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DEVELOP QUALITY OF SYSTEM ENGINEERING PROCESS IN BOTTLED WATER MANUFACTURING SECTORS

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A B S T R A C T

In the economic development of the Ethiopia in recent time it depending on the manufacturing sectors next to agricultural sectors. Among the exist manufacturing sectors, bottled water manufacturing sector is one of which play a great role on economic of the country and it require more attention to increase their competitive advantages of the organization with users satisfaction. Quality of the system engineering process is the basic requirement in the bottled water manufacturing process, because there is a quality system related problems are there in the overall organization. The exist of system engineering process of bottled water manufacturing sectors have problems which related with quality of the system and the exist problems are less quality on system analysis, interrelationship systems and stakeholders, system dynamic system life cycle and waste disposal of the systems are there on bottled water manufacturing sectors. This quality system problems affect the competitiveness of the bottled water manufacturing sectors with customer's dissatisfaction. This study solve those problems through detail analysis the system, subsystems and components, dynamicity and interrelationship of each systems with clear life cycle and proper waste disposal of the bottled water manufacturing sectors with clearly showing and analyzing by using of different interconnections charts and diagrams. The end result of the study is increased of overall quality of system engineering process of the bottled water manufacturing sectors by clearly investigation of the systems with subsystems and components are clearly understands by stakeholders with good and clear life cycle with proper waste disposal proposed and the quality of system engineering process of bottled water manufacturing sectors are increased with sustainable development and customer satisfaction.

1. INTRODUCTION

Manufacturing sectors has to create opportunities to be globally competitive and saving of capital with giving especial attention and expanded in Ethiopia (Abera,. 2020), Due to the increased demand and consumption of bottled water in Ethiopia, there has been a growing concern about the quality and safety of this product (Yilkal et al., 2019). Applying quality of system engineering process on manufacturing sectors it needs to achieve quality objectives with users satisfaction and competitive advantages (Khan et al., 2017), is an

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integrated composite of people, products, and processes that provide a capability to satisfy a stated need or objective (Eisner, 2008). Competing in this global market requires a combination of innovation, integration and management of complex systems, resulting in an increase in system complexity and associated risks for the successful development and management of new complex systems (Lemberger & Erasmus, 2014). Manufacturing sector is the main basic economics of one country and also *the* application of systems engineering it has been successfully developed and applied in manufacturing sectors (Mabelo, 2017) and quality of Systems engineering processes are vital, within any organization, for the development and implementation of successful complex systems, then it has been noted that quality of systems engineering process has the ability to effectively integrate people, processes and technologies to deliver innovative complex systems (Lemberger & Erasmus, 2014).Because, *Systems engineering (SE) is an interdisciplinary approach and a way to enable the realization of successful systems and It focuses on defining customer needs and required functionality early in the development cycle, on documenting requirements, and then proceeding with design synthesis and system validation* (Mabelo, 2017). Quality of a system is an essential element for sustainability and customer satisfaction. In the last few decades, increased attention was paid to quality management at a global level more specifically in the manufacturing sector and also organizations can improve the product quality and even reduce the cost of production in any given industry by implementing quality of system engineering process with practices (Khan et al., 2017). The goal is to provide quality system engineering with advice on how to best control their systems engineering approach to maximize their probability of success (Componation et al., 2015).
The ability of the manufacturing firms to identify the needs of customers, translate them into requirements and quickly engineer the systems that satisfy these requirements through application of quality of system engineering process through the manufacturing systems (Lardeur, 2003). Systems engineering concerns with not only engineering design but also external factors of the system and the interactions between the systems with the environment (Suranto 2015, Madni & Purohit, 2019). The result of the quality of system engineering process is integrate more and more functions, have to interact with other systems, to satisfy increasingly stringent reliability requirements, while also being cost effective, having a low environmental impact and being easy to use and Although each individual stakeholder involved in system development has very specific skills and know-how, none of them have sufficient visibility to be able to grasp the problem in its entirety (Auriol et al., 2011) and with includes the activities necessary to ensure that the disposal of decommissioned, destroyed, or irreparable system components meets all applicable regulations and directives (ITU, 2012; Eisner 2008).

