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Metal Manufacturing Industry Waste Management: A case of Kaliti Metal Products Factory

By:

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School of Mechanical and Industrial Engineering

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This is to certify that the thesis prepared by Moges Hagos entitled: Metal Manufacturing Industry Waste Management: A case of Kaliti Metal Products Factory and submitted in partial fulfillment of the requirements for the degree of, master of Science (Mechanical and Industrial Engineering) complies with the regulations of the university and meets the accepted standards with respect to originality and quality.

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I hereby declare that the work which is being presented in this entitled ": A case study in Kaliti Metal Products Factory'' is original work of my own, has not been presented for degree of any other university and all their source of material used for this have been acknowledged.

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______________________ ___________________

Dr. Kassu Jilcha **Date**

(Thesis Advisor)

DEDICATION

I would like to dedicate this work to my family especially for my daughter, Hanan Moges, for her sacrifice and endless support at her youngster age.

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ABSTRACT

Waste management (WM) looks to be one of the key topics in the manufacturing industry for economical sustainability or a shift towards a circular model of resource consumption, health of nations as well as environmental protection in present days.

The Purpose of the study is to investigate the current situation of waste management in metal manufacturing industry at the case company, Kaliti Metal Products Factory, in Ethiopia. The research methodology followed was applying both qualitative and quantitative methods for the case study approach. Descriptive statistical package for social sciences (SPSS) and Microsoft Excel were applied to analysis of the collected data. In this research the primary data were gathered through questionnaires, structured interviews or group discussion and the secondary data sources were collected through literature reviews from different sources of scientific journals, and observations. On factory shop floor survey was also done to investigate the major problems of the metal manufacturing industries related to waste management, in the case company, Kaliti Metal Products Factory (KMPF).

The results and findings obtained from the data analyses shows 75 % of the total production time for standard products and 56 % of the total production time for other engineered products were found waiting time waste according to lean principle; 331.205 ton of metal wastes from standard products department and 23.15 ton of metal wastes from other engineered products departments, totally 377.505 tons of metal wastes were found. The main sources (causes) of metal wastes in the case company were found to be technology constraints, selecting the lowest price bidder suppliers and sub-suppliers, poor time management (waiting time), damage of output products and poor technology of machines and equipment, lack of contribution of the management system aiming at waste minimization, lack of transformed industrial design, Lack of 100% Recycling and Recovery, and New infrastructure & system thinking were considered as the extreme significant by the respondents for the cause of wastes in the case company.

In general, the mitigation measures to practice for reducing metal products wastes in metal manufacturing industry are, management initiative & focus, giving training for metal products manufacturing personnel on causes and remedies of metal wastes through the integration of the Lean & the Zero Waste Management. So, proper awareness and attention to waste management in the metal manufacturing industry in Ethiopia can improve the profitability and competitiveness of the metal manufacturing industry significantly, particularly for the case company, Kaliti Metal Products Factory (KMPF) since zero metal manufacturing waste is disposed directly to landfill or to incineration without energy recovery.

Keywords: Metal Waste, Lean, Zero waste, waste management, metal manufacturing industry

LIST OF ABBREVIATIONS

KPC = kg per person per year

ISWM = Integrated Sustainable Waste Management

MSW = Municipal Solid Waste

GHG = Greenhouse gas

CH4 = Methane

CO2 = carbon dioxide

N2O = nitrous oxide

3R = Reduction, Reuse and Recycle

MSWM = Municipal Solid Waste Management

GDP = Gross Domestic Products

FDRE = Federal Democratic Republic of Ethiopia

WM =Waste Management

KMPF = Kaliti Metal Products Factory

EU = European Union

USA = United State of America

IWM = Industrial Waste Management

S.S. = slightly significant

N.S. = not significant

RII = Relative Importance Index

EDCM = Environmentally Conscious Design and Manufacturing

GNI = Gross National Income

WPr = Waste Prevention

ZWM =Zero Waste Management

UN = United Nations

HDIR = Human Development Index Rating

SW = Solid Waste

SPSS = statistical package for social sciences

hrs. = hours

CZWE = Circular Zero Waste Economy

BAT = Bet Available Techniques (BAT)

LM =Lean Manufacturing

TPS = Toyota Production system

JIT = JUST IN TIME

WIP = Work in Progress

Dr. Ing. = Doctor Engineer

E.S. = extremely significant

V.S. = very significant

M.S. = moderately significant

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CHAPTER ONE

1. BACKGROUND AND INTRODUCTION

The creation and release of a bulk amount of wastes that have greater negative impact on the human health as well as on the environment are due to population size increment, fast economic growth, rapid expansion of urbanization and fast growing of manufacturing industries across all countries in the world (Owolabi, Mmereki, Baldwin, & Li, 2016). Manufacturing industries have tried to improve the economic growth of nations across the developed and developing countries however, a large amount of industrial wastes is generated daily (Mallak, Ishak, Kasim, & Samah, 2015).The high-income countries usually generate *521.95–759.2 kg per person per year (kpc)* and *109.5–525.6 kpc* on the average by developing countries. Current forecast on municipal solid waste (MSW) generation worldwide surpasses 2 billion tons per year, which is a potential risk to environmental destruction (Karak, Bhagat, & Bhattacharyya, 2012).

Worldwide, one of the considerably contributors to Greenhouse Gas (GHG) emissions is the waste sector and accountable for approximately 5% of the global GHG budget, with total emissions of approximately 1,300 metric tons of CO2.Solid waste disposal areas discharge landfill gases such as Methane (CH4), carbon dioxide (CO2), small amount of nitrous oxide (N2O), but Methane is 21 times more annoying problems related to Global Warming. Additionally, insufficient solid waste management experiences may lead to affect human health, living resources, and environment including water pollution (Starovoytova & Namango, 2018).

The total population, earnings, awareness level, professions and personal approach are indirectly affecting to the waste generation (Zulkipli, Nopiah, Basri, & Kie, 2016). In Asian countries such as Japan, Taiwan and Singapore have enhanced their waste management systems toward more viable approaches with less landfill disposal and more for focusing on waste minimization. The aim of 3R policy launched in Japan was to strategically minimize waste and stimulate Reduction, Reuse and Recycling activities. 3R stands for Reduction, Reuse and Recycle of wastes located at the highest level of waste management hierarchy. In these countries waste minimization has higher preferences with more focused on energy conservations followed by reuse and recycling. Landfill disposal is located at the lower level of the waste management hierarchy followed by energy recovery, recycle, reuse and waste minimization. Nowadays majority of Asian developing countries have lowest interest in landfill disposal to use as a method (Mallak, Elfghi, Rajagopal, Vaezzadeh, & Fallah, 2016).

In Africa some studies show that rapid population growth, increasing in income level, expansion of urbanization, expansion of industrialization and agricultural development in production give high rise of waste generation that highly impacts the nation's health and green environment pollution (Mbuligwe & Kaseva, 2006) (Al-Kindi & Alghabban, 2019). Municipal solid waste management (MSWM) includes the activities of collection, transfer resource recovery, recycling and treatment. The main target of MSWM is to keep the health of nations, motivate environmental quality and give support to economic productivity (K.Henry, Yongsheng, & Jun, 2006).

Globally total municipal solid waste generation was reported to be from 1.7 to 1.9 billion tons per year and the waste collected was 1.24 billion tons per year. The contribution of the manufacturing industry in generation of waste was from 1.2 to 1.67 billion tons of non-hazardous wastes and 0.490 billion tons per year of hazardous wastes; the wastes collected from manufacturing industry was 1.2 billion tons of non-hazardous wastes and 0.3 billion tons per year of hazardous wastes were collected respectively (Singh, Laurenti, Sinha, & Frostell, 2014).

Some studies showed that in developing countries has also faced solid wastes in high production rates problems in the cities more than their capacities. Waste collection rate are usually less than 70% and more than 50% of the collected waste is often disposed in a way of uncontrolled landfilling; particularly in Ethiopia it was described that about 20 % to 30% of the waste created in Addis Ababa, the capital city remains uncollected and the metal wastes collected were about 1 % (Lema, Mesfin, Eshete, & Abdeta, 2019) . Another study in Addis Ababa city shows that it faces solid waste management problems like other cities in developing countries (Regassa, D.Sundaraa, & Seboka, 2011).

Rapid economic development with real Gross Domestic Products(GDP) growth rate of 10.5 % per year has been registered in Ethiopia from the year 2005 to 2014.This sustained double digit economic development has helped in changing millions of people's life standard that increase the consumption of the households (Eshetie, 2018). In Ethiopia due to an immense increment of rapid urbanization and economic development there are high amount of wastes in the cities (Hailemariam & Ajeme, 2014).

The Ethiopian government has been aware of the negative effect on the people's health and environment. In response to this, the Ethiopian government has passed a Solid Waste Management (SWM) proclamation number 513 in 2007 which aims to encourage community participation in order to avoid adverse effects and enrich benefits from solid waste. It provides for preparation of solid waste management action plans by urban local governments (FDRE Ministry of Industry , 2014).

Waste management (WM) looks to be one of the key topics for green manufacturing for both economical sustainability as well as environmental protection in present days and also in the future. Resource management maintainability necessitates 'decoupling' resource consumption with the economic development and a shift towards a circular model of resource consumption, where resource reuse and recycling are introduced through strategic planning throughout the production and consumption chain. This leads to waste management in handling environmental beyond simple safe disposal or recovery of wastes that are generated and seek to address the root cause of the problem by attempting to alter unsustainable patterns of production as well as consumption (Singh, Laurenti, Sinha, & Frostell, 2014).

The Purpose of the study is to investigate the current situation of waste management in the metal manufacturing industry, in the case company of Kaliti Metal Products Factory through the integration of Lean and the Zero Waste Management Strategy.

1.1. Statement of the problem

Metal wastes are critical raw materials that currently has been getting greater focus in economies such as those of European Union (EU), United State of America (USA) and Japan in the issue of significance in material security even if these critical raw materials do not typically produce large volume waste (Hollins & Institute, 2017). Manufacturing of goods produce tremendous amounts of wastes from 1.2 to 1.67 billion tons per year of non-hazardous wastes and 0.490 billion tons per year of hazardous wastes; the wastes collected from manufacturing industry was 1.2 billion tons of non-hazardous wastes and 0.3 billion tons per year of hazardous wastes respectively (Singh, Laurenti, Sinha, & Frostell, 2014).

Low-income and developing Asian countries are facing a number of challenges with respect to sustainable waste managing from their industrial activities. On the other hand, these countries aim to be industrialized and consequently, generate massive industrial solid wastes with an increasing trend. It was pointed out that illegal industrial waste disposal has increased sharply due to the land scarcity. Meanwhile, there is less attention to practicing waste minimization as a sustainable and effective strategy for controlling industrial solid wastes in developing Asian countries. The lack of significant factor such as strict regulation and strong enforcement, awareness and knowledge, adequate financial support, technology and skilled manpower are found as the main obstacles to sustainable industrial waste management of Asian countries (Mallak, Elfghi, Rajagopal, Vaezzadeh, & Fallah, 2016).

African countries involved in industries such as iron and steels, food, textile, furniture, clothing, chemicals, printing and food industry are ranked first for the generation of waste that harms the health and environment (Bello, Ismail, & Kabbashi, 2016).Lack of metal waste management and follow up in manufacturing industries were also reported. (Al-Kindi & Alghabban, 2019) .

Developing countries has also faced solid wastes in high production rates problems in the cities more than their capacities. Waste collection rate are usually less than 70% and more than 50% of the collected waste is often disposed in a way of uncontrolled landfilling; particularly in Ethiopia it was described that about 20 % to 30% of the waste created in Addis Ababa, the capital city remains uncollected and the metal wastes collected were about 1 % (Lema, Mesfin, Eshete, & Abdeta, 2019) .

