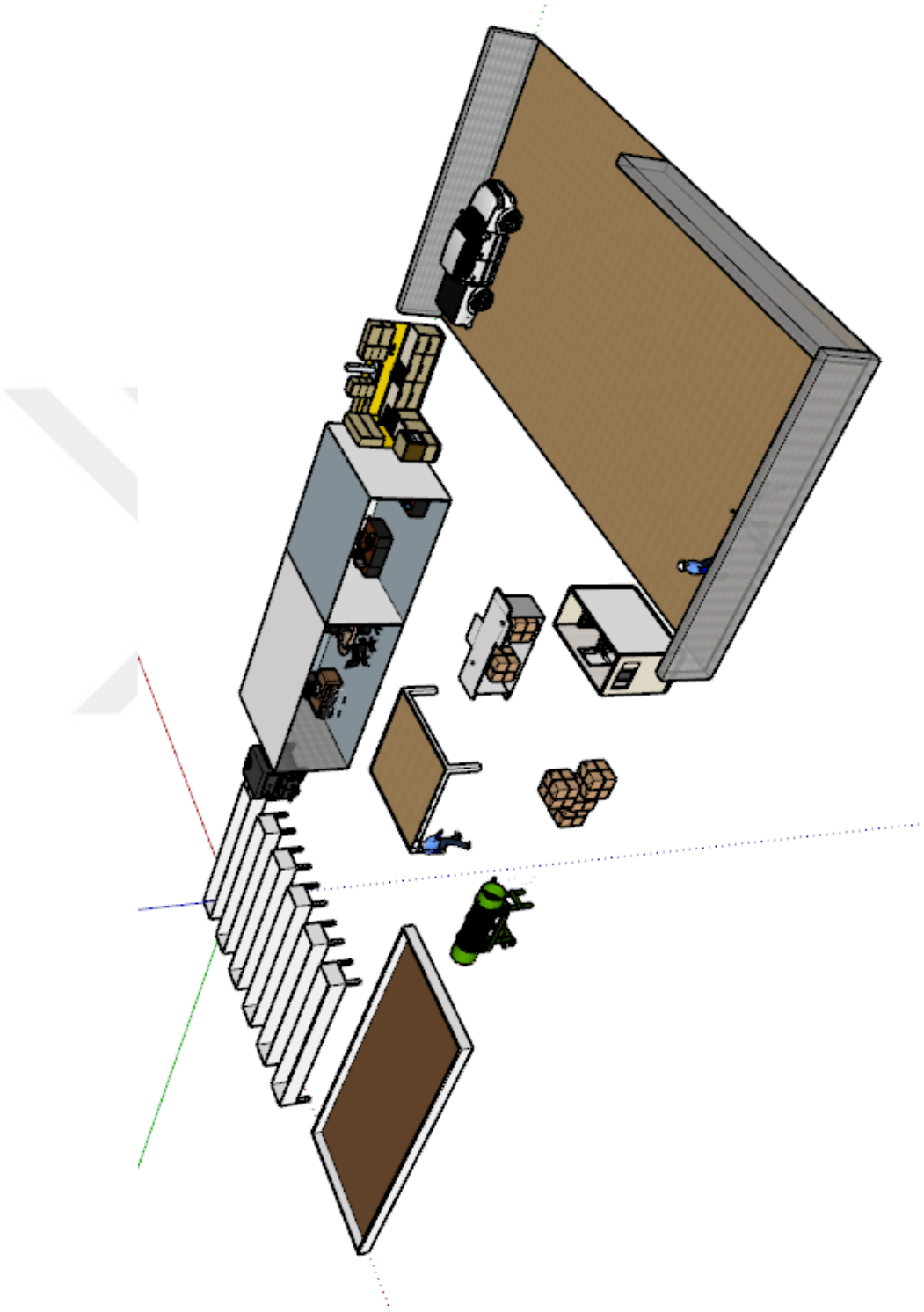

Figure 4.28 Drawing of the facility - 7

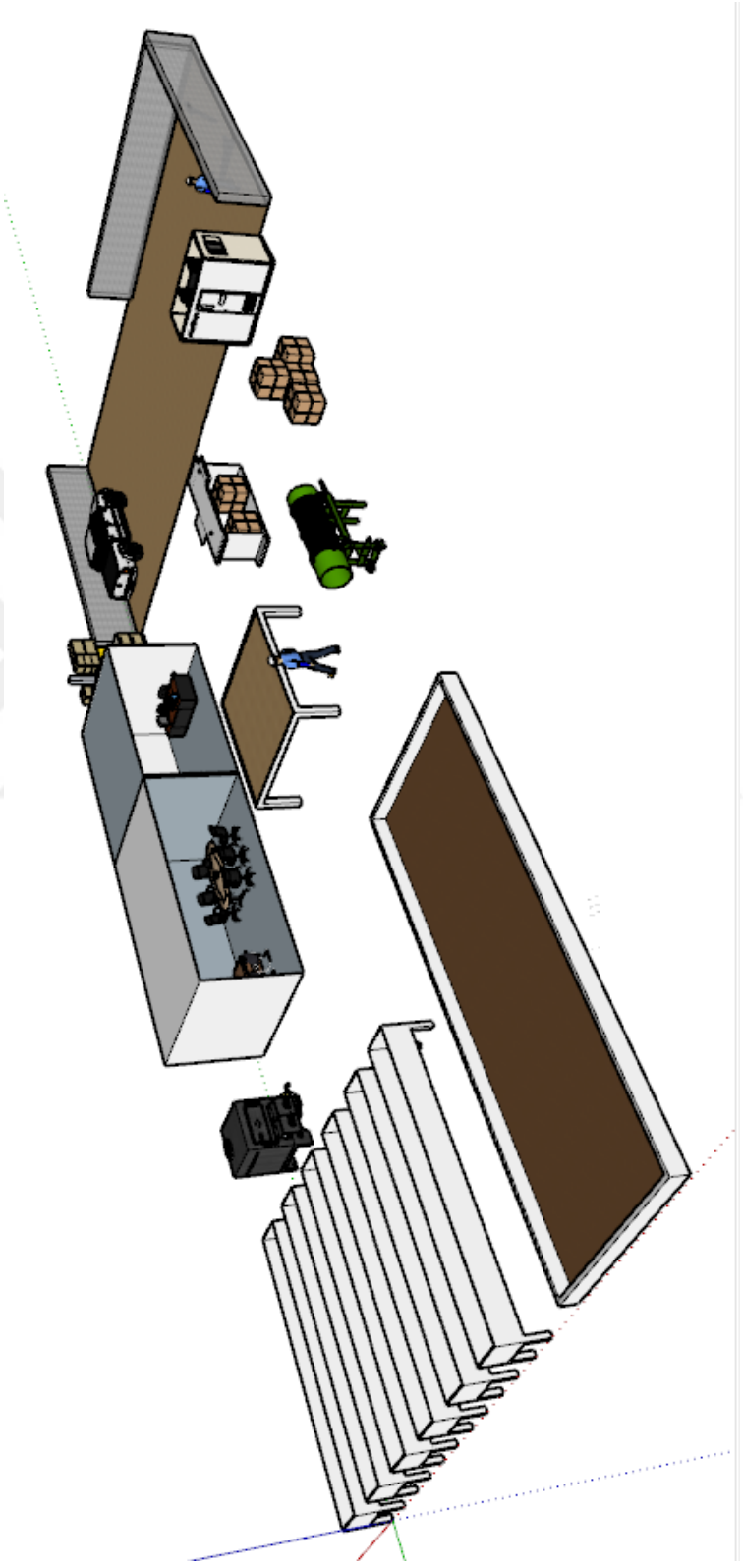

Figure 4.29 Drawing of the facility - 8

CHAPTER 5

RESULTS AND DISCUSSION

Various techniques are used to design a production project. In this study, a turn-key project is designed by using SSADM. The project is to produce vermicompost from Eisenia Andrei and Eisenia Fetida. With SSADM, the system is transformed into activity diagrams at three levels namely departmental level, functional level, and user requirements level. Data and materials flows of the entire system are represented on the diagrams [19].

Today, many farmers use chemical fertilizers in agriculture. Chemical fertilizer caused many negative consequences such as a change in the pH value of the soil, decrease in water retention property, decrease in yield, increase in the probability of erosion, reduction in the retention time of fertilizer in the soil, pollution in ground waters, the decrease in productivity from soil-grown products, blocking the functioning of microorganisms in the soil, and decrease in the amount of organic matters in the soil [1]. For these reasons, the use of organic fertilizer in agriculture has become very important in terms of environmental consciousness and health. Vermicomposting is a preferred activity in the production of organic fertilizer due to such facts it can be started with a relatively low budget, can be applied easily, and the resultant demand for agricultural productivity increases. The yield obtained from the Eisenia Andrei and Eisenia Fetida is higher than the other worms and these worms multiply very rapidly [19].

Gantt chart is used in the manpower planning of the vermicompost production facility. The number of employees is determined by taking into consideration the time required for the job. With the CBS method, costs are presented in a hierarchical order. All costs are calculated on a monthly basis. The first income for this project is obtained in the 7th month. For the first time, profit is made in the 10th month, and the cost of investment is met in the 36th month.

CHAPTER 6

FURTHER STUDIES

The proposed turn-key project can be implemented easily and can further be adjusted according to the needs and requirements of entrepreneurs. Activity-based costing and manpower planning could give great flexibility in applications. To further studies, the user requirements level activities' Functional Flow Block Diagrams can also be created. Moreover, systematization of the entire project will let fully computerization of the process if not in this one but surely in another one. From this perspective, it is also an attempt to understand the Industry 4.0 concept which is come to the fore nowadays [19].

REFERENCES

[1] S. Savcı, Investigation of Effect of Chemical Fertilizers on Environment, APCBEE Procedia, *1*, pp. 287-292. 5-7 January 2012.