2. DEFINITIONS OF BASIC TERMS

Quality and quality system
Quality is the degree to which a set of inherent characteristics fulfils requirements. Quality is a universal value and has become a global issue and also in order to survive and be able to provide customers with good products, manufacturing organizations are required to ensure that their processes are continuously monitored and product through quality systems are improved (Judi et al., 2011). *Quality systems have been developing in a rapid pace over the last century and Quality of the system used to easy understand the overall manufacturing system, Eliminate waste and also used for total customer service and satisfaction* (Hellman & Liu, 2013). *There is a shortcoming in manufacturing and it needs to* develop quality system engineering (Kurniawati & Noordin, 2006)

System Engineering
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 OR 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 (Ryen 2008) and Systems engineering can be applied to any system of manufacturing sectors (Ryen 2008). *There is a shortcoming in manufacturing sector and it needs to* develop quality system engineering (Kurniawati & Noordin, 2006).
Bottled water manufacturing sectors has a lack of quality system engineering process, quality system engineering related problems in bottled water manufacturing sectors are lack of clearly application of system engineering on analysis and Dynamic of systems, interrelationship of systems and stakeholder, life cycle and waste disposal of the system are the major problems those reduce the quality of system engineering on bottled water manufacturing sectors which reduce the competitive advantages of the organization and satisfaction of the users. Then, this study already solve the exist problems and increase quality of system engineering process in order to increases competitiveness of the bottled water manufacturing sectors with customers satisfaction.

3. BASIC COMPONENTS OF THE QUALITY OF SYSTEM ENGINEERING.

Analyze the system, its sub-systems, and components
Analyze the system:

Before starting any process it must identify the user of the systems and its problems of the existing user. The identification of the users is the first steps and the basic of the any process for next steps with specified goals and then identify the user, then depend on the user interest define and state what the system will do for attaining the goals. In this case it give detail definition for the function of the systems will do. Bottled water manufacturing system it depend on the detail investigation of feasibility study, it determine the place were of the overall systems with the time frame with the following analyses steps (Figure 1)/

Figure1. Overall system analyses

Analysis strategy: is developed to guide the project team's efforts.

Gathering requirements: (e.g. through interviews, group workshops, or questionnaires). The set typically includes models that represent the data and processes necessary to support the underlying business process.

System proposal: is a document which is presented to the project sponsor and other key decision makers (e.g. members of the approval committee) who will decide whether the project should continue to move forward.

Sub-systems and components (Figure 2):

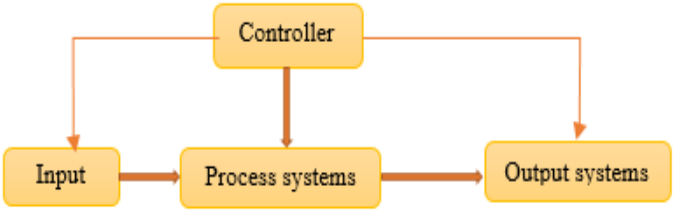

Figure 2. Sub-systems and components

Controller (management system)

The mail goal of this effective management systems in manufacturing systems are:

- Identify and control problems from the users (customers or peoples) which problem related with their product.
- Managing each and every activities in the systems
- Controlling and producing product according to customer needs.
- Initiating their company to competing the other competitors.
- To make easy working condition for attaining their goals.

Input system

In this case, basic raw materials which pass through different process and used for producing an output product for user according to their requirements.

The basic inputs uses are requirements (Figure 3):

- For original: water and carbon dioxide
- For flavor: water, sugar, fruit flavor (citric acid) and color additives