Another study in Addis Ababa city shows that it faces solid waste management problems like other cities in developing countries. Solid waste, which is a consequence of day-to-day activity of human kind, needs to be managed properly. Addis Ababa, like other cities in developing countries, faces problems associated with poorly managed solid waste operations (Regassa, D.Sundaraa, & Seboka, 2011). Lack of better municipal solid waste management in Addis Ababa has many effects on social health, economic and environment every year (Mekonnen & Gokcekus, 2019) .

In Ethiopia, all input materials purchased are not fully converted or transformed to output products during manufacturing due to different constraints such as lack of waste management system and technology. The left-over materials remain as waste that may not be considered for proper control of material effectiveness at different stages of manufacturing related activities has caused waste and associated to environmental and health problems in opposing to the Ethiopian Solid Waste Management Proclamation No. 513/2007 (FDRE Ministry of Industry , 2014) .

During the interview, the Marketing Manager said the metal wastes of the company was increasing and facing raw material scarcity due to various global and local problems. In the case of Kaliti Metal Products Factory (KMPF) less attention is also given to waste management. Products designers and Production process managers often fail to identify and control waste during the product design and production processes because of the absence of appropriate tools to measure waste and indicate their economic advantages. Averagely about 1.5 tons of metal wastes were produced every year in KMPF in the previous five years staring from 2015 up to 2019. In the present situation, the factory is mainly concerned on how to control cost and be profitable company without giving much emphasis on waste generators and controlling mechanisms or strategies.

Hence, this research assessed the types, causes and factors influential to metal waste and measures to effectively control metal waste in metal products manufacturing. Therefore, this research has determined the current situation with regard to waste management in metal products manufacturing industry in the case company, Kaliti Metal Products Factory and assessed the effectiveness of the waste control measures with a view to seeking for ways to minimize metal waste in order to improve resource utilization that leads to company profitability.

Following the problem justification, this research will be expected to answer the following questions:

1. What are the major sources (causes) of wastes?
2. How much is the level of wastes in the metal manufacturing industry, the case company in particular?
3. How can the knowledge of waste management for metal manufacturing industry be upgraded or improved?

1.2. Objectives

1.2.1. General Objective

The general objective of the study is to investigate the current situation of waste management in the metal manufacturing industry in the case company, Kaliti Metal Products Factory and propose waste free metal manufacturing strategies.

1.2.2. Specific Objectives

1. To assess waste management practices in the case company, KMPF.
2. To identify the key causes and levels of waste in case company, KMPF
3. To propose improvement strategies to upgrade the knowledge of waste management for metal manufacturing industry.

1.3. Significance of the Research

This research is very significant in that it will help the people engaged in industrial waste management of the metal products manufacturing industry in Ethiopia, for the case company, kaliti Metal Products Factory (KMPF) while they are designing, manufacturing, transporting and storing at the factory.

In addition, this research intends to provide some framework for the development of policies and regulations in the waste management areas. It can also be useful for academicians and researchers who want participate in the Waste Management in

Metal Products Manufacturing Industry in Ethiopia since there is a research gap in this area.

In research gap finding, extensive literature reviews were conducted to support the thesis with different perspectives. After reviewing these selected papers, the following literature gaps are identified. There are limitations in the definition of waste in the context of zero waste management and lean management that leads to confusion. In the zero-waste management definition *waste* is regarded as material not required by the owner or producer (Zaman & Lehmann, 2013),& (Al-Kindi & Alghabban, 2019). However, the meaning of the word 'waste' in lean manufacturing context, in which it refers to losses in productive systems such as overproduction, waiting and transportation (Tortorella, et al., 2018), (Prasad & S.K.Sharma, 2014) and (Pattanaik & Sharma, 2009). Lean manufacturing is widely adopted and appealed to increase productivity, decrease manufacturing time (lead time) and costs and improve quality, through a systematic reduction of waste (Womack & Jones, 2003),and (Pavnaskar, Gershenson, & Jambekar, 2003). Nevertheless, the so-called lean waste elements such as waiting time, inventory, overproduction, transportation, reworks and loss of employee potentials were not included in the zero-waste concept. Loss of employees' potentials was considered as waste in lean management approach (Womack & Jones, 2003) . The dominate causes of the waste in the metal manufacturing industry waste management in Ethiopia were not addressed.

There is also literature gap about the integration of waste management approaches in the manufacturing industry, environmental and health considerations (Singh, Laurenti, Sinha, & Frostell, 2014), (Karak, Bhagat, & Bhattacharyya, 2012), (Demirbas, 2010) and Quantifying and identifying causes(sources) of wastes in the manufacturing industry were not researched adequately by integrating the zero-waste and lean management(manufacturing) concepts (Shahbazi, Kurdve, Bjelkemyr, Jönsson, & Wiktorsson, 2013),and (Bello, Ismail, & Kabbashi, 2016).In most research theoretical justifications were set as a final destination of paper but in most research not validated practically.

From this research study the following can be beneficiaries:

1. Participants in Industrial or manufacturing industry waste management and general public.
2. Educational institutions, which use the information for academic purposes.
3. Private/governmental organizations or manufacturing factories or firms that use the data for different purposes in order to understand about the waste management in the metal products manufacturing industry.
4. Future studies in manufacturing industry waste management, and related topics.

1.4. Scope and Limitation of the Research

This research was limited and focused on Waste Management in the metal products manufacturing industry in Ethiop at the case company, Kaliti Metal Products Manufacturing Factory. The study only investigated the manufacturing processes and the factory areas to investigate metal waste impacts on health and environment as well as on waste management in the case company.

Due to time and money as well as the pandemic disease called Covid-19 all products design and manufacturing processes were not addressed. Only high-sales income products were selected and studied with careful self-protection from Covid-19.

1.5. Organization of the study

The Organization of the study is classified in different chapters, as follows:
Chapter One: Back ground and Introduction: This section provides a background of the topic researched in during the study. The main idea of this chapter is to explain the background of the problem, the objectives and the contribution made by this research study.

Chapter Two: Literature Review: This chapter provided information about the main subjects of metal manufacturing industry waste management to providing the practical suggestions and recommendations to upgrade the knowledge of waste management in the metal manufacturing industry at the case company, Kiliti Metal Products Factory (KMPF) and drew research gaps that fills the gap in the body of knowledge for the research topic under investigation. In addition, this chapter provides a theoretical foundation with the formulation of some suggestions from the literature, which are the basis for the research methodology.

Chapter Three: Research Methodology: - This chapter provides the plan of the research. In other words, this section explains the research paradigm, approaches, strategies and data collection methods. In this research, a case study strategy is used to answer the research questions.

Chapter 4: Data Analysis, Discussions and Interpretation: - this section provides the results from the case study in the case company and analysis to make a comparison with the existing literature. In addition, these results are used in this section to see the way in which they help confirm. On the other hand, this chapter also provides a critical evaluation of the research work including the limitations of the research.

Chapter Five: Proposed waste management strategy

Chapter Six: Conclusions and Recommendations: This section will be summarizing the main issues of this thesis and it presents an overview of the main findings. It also concludes the research met the proposed objectives or not.

CHAPTER TWO

2. LITERATURE REVIEW

2.1. Introduction

This Literature Review Chapter covers mostly reviewing of literatures about Metal Manufacturing Industry, Waste Management, the zero-waste management strategy and Lean Manufacturing (Lean Management). In each topic and subtopics, the theoretical philosophies, major problems raised, the methodologies and approaches to solve these problems, the results, and conclusions were included. At the same time, the literature gaps were identified from the literature in order to fill the body of knowledge.

2.2. Metal Manufacturing Industry

Globally, manufacturing industries play a vital role in economic development and improving the life standard of nations as a study showed in Malaysia. However, a huge quantity of industrial wastes is generated daily, aggravating landfill disposal issues (Mallak, Ishak, Kasim, & Samah, 2015). According to Zaman (2015), the global population has been increasing along with economic expansion and greater consumption accompanied by rising demand for natural resources. Consequently, there has been a significant depletion of global, non-renewable natural resources over the last few decades, with an increase in waste generation causing an environmental impact (Zaman, 2015).

The ultimate target of manufacturing industry in modern society is improving the living situation with economic growth; however, manufacturing sustainable waste management in many low-income countries and developing Asian countries encountered challenging problems such as expansion of industrialization need and the consequence of large amount of industrial wastes generation with an incremental trend. Most Asian countries have practiced landfill disposal techniques for industrial solid waste even though illegal industrial waste disposal increased due to land shortage (Mallak, Elfghi, Rajagopal, Vaezzadeh, & Fallah, 2016). Waste products discarded to the waste management (WM) systems have been increasing enormously due to product diversity in quantity and variety, but categorizing and sorting waste is limited to few numbers. Products with complex material composition are usual challenging to treat when they are discarded at the end of their useful life span. This shows waste management system to handle the wastes in more appropriate way is challenging due to poor sorting and difficulty of treatment processes of wastes (Singh, Laurenti, Sinha, & Frostell, 2014) .

Solid waste can be defined as," Any material that is not required by the owner, fabricator or processor." Solid Waste may be categorized as Domestic waste, Industrial waste, Waste from oil plant, Electronic-waste, Construction waste, Agricultural waste, Food treating waste, Bio-medical waste, and Nuclear waste (Mekonnen & Gokcekus, 2019)& (Al-Kindi & Alghabban, 2019).

Waste minimization using the mechanisms as reduce, reuse and recycle (3Rs) instead of waste disposal have greater importance for both economic growth and environmental protection. Metal products such as steel may be used in various construction and industrial applications, such as machineries, reinforced bars, structural frames, vessels, highways, cutting tools, and trucks and trailers. Annual production of steel is 1500 million tons and that 85% of annual steel production is recycled globally (Al-Kindi & Alghabban, 2019).

Waste minimization as the best viable approach of waste handling gives an improved reduction of waste. In Malaysia, practicing waste minimization by manufacturing firms is not very common (Mallak, Ishak, Kasim, & Samah, 2015). Controlling industrial wastes in developing Asian countries is given less concern to practice waste minimization as sustainable and effective strategy due to lack of strict guidelines and strong administration, consciousness and knowledge, enough finance, technology and skilled manpower are found as the main hindrances to sustainable industrial waste management among Asian countries (Mallak, Elfghi, Rajagopal, Vaezzadeh, & Fallah, 2016).

Waste generation is predictable during the production and consumption of resources that gives rise for further unplanned outputs, such as wastes from industrial processes that use energy and material during the use-phase of the products manufacturing at the mean time lead to waste collection and treatment in addition to the gaseous emissions generation, which might be unintentionally harmful of the environment as well as public health. Table 2.1 indicates the estimated amounts of wastes generated from different sources such as extraction, production and consumption (Singh, Laurenti, Sinha, & Frostell, 2014). Collection of industrial waste management (IWM) has been done by the source industries (60%) and private contractors (40%). The total industrial waste management generation rate is 39,000 tons/year and of among this 91.7% comes from food and beverage industries (Mbuligwe & Kaseva, 2006).

Industrial wastes in many countries, are managed by the municipalities, thus they are regarded as part of waste management (WM) streams but in some countries, waste generated by the production of energy, and minimizing waste considered as industrial wastes (Singh, Laurenti, Sinha, & Frostell, 2014) and (Mbuligwe & Kaseva, 2006).