[2] Namlı, A., Bekyürek, Y., Topaç, E. Vermikompost (Solucan Gübresi) El Kitabı. Kayseri: Sümer Ofset Matbaacılık. 2016

[3] Ashworth, C., & Goodland, M. SSADM: A Practical Approach. UK: McGraw-Hill Book Company. 1990

[4] Hitchins, D. Systems Engineering A 21st Century Systems Methodology. England: John Wiley & Sons Ltd. 2007

[5] Liu, D. Systems Engineering Design Principles and Models. Boca Raton: Taylor & Francis Group, LLC. 2016

[6] Blanchard, B. S., & Blyler, J. E. System Engineering Management (5th ed.). Canada: John Wiley & Sons, Inc. 2007

[7] About INCOSE, Retrieved January 1, 2019, from https://www.incose.org/about-incose

[8] Goodland, M., & Slater, C. Ssadm Version 4: A Practical Approach. England: McGraw-Hill Publishing Company. 1995

[9] Sadeghi-Dastaki M., & Afrazeh A. A Two-Stage Skilled Manpower Planning Model with Demand Uncertainty. International Journal of Intelligent Computing and Cybernetics, *4*, pp. 526-551. 2018

[10] Li, B., Zhu, Y., Sun, Y., Aw, G., Teo, K. L. Deterministic Conversion of Uncertain Manpower Planning Optimization Problem. IEEE Transactions on Fuzzy Systems, *5*, October 2018.

[11] Maier, C. B., Batenburg, R., Birch, S., Zander, B., Elliott, R., Busse, R. Health workforce planning: which countries include nurse practitioners and physician assistants and to what effect? Health Policy, *122*, pp. 1085–1092. 2018

[12] Safarishahrbijari A. Workforce forecasting models: A systematic review. Journal of Forecasting, *37*, pp. 739–753. 2018

[13] Kaplan, R. S., & Anderson, S. R. Time-Driven Activity-Based Costing, Harvard Business Review. November 2004.

[14] Sıkça Sorulan Sorular. (n.d.) Retrieved January 1, 2019, from http://www.kirmizikaliforniyasolucani.org/sikca-sorulan-sorular/

[15] Figure 3.1 Heat treatment furnace. (n.d.) Retrieved January 1, 2019, from https://www.google.com/search?q=Is%C4%B1l+%C4%B0%C5%9Flem+Makinesi&source=lnms&tbm=isch&sa=X&ved=0ahUKEwiI1pHK6o_gAhXRKewKHe15CqQQ_AUIDigB&biw=1517&bih=730#imgrc=E8J9ytUr-FZCdM:

[16] Figure 3.2 Production pools. (n.d.) Retrieved January 1, 2019, from https://www.google.com/search?q=solucan+g%C3%BCbresi+%C3%BCretim+havuzu&rlz=1C1SQJL_trTR824TR824&source=lnms&tbm=isch&sa=X&ved=0ahUKEwjdk6Kqr9vfAhVGYVAKHfq2Bz8Q_AUIDigB&biw=1366&bih=608#imgrc=_yO9RrA6SSC6fM:

[17] Figure 3.3 Fertilizer sifting machine. (n.d.) Retrieved January 1, 2019, from https://www.google.com/search?q=g%C3%BCbre+eleme+makinas%C4%B1&source=lnms&tbm=isch&sa=X&ved=0ahUKEwiOoI-664_gAhUBfFAKHSn8ALsQ_AUIDigB&biw=1517&bih=730#imgrc=4FLfPWOZdOopHM:

[18] Girişimcilik Destek Programı. (n.d.) Retrieved December 30, 2018, from https://www.kosgeb.gov.tr/site/tr/genel/destekdetay/1231/girisimcilik-destek-programi

[19] Üstünyer, P., Özdoğan, Ş. Z., Arıkan, Ü. Z. B., Ünlü, V., Gündoğan, M., & Erdebilli, B (B. D. Rouyendegh). A Turn-Key Project Design Using Structured Systems Engineering Techniques: Vermicomposting. 12th International Conference on New Challenges in Management and Business, 124. 2018

CURRICULUM VITAE

PERSONAL INFORMATION

Name Surname : Pelin ÜSTÜNYER

Date of Birth : 1993

E-mail : pelinustunyer@gmail.com

EDUCATION

High School : Kars Science High School (2007-2011)

Bachelor : Pamukkale University / DENİZLİ (2012-2017)

Master Degree : Ankara Yıldırım Beyazıt University (2017-2019)

TOPICS OF INTEREST

Systems Engineering

Lean Manufacturing

Industry 4.0

Production Planning

PUBLICATIONS/PRESENTATIONS

Üstünyer, P., Eraslan, E., Yıldızbaşı, A., & Erdebilli, B (B. D. Rouyendegh). Intuitionistic Fuzzy ELECTRE Method for Green Supplier Selection Problem. 11th International Conference on New Challenges in Management and Business, 89. 2018

PUBLICATIONS/PRESENTATIONS DERIVED FROM THESIS

Üstünyer, P., Özdoğan, Ş. Z., Arıkan, Ü. Z. B., Ünlü, V., Gündoğan, M., & Erdebilli, B (B. D. Rouyendegh). A Turn-Key Project Design Using Structured Systems Engineering Techniques: Vermicomposting. 12th International Conference on New Challenges in Management and Business, 124. 2018