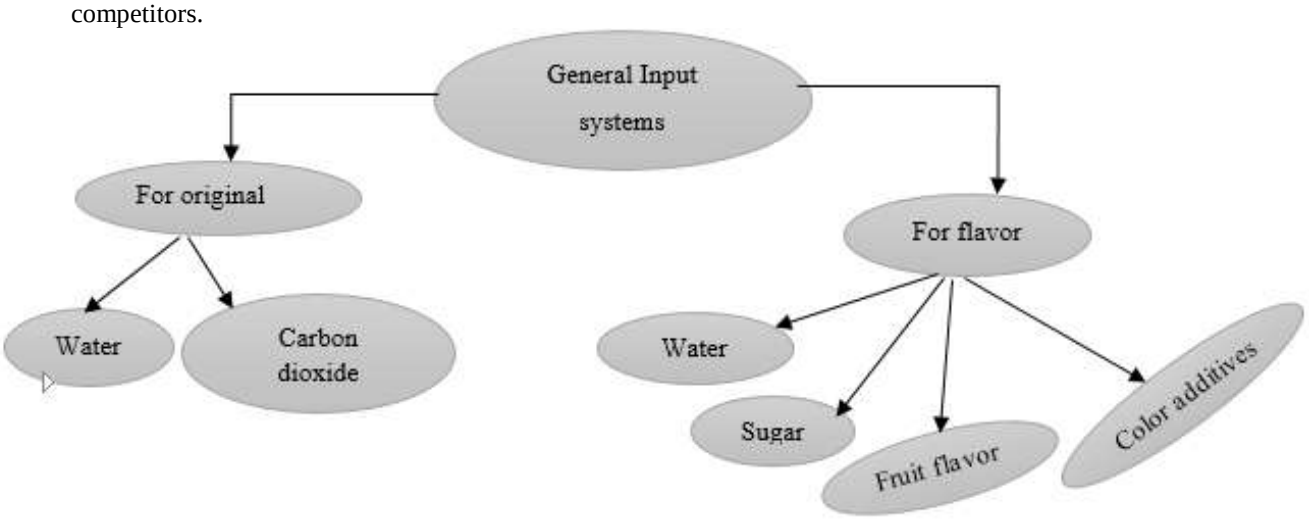

Figure 3. Input system

In general input systems, it prepare according to their amount of requirement from supplier or other place for attaining their goal and controlled by sub division of management systems.

General Input systems responsibility:

- Balance amount of input raw materials with processing efficiency
- Reduce input problems which affect the end product
- Facilitating the input for the next activities /process according to the attainment of the end goals.

Process systems (activities)

In bottled manufacturing system there is different process are there, those process are interconnect to each other in order to attain at the end goals according to its requirements (Figure 4).

Over all flow chart of the bottled water manufacturing process has different process and all are interconnect and follow each other.

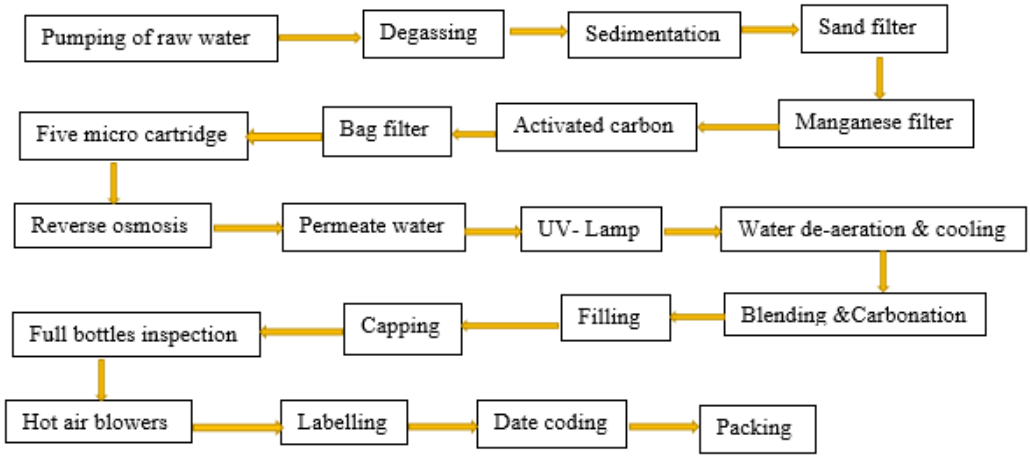

Figure 4. Process systems (activities)

In the process there are interdependent process in order to produce the end usable product according to satisfy the customers/users.

Operators control each and every process by:

- Control any bottleneck problems in each process which affect next process
- Check and control any defective process which affect the end product
- Balance the consecutive process efficiency according to their process.
- Evaluate and managing the responsibility of sub operators exist on the process.
- Check overall output of the process is attain the goal and satisfy the user.

Output systems (end product) is presented on Figure 5.