Table 2. 1 Estimated global waste generation and collection in the year 2006 (Singh, Laurenti, Sinha, & Frostell, 2014)

Sources of waste	Waste (in billion tons/year) Generated	Waste (in billion tons/year) Collected
Mining, electricity and water industry (non-hazardous)	6.4	No data available
Manufacturing industry (non-hazardous)	1.2 to 1.67	1.2
Manufacturing industry (hazardous)	0.490	0.3
World total municipal solid waste	1.7 to 1.9	1.24

Industrial waste generation and composition depends upon various factors, such as the expansion level of industrialization and nature of industrial arrangement in the country. Mining activities to supply raw materials for energy generation and goods manufacturing produce tremendous amounts of wastes, often non-hazardous wastes indicated in Table 2.1 above (Singh, Laurenti, Sinha, & Frostell, 2014). Generally, African countries involved in industries such as food, textile, furniture, clothing, iron and steels, chemicals, printing and food industry are ranked first for the generation of waste that harms the health and environment (Bello, Ismail, & Kabbashi, 2016).

The composition of the Municipal Solid Waste (MSW) of Addis Ababa presented has been very low. The type of source (household, commercial, etc.), revenue level, season and some actions will have pressure on the composition of solid waste (SW). The present composition can have diverse appearance than showed below in the table 2.2 The solid waste management (SWM) status thesis report by Meaza Cheru (2016) shows that 60% of the total wastes are organic, 15% comprises of recyclables materials and others are about 25% (Cheru, 2016).

Table 2. 2 the composition various types of solid waste in AA city (Cheru, 2016) and (Mekonnen & Gokcekus, 2019).

S. N	Major constituents	Percentage
1	Ash, dust, fine	65%
2	Combustible leaves and grasses	15%
3	Vegetables and fruits	4.20%
4	Rubber and plastics	2.9%
5	Non-combustibles	2.50%
6	Papers	2.50%
7	Textiles	2.40%
8	Woods	2.30%
9	Bones	1.10%
10	Metals	0.90%
11	Glasses and ceramics	0.50%

Solid waste comprises many types of solid waste which is generated from different sources and quantity in the city. The main sources of municipal solid waste in Addis Ababa city are household waste, commercial waste, institutional waste, industrial waste, construction waste, and road sweepings (Mekonnen & Gokcekus, 2019).In Ethiopia even though there is an expansion of urbanization such as Adama, there has been inappropriate plan and sustainable implementation of solid waste management system according to the enlargement of the city that in return it may affects the health and environment (Hailemariam & Ajeme, 2014).

In summary to the literature review of metal manufacturing industry, industrial wastes are produced daily worsening landfill disposal due to the expansion of urbanization, industrialization and improvement of life standard of nations, huge amount of consumption, products volume and diversity increment with complexity in an increasing trend particularly the developing countries manufacturing industries. The wastes generated have greater influence on the economy, health, safety and the environment. Hence to minimize wastes, instead of using waste disposal it is recommended to use the mechanisms as to reduce, reuse and recycle(3Rs) for the economic and environmental protection significance. From the data table 2.1 and table 2.2 it can be concluded that all the amount of waste produced have not been collected both in the developed and developing countries. This indicates less focus is given for controlling manufacturing waste or industrial wastes due to some factors such as awareness, manpower skill, technology advancement and innovation, stakeholders less participation and shortage of financial support. The amount of metal waste contribution to the total waste is less when compared with other types of wastes such plastic wastes. The negative impact of meat waste is creating health problems, safety problems, the environment pollution and brings loss of profitability to the metal manufacturing industry.

2.3. Waste Management

A typical waste management system encompasses gathering, moving, pretreatment, processing, and final reduction of residues. The aim of waste management is to provide clean living atmosphere to reduce the quantity of substance that enters or leaves the society and inspire the reuse of matter in the society (Demirbas, 2010). Waste management is the gathering, transporting, treating, recycling or disposing, and controlling of waste ingredients (Rushton, 2003) and (Demirbas, 2010).

A waste management concept includes the goals of reduction of the whole quantity of waste by reduction and recycling of waste, recycling and re-establishment of appropriate groups of substances towards production cycles as secondary raw material or energy transporter, re-establishment of biological waste into the natural cycle, best possible reduction of residual waste quantities, which are to be disposed on ‘‘suitable” landfills, flexible concept concerning variations in waste quantities and the composition of domestic waste, new technology in the field of waste management must be incorporated into the system (Demirbas, 2010).

According to Rushton (2003), the main methods of waste management were listed as follows:
Recycling: - the recovery of materials from waste products after they have been used by consumers, Composting: - ‘an aerobic, biological process of degradation of biodegradable organic matter’, Sewage treatment: - a process of treating raw sewage to produce a non-toxic liquid effluent which is discharged to rivers or sea and a semi-solid sludge, which is used as a soil amendment on land, incinerated or disposed of in land fill, Incineration: - a process of combustion designed to recover energy and reduce the volume of waste going to disposal, Landfill: -the deposition of waste in a specially chosen area, which in modern sites consists of a pre-constructed ‘cell’ lined with an impermeable layer to decrease emissions (Rushton, 2003).

Municipal solid waste management (MSWM) seems to be one of the key topics for environmental protection in present days and also in the future (Karak, Bhagat, & Bhattacharyya, 2012). Fast economic growth, development of urbanization and increasing population amounts have caused resource consumption to increase, and consequently the release of large amounts of waste to the environment. Presently, waste and resource management lack a holistic approach covering the whole chain of product design, raw material mining, production, consumption, reprocessing and waste management (Singh, Laurenti, Sinha, & Frostell, 2014).

Solid waste (SW) management has become a global concern due to increasing population, rapid economic growth, complexities in consumption patterns, rapid urbanization and worldwide industrialization, inadequate knowledge to implement integrated programs that integrate environmental and cleaner technologies, and the inclusion of hazardous materials in municipal solid waste (SW). For a comparative analysis and discussion, the common practice of using the income criterion, Gross National Income (GNI) per capita, and the 2015 UN World Economic Situation and Prospects report as the main measures for development were followed. Lesser developed countries are defined as countries which are usually poor as measured by per capital gross domestic product, and show the lowest indicators of socio-economic development, with the lowest Human Development Index ratings (HDIR) of all countries in the world and a gross national income (GNI) of US$1025 or less (Owolabi, Mmereki, Baldwin, & Li, 2016).

Waste is defined as anything discarded by any person, household or organization. As a result, waste is a complex mixture of different substances, only some of which are inherently hazardous to health (Rushton, 2003)and (Al-Kindi & Alghabban, 2019). The collection, processing, transport and disposal of solid waste are all important aspects of waste management for public health, beautifying, and environmental reasons (Al-Khatib, et al., 2007).

The volume of waste has been constantly increasing due to the incremental human people and urbanization. Waste materials are generated from manufacturing processes, industries and municipal solid wastes (MSW). Municipal Solid Waste is defined as waste long-lasting materials, nondurable materials, containers and packaging, food leftovers, yard trimmings, and various inorganic wastes from households, *commercial*, and industrial sources. Waste management practices differ for developed and developing nations, for urban and rural areas, and for residential and industrial, producers. The process of extracting resources or value from waste is generally referred to as recycling, meaning to recover or reuse the material (Guerrero, Maas, & Hogland, 2012).

However, waste in Lean Manufacturing (Pavnaskar, Gershenson, & Jambekar, 2003) defines as 'anything other than the minimum amount of equipment, materials, parts, space, and time that are essential to add value to the product'. Waste may be in any forms and can be found at any time and area. There is the waste of complexity, labor (the unnecessary movement of people), overproduction, space, energy, defects, materials, time and transport. Waste uses resources but has no value addition to the product (Pavnaskar, Gershenson, & Jambekar, 2003).

Waste management (WM) actions around the globe have improved continuously in several aspects operationally, technologically and institutionally. Better-quality public health, environment protection, resource effectiveness, struggling climate change, enhanced institutional capability, and increased public awareness and participation were identified as drivers for waste management enrichment. (Singh, Laurenti, Sinha, & Frostell, 2014). Waste related ideas were familiarized as global sustainability problem instead of a local environment challenge. Consolidation of environmental information exchange within the design process, production and waste management (WM) systems has been increased. The focus has been shifted from ‘end-of-pipe’ practices to systems-oriented resource management by preventing waste generation and sustainable treatment of resource wastages (Singh, Laurenti, Sinha, & Frostell, 2014).

Solid waste management is a challenge for the cities’ authorities in developing countries mainly due to the increasing generation of waste, the burden posed on the municipal budget as a result of the high costs associated to its management, the lack of understanding over a diversity of factors that affect the different stages of waste management and connections necessary to enable the whole handling system functioning (Guerrero, Maas, & Hogland, 2012) . The information provided is very useful when planning, changing or implementing waste management systems in cities (Hailemariam & Ajeme, 2014), and (Lema, Mesfin, Eshete, & Abdeta, 2019).

The model admits the importance of three dimensions when analyzing, developing and changing a waste management system. The dimensions are: the stakeholders that have an interest in solid waste management the elements or stages of the movement or flow of materials from the generation points towards treatment and final disposal and the aspects through which the system is analyzed (Guerrero, Maas, & Hogland, 2012).

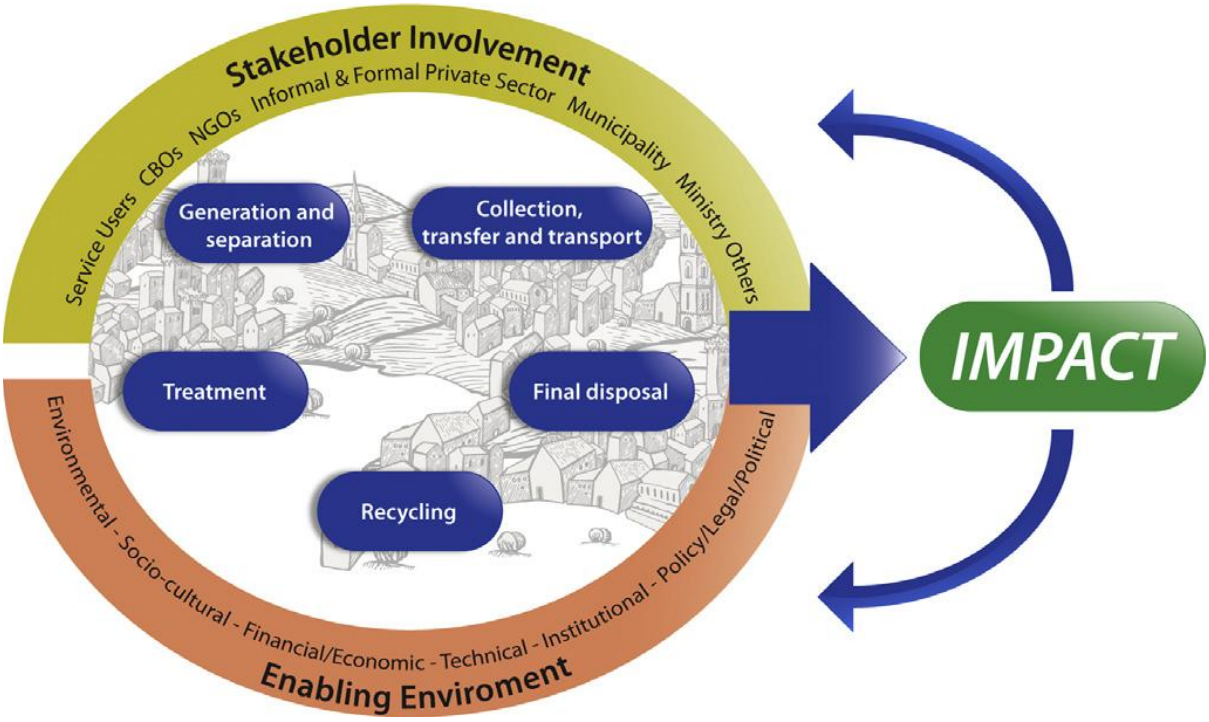

Figure 2. 1 The integrated sustainable waste management (ISWM) model **(Guerrero, Maas, & Hogland, 2012)**

The present work is set within an adapted ISWM framework (Figure 2.1). Especially, it focuses on studying the measures (actions) of the stakeholders, behavior and factors that influence the elements of the city's waste management system and the technical but also environmental, socio cultural, legal, institutional and economic linkages present to enable the overall system to functioning. The existing elements of the waste management systems has been described in terms of waste source and separation, collection, transfer and transport, treatment, recycling and final disposal to facilitate analysis of the information (Guerrero, Maas, & Hogland, 2012).

The waste prevention (WPr) concept according to most of the definitions does not cover the potential of increasing resource efficiency by designing products for recycling and by recovering wastes. Discarded material is by definition waste, even if it is recycled. According to Lilja, 2009 ''*prevention'' means measures taken before a substance, material or product has become waste, that (1) reduce the quantity of waste, including the reuse of products or the extension of life span of products; and (2) reduce the negative impacts to the environment and health of the waste generated, and reduce the content of harmful substances in material and products.*

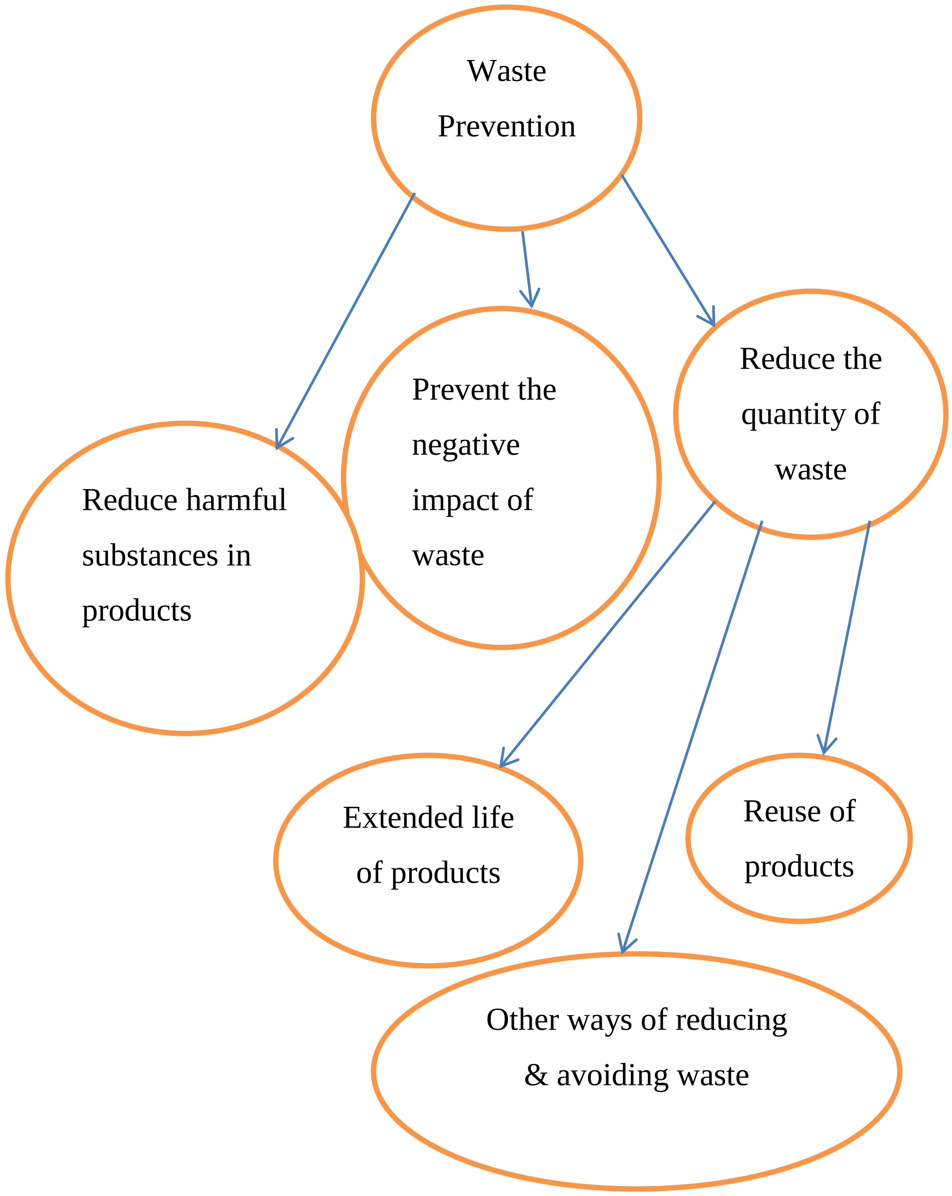

Figure 2. 2 Visualization of the concept of waste prevention **(Lilija, 2009)**

In summary to the literature review of waste management and minimization, waste management problem was reported as a worldwide concern. The generation of wastes were due to population growth, industrialization expansion, lack of awareness and skill, shortage of financial support, inadequate knowledge to perform combined programs to integrate production and environment. The waste definition has limitations from waste management research and from the lean management(manufacturing) context. The waste management includes the whole chain from the production of wastes through waste treatment and finally to the circular economy loop or disposal. The major methods used for the elimination of wastes in the literature were prevention, recovering, composting, waste treatment, incineration and landfill. Most of the developing countries use the landfill techniques that is simple in terms of skill and financial requirements even if it harms the heath of nations who live in nearby and also consumes and affects the valuable land resources. Developed countries use circular economy or closed loop manufacturing system where developing countries use the pipe-flow manufacturing system. Ethiopian metal manufacturing industries use traditional manufacturing practices that should be replaced by circular loop manufacturing system to bring the waste products to zero and to increase the manufacturing industries profitability and competitiveness, nations health and environmental protection will be improved.

2.3.1. Zero Waste Management (ZWM)

Alongside extending and formalizing manufacturer responsibility and revising legislation to support recovery and recycling versus disposal, the transition to a cradle-to-cradle towards zero waste economic models also necessitates transformation in our concept of citizenship, internationally, so as to include sustainable and responsible configurations of purchase and consumption. In this modality, traditional "end of pipe" waste management will be restructured by the new environmental services demanded by 'closed-loop recovery' and 'recycling' systems. A core function of future (zero) waste management systems, is to cycle resources between manufacturers and users for resource efficient and circular zero waste economy (CZWE) (Hannon & Zaman, 2018).

The Zero waste focuses on *waste prevention, minimization and reusing by considering* waste as valuable resource rather than a problem for factories. It aims to utilize the concept material efficiently and uses all material inputs in the final product or changes it into other inputs for another process. Matching input and output of different industries is one of the key challenges that need to be solved, possibly by industrial ecology through eco-industrial parks, industrial symbiosis, and new technologies (Shahbazi, Kurdve, Bjelkemyr, Jönsson, & Wiktorsson, 2013). On smaller scale products also need to be designed to meet the requirements of multiple lifecycles, for example through eco-design and design for disassembly and reassembly. With the same intention, Environmentally Conscious Design and Manufacturing (EDCM) address the existing and future relationships between design, manufacturing, and environment. Environmentally conscious technologies and design practices help manufacturers to minimize waste and go it into a profitable product (Shahbazi, Kurdve, Bjelkemyr, Jönsson, & Wiktorsson, 2013). Waste minimization in the industry is motivated by environmental legislation and regulations that try to more equitably evaluate the long-term costs of waste generation to the sources of such generation. Relevant federal legislation includes the Clean Air Act Amendments, the Clean Water Act, and the Pollution Prevention Act. California and Texas are states in the USA that are emphasizing waste minimization directly through legislation (Gilles, Loehr, & Fellow, 1994).

The zero-waste vision and closed-loop are both directed towards preventing waste rather than managing generated waste, however zero waste can be integrated with other approaches including *industrial ecology, cleaner production, pollution prevention, zero emissions and natural capitalism.* Furthermore, tools including Green performance map, eco-mapping and waste diversion planning system can be commonly used to pursue zero waste vision as all are based on eliminating wasteful usage of energy, material, emissions and resources. Regulatory factors commonly play a key role to encourage waste minimization activities; however, geographically limited regulations generally drive costs in the short term. Therefore, it is easier to establish and enforce regulations when the economy is good (Shahbazi, Kurdve, Bjelkemyr, Jönsson, & Wiktorsson, 2013).

Minimization of waste generation must be operated in such a way as to meet six prime objectives: application of Best Available Techniques (BAT) to prevent pollution, no significant pollution, waste minimization and the recovery of unavoidable waste, efficient use of energy, prevention of accidental releases, and Remediation of the plant site back to its original state after plant closure (M.C.Monte, E.Fuente, A.Blanco, & C.Negro, 2009).

An active waste minimization program can reduce the costs, liabilities and regulatory burdens of hazardous waste management, while potentially enhancing efficiency, product quality and community relations (M.C.Monte, E.Fuente, A.Blanco, & C.Negro, 2009). Waste minimization techniques that can help to reduce the amount of hazardous waste generated include: production planning and sequencing, process/equipment adjustment or modification, raw material substitution, loss prevention and housekeeping, waste segregation and separation, recycling (M.C.Monte, E.Fuente, A.Blanco, & C.Negro, 2009).

Proper practice of waste management comprises of elements such as reduce, reuse, recycle and disposal methods. In construction industry common approaches used to monitor waste are by controlling waste generation from its source, and reduce the production through recover, reuse, and recycle. Recycling of the construction waste means that the division of the waste and reproduce the waste to be a new material. Some material in construction site can be used recently, for example formwork can be used several times before it is disposed to landfill or recycled. To reduce the construction waste, the material transported to the site should be short listed in the earlier stages (Jamaludin, et al., 2017).

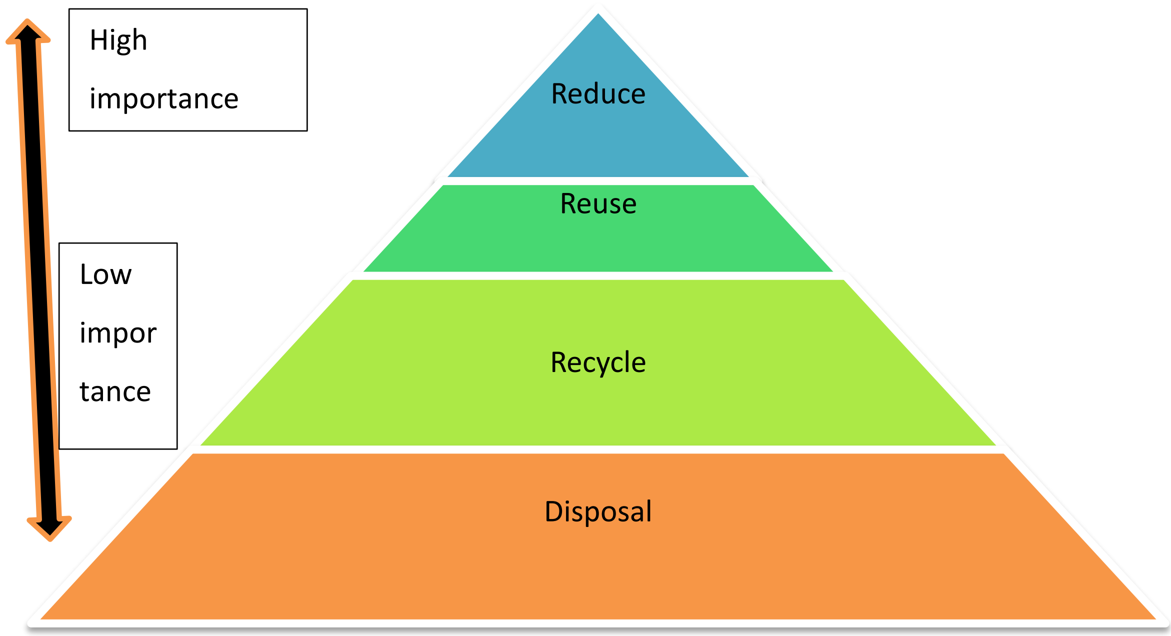

Figure 2. 3 Waste Management hierarchy (Jamaludin, et al., 2017).