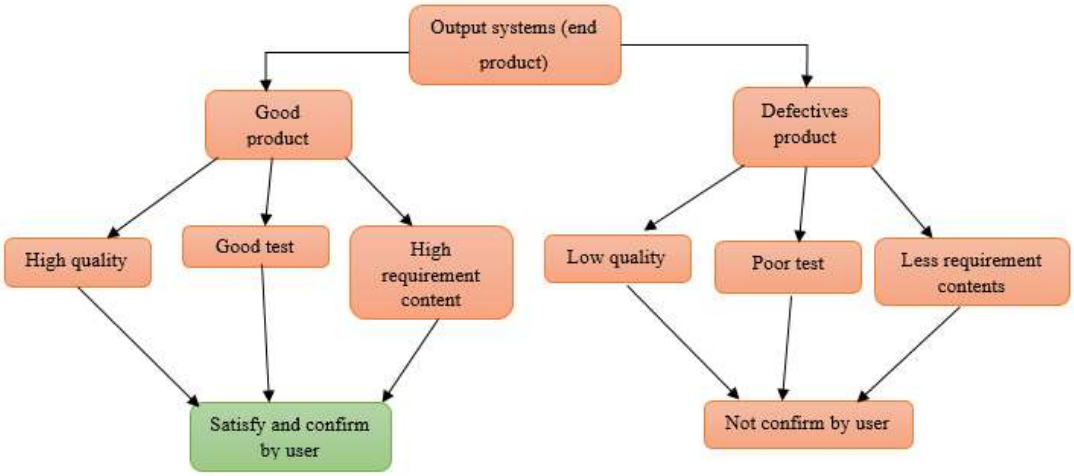

Figure 5. Output systems (end product)

Apply system engineering processes for the analysis

System engineering process input

In manufacturing system the engineering inputs depend on the goal of that manufacturing sectors, but in bottled water company, the system engineering process inputs it contain the basic requirement for the system engineering process and output (Figure 6).

Figure 6. System engineering inputs

Exist problems: it needs to as input for starting a given project or manufacturing process, because if there is a problem there is customers' needs problems.

Goal/objectives**:** then depend on the identified problems, next identify the general objective and specific objective in order to attain at the requirement.

Requirement: in this case specify the steps, material/equipment, cost, man power etc. needed.
Project: is the over all of the input and prepare the next steps of the system engineering process output

Systems Engineering Process Output
To solve the exist problems applying engineering process start from identifying problems up to getting solution for users it looks as follows (Figure 7):

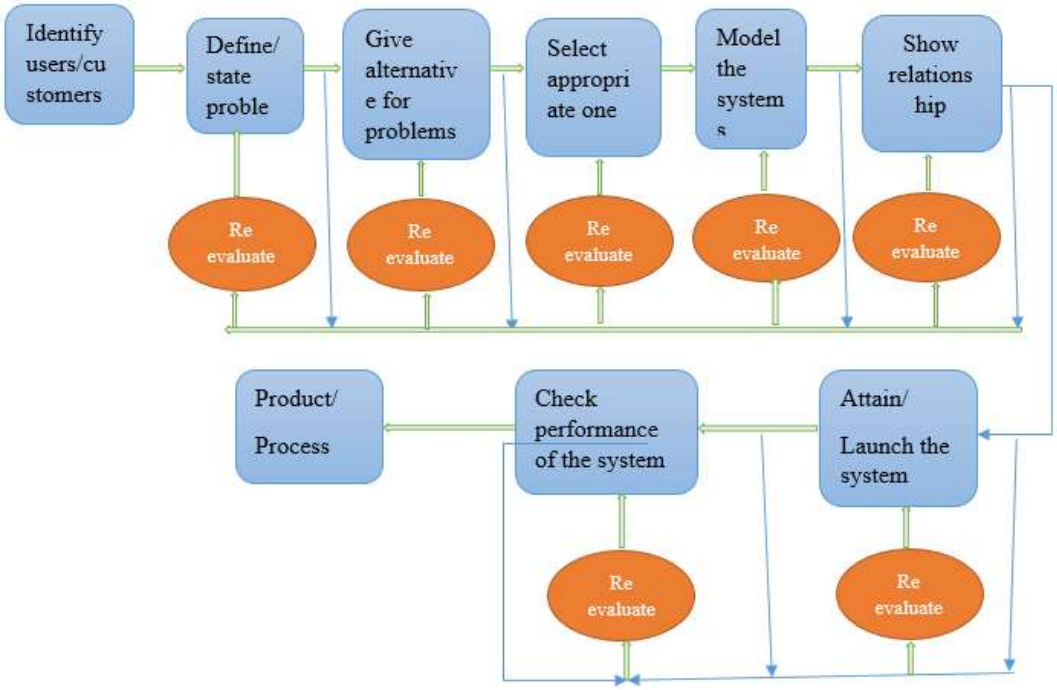

Figure 7. System engineering process output

Identify users/customers need:
Identification of the customer needs is essential in establishing a given system or manufacturing systems. Then first identify the exist systems and systems not exist around the customers.
The way to identify the customer needs:

- Asking/communicating with customers about their interests.
- Checking of existing gap around the customers.
- Supply – Demand gap analysis.
- Identify exist conditions which different from others area.