Waste is the symbol of inefficiency of any modern society and a representation of misdirected resources. *More than 50% of the world's population* live in urban areas and some estimates have suggested that 80% of the human population will live in urban areas by 2030 in the world. *Cities cover only around 2% of the world's surface consume over 75% of the world's natural resources and generate 70% of* all the waste produced globally (Zaman & Lehmann, 2013).

Production of any waste diminishes natural resources, uses energy and water, places pressure on land, pollutes the environment and, finally, creates an additional economic cost for managing the waste. We need to move to a position where there will be no such thing as waste, simply transformation and this situation is called *zero waste that* is the most visionary concepts for solving waste problems. Many cities around the globe such as Adelaide, San Francisco and Stockholm have declared their zero-waste vision and these cities are working to be the world's first zero waste city (Zaman & Lehmann, 2013).

In summary to the literature review of the Zero-Waste that one of the main approaches to transform current manufacturing industries or cities to zero-waste industries or cities. The main enablers to waste free (The zero-waste) industries or cities are awareness and education, new infrastructure and mind set up (new thinking),100% recycling and recovery, consumption& behavior change, transformed industrial design, and Zero depletion legislation and policies. The circular loop design, cleaner production and manufacturers responsibility are the main factors to be considered in the metal manufacturing industry that lacks consideration. The Zero waste definition or concept has gap or limitation that time waste or waiting, unnecessary movement waste, over production, reworks, unnecessary inventory and underutilization of workers were not included since in the zero-waste concept waste definition only considers the discarded material waste.

2.3.2. Lean Management

Lean Manufacturing (LM) or management is a manufacturing system as well as philosophy. LM was originally developed by Toyota factories mainly in automotive industry in Japan. Lean Manufacturing is now widely experienced by many manufacturing companies throughout the globe. Lean manufacturing is a systematic approach to identifying and reducing waste (non-value-added activities) through continuous improvement by following the product towards perfection in order to fulfill the customer satisfaction. Hence LM is important, principally for waste reduction and lead time reduction without additional resources (Dixit, Dave, & Singh, 2015).

In Toyota motor company, Eiji toyoda and Taiichi ohno set a concept of *Toyota Production System*, and currently known as *Lean Manufacturing* in order to remove the wastages. After the rapid success of lean manufacturing in Japan, different industries and companies in US applied the method and get some achievements. The word "Lean" is defined as *less utilization* in term of all inputs to produce the similar outputs as those gained by a predictable mass production system, while contributory improved varieties for the end customer (Chahala & Narwalb, 2017). Lean Manufacturing aims to achieve, for a large variety of products, high productivity and at the same time, combining of production and demand (Moreira, Alves, & Sousa, 2010). To achieve these purposes, five principles were established: generate value for the customer satisfaction, identify the value stream, create flow, produce only what is required by the customer, and pursuing the perfection by successively identification and elimination of waste (Moreira, Alves, & Sousa, 2010). According to Rechna Shah and Pete T. Ward (2007), lean production is described as an 'socio-technical system' whose major aim is to eliminate waste at the same time reducing or minimizing supplier, customer, and internal variability (Shah & T.Ward, 2007).

Manufacturing method design was spotted as a potential source for improving recyclability stages, since it normally results in lower number of different materials usages. Along with materials type, identification and marks to facilitate disassembling for easy materials separation and dismantling tasks at end of life. There is strong evidence that the scientific community holds a positive view on the factual impact of Lean on enhancing environmental performance of production systems. This is mainly true for nonstop improvement of culture and waste reduction (Moreira, Alves, & Sousa, 2010). Toyota production system (TPS) or Just-In –Time (JIT) system was come to the practice of manufacturing Japan, after World War II, to overcome the turbulent of international market and to compete with giant manufacturers like Ford in the foreign market in the long run. Customer driven (pull) system was developed in Toyota from 1945 to 1975 aiming at complete elimination of waste. The concept is very crucial even today's competitive world to eliminate any waste (Kumar & A.N.Balaji, 2014).

In lean manufacturing the wastes have been described as anything that does not contribute to the final output since customer is expected to see the value with the end product, it is adequate to define a waste in this manner. Users (clients) do not care how much it costs you to repair defects, cost for your bulky stocks and stores or other additional costs. Some wastes can be avoided easily but some of them cannot be avoided easily due to various reasons (Abdullah, 2003). When sorting the wastes and classify them in to removable and irremovable, you have to think about removing the wastes from the system. However, lean manufacturing usually discusses about removing, not minimizing. The wastes are in any place in many various forms. It is worthier to have a closer attention to wastes since every enterprise wastes a lot of their resources. *The waste categories are over production, waiting, including time in queue, work In Progress (WIP), transportation between workstations or between supplier and customers, inappropriate processing, excess motion or ergonomic problems, defected products, and underutilization of employees* (Abdullah, 2003).

According to Womack and Jones (2003) promoter of the application of Lean thinking in the manufacturing industry, lean thinking can also be applied to metal manufacturing industries as they argue that the first step in implementing Lean thinking in any industry is to put the customer in the foreground, time and satisfaction of customer as key performance measures of the system at the same time they also considered teams having multi-skills can handle the customer orders with the active involvement of the customers (Womack & Jones, 2003).Some of the lean wastes are over production, transportation, waiting, inventory, motion, over processing, defects.

James Womack stated an additional waste type than what was previously stated by Taiichi Ohno to be added as the 8th waste type "**Lost people potentials".** This waste is due to underutilization of people skills, knowledge and abilities which should be used to the fullest capacity (Womack & Jones, 2003).The emphasis on zero defects and continuous improvements Lean concepts is particularly applicable. The establishment of customer interaction is equally important in the manufacturing industry particularly in the metal products factories (Karlson, 1995).

As Young et al. (2004) stated that application of Lean thinking helps in avoiding delays, errors and inappropriate procedures (Young, 2004). Applied methodology for scientific and objective methods that cause work tasks in a process to be performed were used by Pattanaik et al. (2009) to avoid non-value adding activities in order to greatly eliminate waiting time, queuing time, moving time, and other delays (Pattanaik & Sharma, 2009).

In summary to the literature review of lean management (lean manufacturing), lean management concerns about eliminating wastes in the manufacturing system in order to fulfill the customer satisfaction, be profitable and competitive in the current international market. There are eight types of wastes in lean management concept such overproduction, extra processing, waiting, inventory, defects, transportation, work-in-progress, and underutilization of employees. In the literature of lean manufacturing there is limitation that does not discuss or give emphasis to the health of nations and the environmental concerns. There is also limitation in giving attention or concern to waste management, waste treatment and final waste recovering or recycling systems.

2.4. Summary of literature review and research gap

Summary of reviewed papers using key words of Metal Waste, Lean, Zero Waste, Waste Management, Waste Minimization, and Metal Manufacturing Industry in different databases has been searched for accessing journal articles relevant to the research topic. The inclusive databases were Emerald, Google scholar, Elsevier, Springer, science-direct, IJERT, Taylor & Francis, Research gate, etc.

The major sections of literature review were: manufacturing industry, waste management and minimization, the Zero Waste Management and the Lean Manufacturing(management) literature review parts are outlined and structured in a manner that the reader can easily understand and research gaps can be identified. The types of journal papers reviewed were summarized but according to the degree of relation and proximity forty-two journals were detail revised by table form as shown in Appendix-D. The dominant waste management and minimization approaches in manufacturing industry were the zero-waste management and the lean management (Manufacturing) with a little difference in the definition of 'waste'.

In research gap finding, extensive literature reviews were conducted to support the thesis with different perspectives. This study had examined 15 papers in detail directly related to the subject matter under examination. After reviewing these selected papers, the following literature gaps are identified. These are:

1. There are limitations in the definition of waste in the context of zero waste management and lean management that leads to confusion. In the zero-waste management definition *waste* is regarded as material not required by the owner or producer (Zaman & Lehmann, 2013),& (Al-Kindi & Alghabban, 2019). However, the meaning of the word 'waste' in lean manufacturing context, in which it refers to losses in productive systems such as overproduction, waiting and transportation (Tortorella, et al., 2018), (Prasad & S.K.Sharma, 2014) and (Pattanaik & Sharma, 2009). Lean manufacturing is widely adopted and appealed to increase productivity, decrease manufacturing time (lead time) and costs and improve quality, through a systematic reduction of waste (Womack & Jones, 2003),and (Pavnaskar, Gershenson, & Jambekar, 2003). Nevertheless, the so-called lean waste elements such as waiting time, inventory, overproduction, transportation, reworks and loss of employee potentials were not included in the zero-waste concept. Loss of employees' potentials was considered as waste in lean management approach (Womack & Jones, 2003) . The dominate causes of the waste in the metal manufacturing industry waste management and minimization in Ethiopia were not addressed.
2. There is literature gap about the integration of waste management approaches in the manufacturing industry, environmental and health considerations (Singh, Laurenti, Sinha, & Frostell, 2014), (Karak, Bhagat, & Bhattacharyya, 2012), (Demirbas, 2010) and Quantifying and identifying causes(sources) of wastes in the manufacturing industry were not researched adequately by integrating the zero-waste and lean management(manufacturing) concepts (Shahbazi, Kurdve, Bjelkemyr, Jönsson, & Wiktorsson, 2013),and (Bello, Ismail, & Kabbashi, 2016).
3. In most research theoretical justifications were set as a final destination of paper but in most research not validated practically.

Based on the literature summary and survey the problems area through which the Thesis paper main target was:

1. These concerns on the causes(sources) of metal wastes and quantifying the amount of wastes created in the case company.
2. These concerns on profitability improvement through the proposed waste management strategies or recommendation.

These identified research gaps can be considered as a unique work in this Thesis paper.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1. Introduction

There are two methods of data collection for producing empirical researches: Qualitative and Quantitative. These techniques have their own strength and weakness. The qualitative method permits researchers to study selected issues in detail. Approaching field survey without being influenced by predetermined categories of analysis contributes to the depth, openness, and detail of qualitative inquiry (Creswell, 2014). This method, however, particularly provides important detailed information about a much smaller number of people or cases that in turn increases understanding of the cases and situations studied but reduce generalization (Lewis, 2003).

The quantitative method, on the other hand, needs the use of standardized instruments so that the different perspectives and experiences of the people can fit a limited number of predetermined response categories, to which numbers are assigned. The advantage of quantitative method is to measure the reaction of many people to a limited set of questions in numerical figures. Thus, it facilitates comparison and statistical aggregation of the data, which in turn gives a broad and generalized set of findings. Besides, structured interview has been held with top management officials of the case company. Furthermore, questionnaires, discussion and consultation with the Kaliti Metal Products Factory (KMPF) experts and practical observation have been included to crosscheck the collected data (Yin, 2003).