Define/state problems:
After customers need identified, then define the problems in each term step by step. Because it used to detail understanding of exist problems with different comparison in order to give priority for the selection among exist.
Give alternative for problems:
Different problems not solved at the same time, so depend on the stated criteria it give alternative among the exist problems.
It give alternative depend on the:

- Level of customers need.
- Existing resource
- Degree of requirements
- Easy to solve and attain for the goals.
- Level of supply – demand gap with market gap.

Select appropriate one:
Depend on the above criteria it select which affordable one among all.
Which is:

- Fulfil customers need
- Establishing/ building by existing resources
- has high degree of requirements
- Easy to apply in a requirement time according to its needs.
- Reduce supply demand gaps.

Model the systems:
According to its requirement it model the system in detail form with its sub system. In manufacturing process it start from input up to end product/process with the users it needs clear modelling of the system.
Show relationship/ integration:
Clearly show the relationship between each sub system with each other's. Because there is a different process and activity are there in manufacturing system, so it require detail understand of their integration.
Attain/launch the system:
Check the fulfilments of the system according to its requirement. Because there complex systems with interconnect to each other during this may be the system fail, so it require more attention check-up in each sub system for attainment of the goals.
Check performance of the system:

Evaluate the performance of the system in each process with sub system. The systems which install is working according to expectations or not. If it is not, take some actions according to its systems.

Product/process:

In manufacturing process the end product should be produced according to the customers need. It evaluate in different form:

- Customer/users satisfactions
- High Quality
- Less cost of production
- Less defects

System Dynamics to analyses interactions and relationships within the system

In system dynamic there is nonlinear behaviour of complex systems over time and also there is variables and relations vary with time (Figure 8).

In bottled water manufacturing systems, the overall systems are dynamic. It means it change with a time through the process. Those systems are changed by positive or negative way. Like:

- Raw materials**:** in this case raw material level is not constant through the process. Because it increase sometimes (+ve) and it decrease other times (-ve), in case of changing on raw materials it may affect or change the other systems.
- Demand (customer interest): the demands for the product is also it change through the time.
- Workers force**:** start from overall management system to the operators, it change through time depend on the experience, education level, Age, gender, etc.
- Stock**:** stock also change through time it depend on the customers. If there is intensive costumers may be exist product on the store is decrease and if there is less customers it increase the stock.
- Product price**:** price of the product also change though a time with it increase or decrease pricing.
- Costs**:** the overall manufacturing costs also change over a time.
- Machine efficiency**:** may depend on the working duration the efficiency of the machine also it change through the time.
- Technology**:** in manufacturing system technology play a great role, but it change through the time. Like updating exists, adopting and introducing a new technology.
- Contents of the products**:** depend on the customers' need sand quality of product, contents also it change.

Feedback**:** through the time the way and style of the feedback it also change and it depend on the exist conditions. All above things when it changed it affect the other directly or indirectly, because there is interaction and interdependent between them. There interaction is as follows:

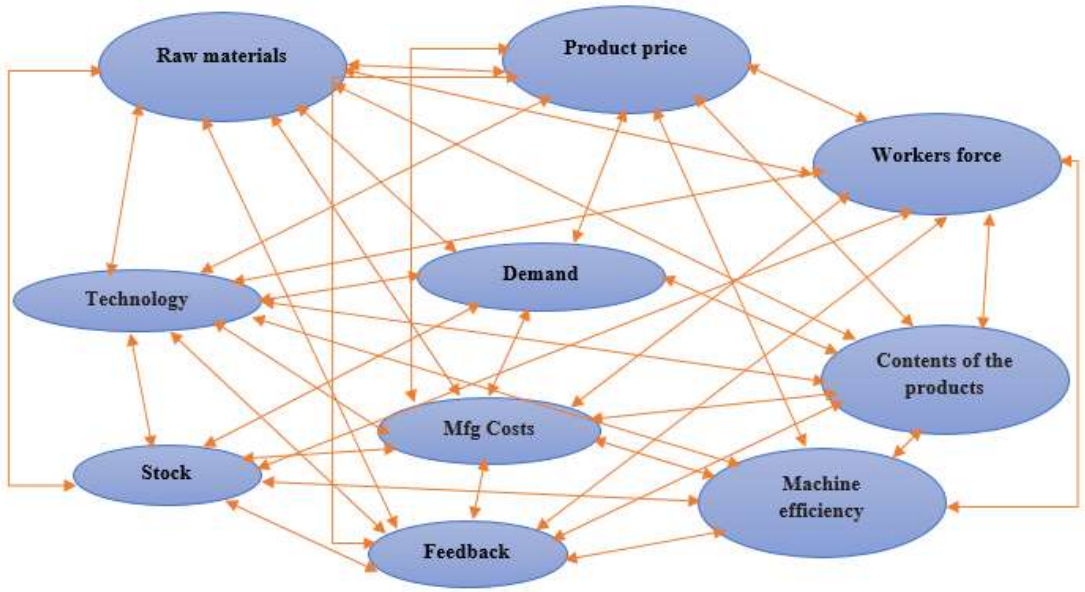

Figure 8. Interaction and relationship between of system dynamics

Conduct stakeholder analysis and life cycle analysis

Stakeholders:

A stakeholder is anyone or in organization having a vested interest in a system and its outcomes. Every human-made system is supported by human roles with different objectives and agendas that contribute to the overall longevity and performance of the system throughout its life cycle.

In the bottled water manufacturing systems there are different stakeholder:

- Owners of the systems
- user(s) of services and end products
- Services provider
- System administrator
- Mission planner
- Analyst of the systems
- Maintainer

- System instructor
- System competitor
- System adversary
- System threat
- Operators and supervisors

Requirement analysis stakeholders and life cycle analysis

The requirements of the stakeholders are it depend on the size of the systems. Number of users of the product used to determine amount of product produce by the company, but all users/customers need satisfaction in order to fulfil the customers' needs it to make balance between stakeholders and each activity in the systems (Figure 9). The main requirement and life cycle of the systems and this life cycle of the systems it shows interconnection between users' needs and user's satisfaction and also it shows all elements of the systems goals are the same with satisfaction of the user at the end of the product.

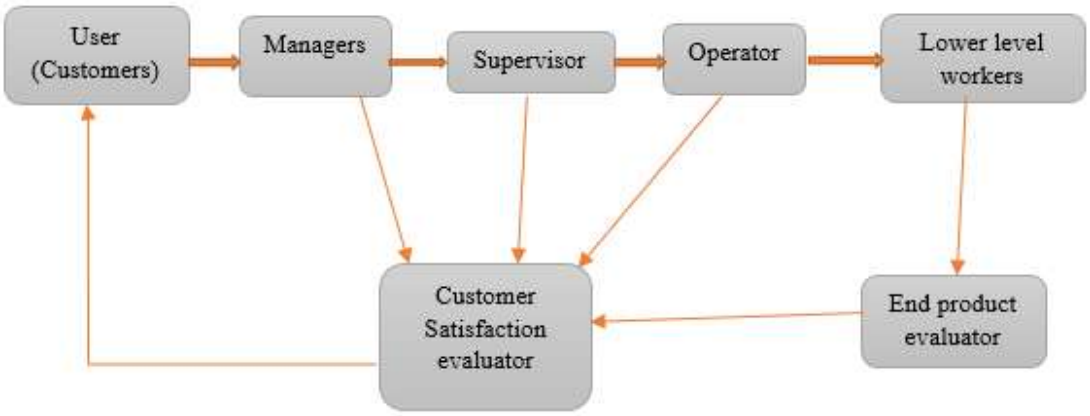

Figure 9. Stakeholders' requirement analyses

Life cycle bottled manufacturing sector

In each life cycle it depend one on other life cycle in each process in bottled water manufacturing sector, this indicates no one processed and attain the goals alone. Main elements of the systems and their life cycle on bottled water (Figure 10):