Generally, this chapter includes the methodology used in this thesis work and provides information about the research strategy, research design, research location, case study, questionnaire design, questionnaire content, and validity of questionnaire and the last thing is the process of data analysis.

3.2. Data source and Collection

The study depended on both primary and secondary data. Primary data was made up of first-hand data collected by the candidate through the use of questionnaires, interviews. The secondary sources of data were obtained from different journal articles, conference proceedings, books, magazines and research papers to gather data on waste generating sources using research instruments.

Field observations through factory visits were also employed to gather data on high waste generating sources. Pilot test was done before all the questionnaires were distributed to the respondents and feedbacks were collected. Finally, questionnaires including the feedbacks to the pilot test were distributed to the respondents.

3.2.1. Questionnaire Design

The questionnaire design research instrument was undertaken to determine the opinion of managers, employees and clients regarding the causes of material waste in the case company, Kaliti Metal Products Manufacturing Factory (KMPMF), in Addis Ababa Ethiopia. The questionnaire was consisting of three major sets of closed-ended and open questions on the sources and causes of materials waste and waste minimization measures, the questionnaire further sought to obtain information on the level of knowledge of industry professionals on the concept of waste management and minimization of metal products in the Ethiopian manufacturing industry. Interviews and factory visits were also used to obtain specific information about wastes in the case company factory.

3.2.2. Structure of questionnaires

The **purposive** sampling technique was used for determination of sample size of questionnaires respondents to get trusted data from the professionals in depth that the person connected to the metal manufacturing and assembly departments only. Questionnaires were constructed using the Likert Scale. The respondents were asked to rank on a scale of 0%-100% factors that cause metal waste in Metal Products Manufacturing Industry in the case company Kaliti Metal Products where E.S. = extremely significant [100%], V.S. = very significant [75%], M.S. = moderately significant [50%], S.S. = slightly significant [25%] and N.S. = not significant [0%].

3.2.3. Secondary data

Systematic Literature review on the research topic waste management and minimization was done using different research key words. The literature reviews were on the following specific areas as can be seen in Table 3.1statistics of the literature review on secondary data.

Table 3. 1 Secondary data distribution

Area of Study	Percentage of the area	Year of publication range
Manufacturing Industry	27%	2006-2019
Waste Management &Minimization	29%	2003-2019
Lean Manufacturing	20%	1994-2017
Zero Waste management	16%	2003-2018
Research Methodology	8%	2002-2015

Research methodology area of study includes the quantitative and qualitative study theoretical backgrounds and the applied methods and materials used for the study. One of the best research methods is case study approach to get specific knowledge in-depth.

3.2.4 Interviews and Observations

Interviews were made with different experts and managers in order to get deep understanding about the subject matters as well as the current metal waste management in the case company. Observation were also done in the case company through different manufacturing processes and metal waste disposal areas.

3.3. Method of data analysis

Descriptive statistics analysis method was applied. As a result, the analysis had combined all groups of respondents in order to obtain significant results. Data was analyzed by calculating frequencies and Relative Importance Index (RII). The Relative Importance Index (RII) is calculated as follows (Aibinu & Jagboro, 2002).

$RII = (4n_1+3n_2+2n_3+1n_4+0n_5)/4N$ -- Equation 3.1

Where:

N = Total number of respondents

n_i = the variable expressing the frequency of the i^{th} response.

n_1= Number of frequencies 'extremely significant' response,

n_2= Number of frequencies 'very significant' response

n_3 = Number of frequencies 'moderately significant' response

n_4 = Number of frequencies 'slightly significant' response.

n_5 = Number of frequencies 'not significant' response.

The levels of response are:

E.S. = extremely significant [100%]

V.S. = very significant [75%], M.S. = moderately significant [50%]

S.S. = slightly significant [25%], and N.S. = not significant [0%]

Likert scale is applied as one of the most fundamental and frequently used psychometric tools in educational and social sciences research using questionnaires were described. The original Likert -scale is a set of statements (questionnaires) provided for a real or hypothetical condition under study. Participants are asked to show their level of agreement on the importance (from extremely important to no significant) with the given statement (questionnaires) on a metric scale (Joshi, Kale, Chande, & Pal, 2015) . Here all the statements in combination reveal the specific dimension of the attitude towards the issue, waste management and minimization in the metal Manufacturing Industry.

3.4. Data quality management

In order to attain the objectives of the research, some means of collecting quality and managing data must be developed. Here, the methodology used must incorporate the advantages of most data collection techniques. Therefore, it is aimed to use Personal interaction which includes questionnaires, interviews of personnel both directly and indirectly related to the process, document review and direct observation of the actual working environment and the condition of the shop floor.

3.5. Research Ethical Consideration

In this Thesis, all the research ethical considerations have been considered to the level of my knowledge. All the necessary acknowledgements were given and cited properly to avoid plagiarism in the Thesis work that is not worked in any place or university by other researchers. There is no cheating in this Thesis intentionally since I am aware that the Addis Ababa University Students Legislation about Ethical consideration, the cheating leads to disqualify and penalty. Concepts from the literature reviews articles taken were written in my own words and understandings by giving acknowledgments to the author(s).

Willingness of the respondents to participate in filling the questionnaire were asked and purpose of the data collection was explained that only for the research study, it has no relation with their personal work or life. It was explained that the data will be kept secret even from their employees and supervisors so that they fill confidence to give the right response.

Ethical Considerations can be specified as one of the most important parts of the research. Theses may even be doomed to failure if this part is missing. The most important principles related to ethical considerations includes: research participants should not be subjected to harm in any ways whatsoever; respect for the dignity of research participants should be prioritized; Full consent should be obtained from the participants prior to the study; the protection of the privacy of research participants has to be ensured; any deception or exaggeration about the aims and objectives of the research must be avoided; affiliations in any forms, sources of funding, as well as any possible conflicts of interests have to be declared; Any type of communication in relation to the research should be done with honesty and transparency; any type of misleading information, as well as representation of primary data findings in a biased way must be avoided.

3.6. Research Dissemination Techniques

Once the dissemination objective and the audience of the research study are identified, there are a variety of ways to share the developed content. Common techniques of dissemination include, publishing program or policy briefs, publishing research findings in national journals and statewide publications, presenting at national conferences and meetings of professional associations, presenting program results to local community groups and other local stakeholders , creating and distributing program materials, creating toolkits of training materials and curricula for other communities ,sharing information through social media or on an organization's website, summarizing findings in progress reports for funders , disseminating information on an organization's website, discussing research activities on the local radio ,and publishing information in the local newspapers.

3.7. Structured research frame work or flow diagram

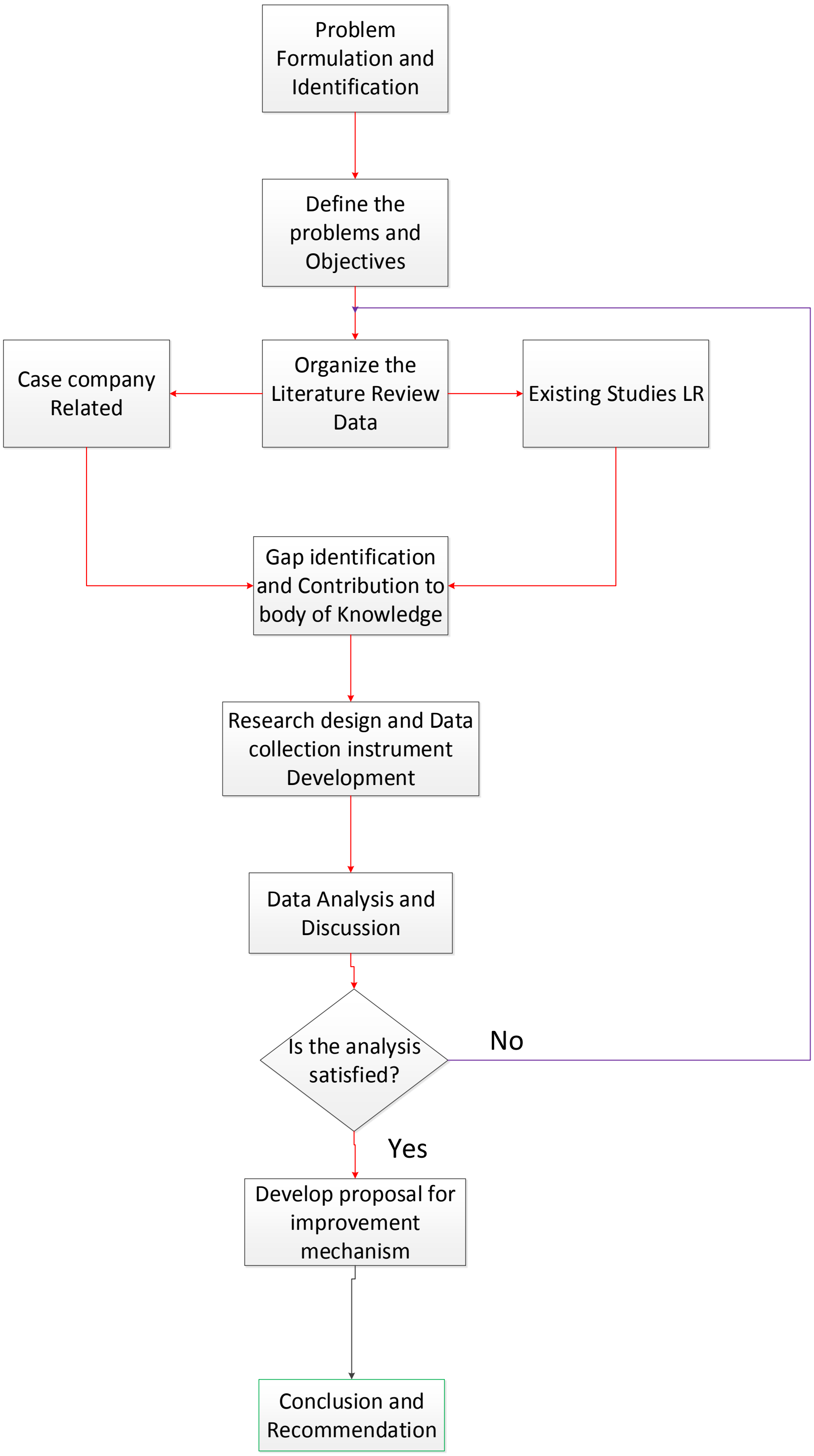

Figure 3. 1 Structured research frame work

CHAPTER FOUR

4. DATA ANALYSIS, DISCUSSION AND INTERPRETATION

4.1. Introduction

This chapter reports and discusses the study area as well as the survey findings. After the questionnaire survey was carried out, statistical analyses were undertaken on the responses using various methods described in the research methodology.

The study area of this thesis work is at the capital city of Ethiopia, called Addis Ababa in the Metal Products Manufacturing Industry by taking case study the factory called Kaliti Metal Products Factory (KMPF) on the research topic Waste Management. Profile of the case company, Kaliti Metal Products Factory (KMPF), was established in 1968 with the objective of producing structural and furniture hollow sections, door and window frame profiles, EGA and ribbed sheets for roofing and wall cladding, pressed and plain sheet metal products and other job order products.

The company has 417 (four hundred seventeen) permanent employees. Among them 359 (three hundred fifty-nine) were males and 58 (fifty-eight) were female employees. On the contract bases there were about 8(eight) male employees. So totally the company had about 425 (four hundred twenty-five) employees.

The factory is located on the main road to Bishoftu, 20 Kilometers away from the center of Addis Ababa (capital city). It occupies a total land area of about 98,000 square meters. It benefits from the Addis –Djibouti railway line.

The company target is to play leading role in metal sector by manufacturing quality metal products, equipment and machineries and export abroad in addition to satisfying the local demand.