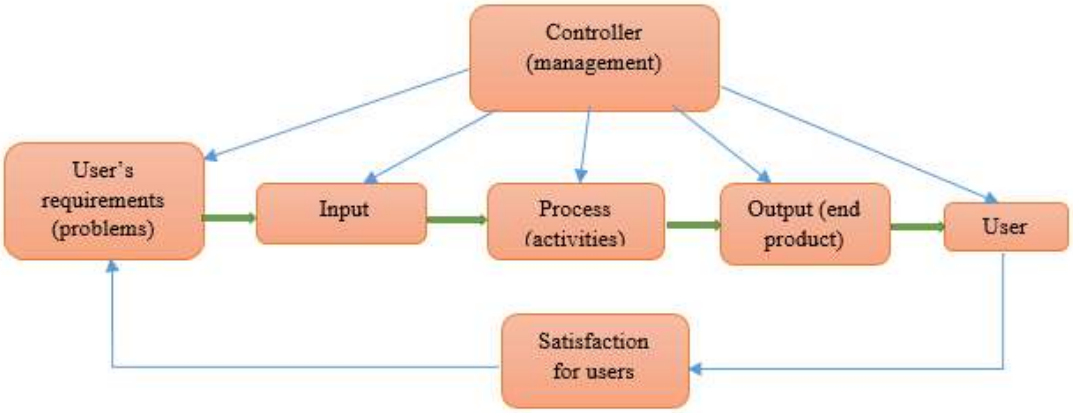

Figure 10. Life cycle system

Propose ways of manage of waste disposal at the end of life cycle

At the end life of system there is disposal in any manufacturing systems, it may be different from organization to organization. In order to save peoples and environment from deferent problems it needs to properly manage this wastages (Figure 11). Major waste disposal of bottled water manufacturing are:

- **Plastic bottles:** after it uses, those plastics can recycle and re uses. If it mixed with environment it affect, because it is not easily changed to the soil.
- **Sewages:** this disposal is after the end process or in the process some unwanted liquid are released from factory. Those sewages are if mixed with lake or river it affect the peoples around the factory also affect the environment. So by using underground piping possible to remove this unwanted substances through separating from rivers.

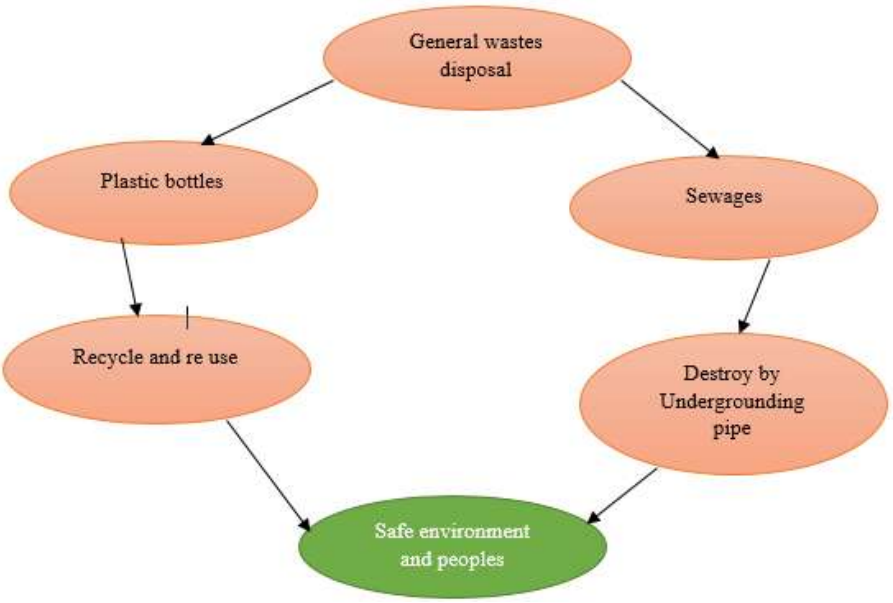

Figure 11. Ways of waste disposal at the end of life system

4. CONCLUSION

To increase the competitiveness of the bottled water manufacturing sectors in Ethiopia, it needs to develop the quality system of engineering throughout the organization. Because of Quality of the system engineering process is the basic requirement in the bottled water manufacturing process, because there is a quality system related problems are there in the overall organization. Solve of quality system engineering problems through detail analysis the system, subsystems and components, dynamicity and interrelationship of each systems with clear life cycle and proper waste disposal of the bottled water manufacturing sectors with clearly showing and analyzing by using of different interconnections charts and diagrams and it used to increases of overall quality of system engineering process of the bottled water manufacturing sectors by clearly investigation of the systems with subsystems and components are clearly understands by stakeholders with good and clear life cycle with proper waste disposal proposed and the quality of system engineering process of bottled water manufacturing sectors are increased with sustainable development and customer satisfaction.

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