The Kaliti Metal Products Factory, KMPF, aspires to become the leading enterprise by providing its customers high quality metal products at a competitive price with the sense of responsibility to support the national economy.

Regarding production and marketing, the factory uses imported steel sheets in coils as its major input to produce standardized and job order products. The factory distributes its high quality and dependable products to the local market from the factory premises and through its branch sales centers located in Teklehaimanot area (Addis Ababa) and outside Addis Ababa at Hawassa and Adama cities.

Main products and services of the factory are: rectangular and circular hollow sections for furniture and structural purposes, Black LTZ door and window profiles, Galvanized & Black SECCO door and window profiles, Door and windows manufacturing and Assembly, Galvanized and Pre-coated EGA sheets, Plain and Press formed metal products, Truss & Purlin, Erection on site, Furniture, Water, fuel and garbage tankers, Dixon Shelves, Galvanized corrugated iron sheet, Construction form works, Cable tray and Other metal products as per customers' design and order.

Product selection for the study, when considering a particular job to be carried out for study certain factors such as economic considerations, and technical considerations should be considered.

Economic considerations can be important at all processes (steps). It is clear a waste of time to begin or carry on a long-time investigation if the economic importance of the job is small. Operations involving repetitive work using a great deal of labour and liable to run for a long time (Kitaw(Dr.-Ing.), 2009).In technical considerations the most important point is to make that enough technical knowledge is available with which to perform the study (Kitaw(Dr.-Ing.), 2009).

According to the above criteria, Tubular [Square, Rectangular and Circular Hollow sections (Standard Products)], Galvanized corrugated Iron sheet (Engineered Products Manufacturing) and Truck (Welding and Assembly Workshop) have been studied.

4.2. Data Analysis and Results

The results that have been obtained from processing of the questionnaires using Microsoft Excel and statistical package for social sciences (SPSS) as well as interview and observation results. The results are prepared to present the information about the solid waste management characteristics in the case company, Kaliti Metal Products

Factory (KMPF). It also includes the identification of factors affecting the waste in the case company based on the questionnaires, interviews and observations to the causes of waste in some important materials, magnitude of waste, waste minimization strategies and the relative significant of manufacturing industry waste sources.

4.2.1. Metal Waste Products in the case company

In the case company Kaliti Metal Products Factory (KMPF) different metal wastes were observed. Some of them were collected and sorted according to their shapes near at the workshop doors. The bulky amount of metal wastes was collected and sorted at the solid dry waste storage site. The following pictures illustrate the metal wastes in the case company partially for visualization purpose for this study.

Figure 4. 1 Corrugated sheet metal waste in the metal waste site

Figure 4. 2 Sheet metal coil holders (containers) as metal wastes

Figure 4. 3 Different metal wastes sorting styles

Figure 4. 4 Metal strip wastes

Figure 4. 5 Drilled out Metal wastes

4.2.2. Questionnaires Data analysis regarding managers respondents

I. Responses for Part I questionnaires

There were seven participants of managers in the case company. They were the human resource(manager) department head, the marketing and Sales(manager) department head, the planning department (manager) executive officer, the standard products (manager) executive officer, other engineered products executive officer, Truck and trailer Assembly manager, and Quality assurance and control (manager) executive officers.

Regarding the gender distribution for the managers or executive officers that were under consideration has been 100% Males. The frequency and the cumulative percent were 7 and 100 respectively. The age distribution analysis of the managers (executive officers) respondents shows 57.1 % ,28.6%, and 14.3% of the respondents among the executive officers (managers) their ages were more than (fifty) 50 years old, between 30-40 years, and between 41-50 years old respectively.

The relevant work experience distribution analysis of the managers (executive officers) respondents shows 42.9% of the respondents work experience were in the range between 11(eleven) and 20(twenty) years (or 11-20 years), 28.6 % in the range between 21 and 30 years (or 21-30 years), 28.6 % of the respondents' relevant work experiences were more than 30 (thirty) years.

The position of the respondent managers (executives) includes the following: The standard products Manager, Marketing and Sales Manager, Human resource Manager, Other engineered products Manager, Truck and trailer Assembly Manager, Quality assurance and control Manager and Planning manager are the main respondents to the questionnaires prepared for managers(executives) to get in depth answers for understanding the subject matter in the case company through the questionnaires given to them.

II. Responses for Causes and sources of metal wastes (Responses for Questionnaires prepared for Managers part II)

To identify Sources and causes of wastes in Kaliti Metal Manufacturing Products Factory questionnaires were provided for the managers (executives). The response has been provided as follows:

A. Group I. Design Issues (For Manager Questionnaires responses): - Regarding the Design Issues ten (10) questionnaires were distributed but seven (7) questionnaires have been collected from the managers.

Table 4. 1 Results for Design Issues Likert Scale Questionnaires

Rank	Description of Design Issues	Frequency	percentage
1	Technology constraints are causes of wastes in the case company, KMPF.	7	82.1
1	The increment of engineered products (designing of Products out of standard or as customer desired)	7	82.1
2	Shortage of time for urgent design activities is the cause of wastes in the case company.	7	50.0
2	Selection of low-quality input materials during the design process are the causes of wastes in the case company	7	50.0
3	Design changes and revisions are causes of wastes in the case company, KMPF.	7	28.6
4	Lack of information in the drawings are causes of wastes in the case company	7	25.0
4	Big estimation of specification tolerances (allowances) is the cause of wastes in the case company	7	25.0
4	Poor communication with stakeholders leads to mistakes and errors are the cause of wastes in the case company	7	25.0
	Valid N (list-wise)	7	

As shown from the Table 4.1., the following conclusions can be drawn: *Technology constraint*, and *the increment of other engineered products* (designing of Products out of standard or as customer desired) were scored very significant. So these variables should be considered as main constraints or main causes of wastes sources and the case company also try to solve these problems or minimize them; *Shortage of time for urgent design activities* and *Selection of low quality input materials during the design process* averagely scored moderately significant (M.S.50%); *Design changes and revisions*, *lack of information in the drawings*, *big tolerance estimations for* *specifications in the drawings designed* and *Poor communication with stakeholders leads to mistakes and errors* averagely scored 25% slightly significant.

B. Group II. Materials and Products (For Manager questionnaires responses)

a: Regarding Procurement

Table 4. 2 Results of Procurement issues

Rank	Description of Procurement Issues	Frequency	Percentage
1	Selecting the lowest bidder suppliers and sub-suppliers is the cause of wastes	7	75
2	Damage of materials in the store are the causes of wastes	7	50
3	Purchased materials that don't comply with specifications are the causes of wastes	7	25
4	Poor storage system is the cause of wastes	7	21.4286
5	Over ordering or under ordering due to mistakes in quantity surveys is the cause of wastes	7	7.1429
6	Poor schedule to procure materials is the cause of wastes in the case company.	7	3.5714
	Valid N (list-wise)	7	

From the above table the following points can be drawn: Selecting the lowest price bidder suppliers and sub-suppliers were scored highest point 75% to mean very significant by the respondents of managers as causes of wastes in the case company, Damage of materials in the store has been scored averagely 50% that is moderately significant as given by the respondents, Purchased materials that don't comply with specifications and poor storage system averagely scored 25% slightly significant to the cause of wastes in the case company, and Poor schedule to procure materials, over ordering or under ordering due to mistakes in quantity surveys [Inventory is regarded as waste in Lean principle] and poor storage system have almost no significance to the causes of wastes in the case company.

b: Regarding Manufacturing Processes

Table 4. 3 Results for manufacturing issues

Rank	Description of manufacturing issues	Frequency	Percentage
1	Poor time management [Downtime is waste with regard to Lean principles] is the cause of wastes	7	100.00
2	Damage of output materials(products) are the causes of wastes	7	75.00
2	Machines and equipment frequently breakdown are the causes of wastes	7	75.00
2	Poor technology of machines and equipment are the cause of wastes	7	75.00
3	Damage of input materials arrival from abroad are the causes of wastes	7	50.00
3	Lack of employee's motivation and incentives are the causes of wastes	7	50.00
4	Poor workmen relation in the company are the causes of wastes	7	25.00
4	High product rejection rate [Rejected products are wastes with regard to Lean principles] is the cause of wastes	7	25.00
4	Over processing [with regard to Lean principle] is the cause of wastes	7	25.00
4	Unnecessary movement of products (materials) and workers [Motion is waste with regard to Lean principles] are the causes of wastes	7	25.00
5	Operators negligence or lack of skill are the causes of wastes	7	21.43
5	Design change of customers or order change.	7	21.43
5	Machine and equipment depreciation are the causes of wastes	7	21.43
5	Poor product handling system is the cause of wastes	7	21.43
5	Reworks due to mistakes [Reworks are wastes with regard to Lean principles] are causes of wastes	7	21.43
6	Lack of Product controlling systems are the causes of wastes	7	3.57
6	Lack of production methods clarity are the causes of wastes	7	3.57
6	Frequent accidents are the causes of wastes	7	3.57
6	Using untrained(new) workers are the cause of wastes	7	3.57

Rank	Description of manufacturing issues	Frequency	Percentage
6	Shortage of tools and equipment required are the cause of wastes	7	3.57
6	Lack of understanding the design or drawings given to operators is the causes of wastes	7	3.57
7	Over production [Over productions are wastes with regard to Lean principle] is the cause of wastes	7	0.00
7	Shortage of manpower is the cause of wastes	7	0.00
7	Poor floor plan layout is the cause of wastes	7	0.00
	Valid N (list-wise)	7	

Poor time management [Downtime is waste with regard to Lean principles] was considered as extreme significant (100%) averagely; damage of output materials (products) during manufacturing processes, machine& equipment frequently breakdown and Poor technology of machines & equipment were considered as very significant scored averagely 75% for the cause of wastes in the case company; damage of input materials arrival, and Lack of employees' motivation and incentives were considered as moderately significant (50%) averagely for the cause of wastes in the case company. Operators negligence or lack of skill , Design change of customers or order change, Machine and equipment depreciation, Poor product handling system, Poor workmen relation in the company, Reworks due to mistakes[Reworks are wastes with regard to Lean principles], Product rejection rate [Rejected products are wastes with regard to Lean principles], Over processing (waste as regard to Lean principle) and Unnecessary movement of products (materials) and workers [Motion is waste with regard to Lean principles] were considered as slightly significant averagely scored 25% (or nearer to it) for cause of waste in the case company as given by the respondent managers. Lack of product controlling system, Lack of understanding the design or drawings given to operators, Lack of production methods clarity, over production [Over productions are wastes with regard to Lean principle], frequent accidents, shortages of manpower, unskilled (untrained) manpower, Shortage of tools and equipment required, and poor plant layout were considered not significant for the cause of wastes in the case company during the current status of the case company.

C. Group III. Waste Management and Minimization questionnaire responses for managers (executives).

Table 4. 4 Results for Waste Management &Minimization

Rank	Description of waste management &Minimization	Frequency	Percentage
1	Lack of Contribution of the Management System aiming at waste minimization	7	92.9
1	Lack of Transformed Industrial design (such as cradle –to- cradle design, cleaner production, producer responsibility) is the cause of wastes	7	92.9
1	Lack of 100% Recycling and Recovery (such as reduce, repair/reuse and Recycling/recovery) are the cause of wastes	7	92.9
1	New infrastructure and system thinking (includes new infrastructure, New technologies, and zero waste Governance) are the cause of wastes	7	92.9
2	Lack of proper waste management plan and control are the causes of wastes	7	75.0
2	Unavailability of strategy to waste minimization is the cause of wastes	7	75.0
2	Provision of information to participants in the Factory are the causes of wastes	7	75.0
2	Ineffective planning and scheduling of the Production byproducts are the causes of wastes	7	75.0
2	Lack of Awareness, education and Research includes Zero waste programs, Transformative education and zero waste research are the cause of wastes	7	75.0
3	Lack of Material or product transportation system [unnecessary transportation is waste with regard to Lean Principle] is the cause of wastes	7	53.6
4	Lack of Zero depletion legislation and policies (such as zero landfill legislation, zero –incineration legislation and Incentives) are the causes of wastes	7	25.0
4	Lack of Sustainable consumption and behavior (includes collaborative consumption, behavioral change and sustainable living) are the cause of wastes	7	25.0
5	Qualification of the operators, technical staff assigned to the Factory are the causes of wastes	7	3.6

Rank	Description of waste management &Minimization	Frequency	Percentage
5	Ineffective control of the quality controllers and inspectors are the causes of wastes	7	3.6
5	Unavailability of technical senior professionals in the Factory	7	3.6
5	Lack Waste Separation system in the Factory are the causes of wastes	7	3.6
	Valid N (list-wise)	7	

Responses of managers for the cause of wastes in the case company for the questionnaires under waste management and minimization have been given as follows: Lack of Contribution of the Management System aiming at waste minimization, Lack of Transformed Industrial Design(such as cradle –to- cradle design, cleaner production, producer responsibility), Lack of 100% Recycling and Recovery (such as reduce, repair/reuse and Recycling/recovery),and New infrastructure & system thinking(includes new infrastructure, New technologies, and zero waste Governance) were considered the extremely significant averagely by the respondents for the cause of wastes in the case company; Lack of proper waste management plan and control, Lack of availability of strategy to waste minimization, lack of provision of information to participants in the Factory, ineffective planning and scheduling of the Production byproducts, Lack of Awareness, education and Research (includes Zero waste programs, Transformative education and zero waste research) were considered as very significant averagely scored 75% for the cause of wastes in the case company; Material or product transportation system [unnecessary transportation is waste with regard to Lean Principle] was considered as moderately significant averagely scored 50% for the cause of waste in the case company; Lack of Zero depletion legislation and policies (such as zero landfill legislation, zero –incineration legislation and Incentives) and Lack of Sustainable consumption and behavior (includes collaborative consumption, behavioral change and sustainable living) were responded as slightly significant averagely scored about 25% as cause of wastes; Qualification of the operators, technical staff assigned to the factory, ineffective control of the quality controllers and inspectors, unavailability of technical senior professionals in the factory and lack of waste separation system in the Factory were considered as has no significance for the cause of waste in the case company averagely scored nearly to 0%. That is, their contribution to the cause of wastes is almost negligible.

Here it can be explained that prioritization of the contributing factors to the causes of waste are very important so as to focus and manage metal wastes.

Note: - Mean values were approximated to fit the Likert Scale appropriate values of 100%,75%,50%,25%, and 0 % to represent extremely significant, very significant, moderately significant, slightly significant, and has no significant respectively.

III. Causes of metal wastes for key products (Responses for Questionnaires prepared for Managers part III).

The causes of wastes for key product/material in the manufacturing workshops for the highest income sold products (highest sales income products) questionnaires were distributed for the managers and their responses have been presented as follows:

I. Tubular products

Table 4. 5 Results for Tubular Products (Managers)

Rank	Descriptions for Tubular	Frequency	percentage
1	Defects in products due to the process sudden interruption are the causes of wastes	7	75.0
2	Excessive dimensions of the designs are the causes of wastes	7	50.0
2	Poor machine and equipment maintenance skill, old machines are the causes of wastes	7	50.0
2	Poor machine and equipment installation are the cause of wastes	7	25.0
3	Use of poor cutting tools and equipment are the causes of wastes	7	25.0
3	Poor material and product handling are the causes of wastes	7	25.0
3	Poor production process managing is the causes of wastes	7	25.0
3	Operators lack of skill or negligence is the cause of wastes	7	25.0
4	Poor performance leading to rework is the cause of wastes	7	25
5	Poor shifts managing style is the cause of wastes	7	10.7
	Valid N (list-wise)	7	

Defects in products due to the process sudden interruption was considered the key cause of waste during the products manufacturing processes as responded by the managers (executives) and averagely scored 75% to mean very significant; Excessive dimension allowances for the tubular and Poor machine and equipment maintenance skill were considered to moderately significant averagely scored about 50% as key cause of waste for the tubular products; Use of poor machine and equipment installation, poor material and product handling, poor production process managing, poor performance leading to rework and Operators lack of skill or negligence were considered to be slightly significance averagely scored 25% as cause of key cause of waste for the tubular products; Poor shifts managing style was considered as has no significance averagely scored 0% for the cause of wastes for the products under investigation.

I. Galvanized corrugated Iron sheet (Engineered Products Manufacturing)

Table 4. 6 Results for Galvanized Corrugated Iron sheet

Rank	Description for Galvanized Corrugated Iron sheet	Frequency	Percentage
1	Defects in products due to the process sudden interruption are the causes of wastes	7	75.0
2	Excessive dimensions of the designs are the causes of wastes	7	50.0
2	Poor machine and equipment installation are the cause of wastes	7	50.0
2	Poor machine and equipment maintenance skill, old machines are the cause of wastes	7	50.0
3	Use of poor cutting tools and equipment are the causes of wastes	7	25.0
3	Poor material and product handling are the causes of wastes	7	25.0
3	Poor production process managing is the causes of wastes	7	25.0
3	Poor performance leading to rework is the cause of wastes	7	25.0
3	Operators lack of skill or negligence is the cause of wastes	7	25.0
4	Poor shifts managing style is the cause of wastes	7	10.7
	Valid N (list-wise)	7	

In this case defects in products due to the process sudden interruption was considered as the key cause of waste during the products manufacturing processes as responded by the managers (executives) and averagely scored 75% to mean very significant; Excessive dimension allowances for the galvanized corrugated iron sheet, Poor performance leading to rework, poor machine & equipment installation and Poor machine and equipment maintenance skill (old machines) were considered to be moderately significant averagely scored about 50% as key cause of waste for the engineered products; Use of poor cutting tools and equipment, Poor material and product handling, Poor production process managing, operators lack of skill or negligence, and Poor performance leading to rework were responded as slightly significant averagely scored about 25%; and Poor shifts managing style were responded as has no significant to the causes of wastes for the other engineered products averagely scored about 0% according to the Likert Scale given values.

II. Truck (Welding and Assembly Workshop) response for the managers' questionnaires

Table 4. 7 Results for Truck section

Rank	Description of truck	Frequency	percentage
1	Defects in products due to poor welding are the cause of wastes	7	75.0
2	Poor performance leading to rework is the cause of wastes	7	50.0
3	Excessive dimensions of the designs are the cause of wastes	7	25.0
3	Use of poor welding and cutting tools and equipment are the cause of wastes	7	25.0
3	Lack material and product handling are the cause of wastes	7	25.0
3	Poor production process managing is the cause of wastes	7	25.0
3	Poor equipment operating skill, old machines are the cause of wastes	7	25.0
3	Poor electric power setting for the required work is the cause of wastes	7	25.0
3	Operators lack of skill or negligence is the cause of wastes	7	25.0
7	Poor machine and equipment installations are the cause of wastes	7	7.1
	Valid N (list-wise)	7	

Defects in products of trucks due to poor welding was responded as very significant averagely scored 75% to be the key causes of wastes in the welding and Assembly workshop for truck assembly; Poor performance leading to rework was responded averagely scored 50% to be moderately significant for the cause of the key product truck from the welding and assembly workshop; Poor equipment operating skill, old machines, poor electric power setting for the required work, operators lack of skill or negligence, Lack material and product handling, Poor production process managing, excessive dimensions of the designs, and use of poor welding and cutting tools and equipment were responded as slightly significant averagely scored about 25% for the causes of the wastes for key product in this case a truck; Poor machine and equipment installation was responded as has no significance for the causes of waste for key product, truck.

IV. Responses for open ended questions prepared for Managers, part IV.

Open ended questions were distributed to the managers and their responses were presented as follows.

The impact of metal products wastes described as spoiling attractiveness of the manufacturing compound related to green production and environmental issues, needs additional financial, human resource, material handling equipment as well as the precious time for collecting, sorting, transporting and selling. The waste products occupy large amount of land that can be used other valuable investment since land is the very important and scarce resource in Ethiopia especially in Addis Ababa. The area of the site for the metal waste products storage is about 500 square meters within the factory compound.

The responses for the question "Which company is beneficial by managing and minimizing waste of metals in the Metal Manufacturing Industry or other sector? and how?" were given. The case company will be beneficiary by managing and minimizing metal products wastes as it can increase profitability by reducing human resource cost, material handling equipment cost and the precious time saving. The precious time saving was described as the time taken for collecting, sorting, transporting to the required site, and the process of selecting bidders for selling the metal waste. Minimizing significant amount of metal products waste can lead to increase the life time of the expensive cutting tools and at same time can increase the products quality. The site for metal products waste storage, about 500 square meters, can be save and considered as profit for the case company under investigation. Health and safety benefits also were considered as potential gains from managing and minimizing the metal products waste in addition to economical and environment concerns.

The response for the question,” actions to reduce metal wastes”? was presented as follows: To reduce metal wastes, government policy makers, Industrial managers and experts, researchers, factory experts, environment and health experts and researchers, global policy makers as well as political parties can take actions to reduce wastes.

Frame work for future metal waste management and minimization was asked to the respondents. 86% of the respondents had not stated the future frame work for metal waste management and minimization, but 14% of the respondents were stated as to use the continuous improvement method called Kaizen as improvement tool for a metal wastes management and minimization.

4.2.3. Questionnaires Data analysis regarding marketing and sales

Regarding part I questions, ten questionnaires were distributed for marketing and sales department but only five questionnaires were returned for part I questions.

Regarding the gender distribution for the marketing and sales personnel that were under consideration has been 40 % females and 60 % males. The age distribution of the marketing and sales personnel respondents have been recorded as: the ages of the female respondents were 25 and 29 years old (between 21-30 yrs.);The ages of the male respondents were between 21-30 years and more than 30 years; Generally, 80 % of the respondents’ age distributions were between 21-30 years old and the rest 20 % of the respondents’ ages were more than 30 years old.

The work experience of the respondents for marketing and sales personnel were all lying between 1 and 10 years. The position of the respondents for marketing and sales personnel, all were experts starting from junior about 40 % up to senior experts about 60%.

Regarding Part II questionnaires responses prepared for marketing and sales, Technological constraints were considered as the source and cause of the metal wastes in the case company and scored almost 100% by the respondents averagely to mean extremely significant ; Selecting the lowest bidder suppliers and sub-suppliers that lead to poor quality were considered as very significant averagely scored 75 % for the source and cause of metal products in the case company; Lack of rules and regulations, purchased materials that don't comply with specifications, Change of customer orders and designs, Lack of incentives, and Poor schedule to procure materials were responded as slightly significant averagely scored about 25 % as a source and cause of metal wastes in the case company; Shortage of foreign currency, scarcity of raw materials, and damage of materials in the store were reported as has no significant averagely scored 0 % to be considered as sources and cause of metal wastes in the metal products manufacturing factory.

Responses for the open questions prepared for marketing and sales, part III, is presented in this section. The major impacts of metal products wastes were reported as can have negative impacts for health, safety and environmental issues in addition to the economic and manufacturing time wastages while taking actions during the waste management time.

The company that produces the metal wastes as byproducts because of different driving factors such as technological constraints and trained manpower to the required level will be beneficial by using them for another production means as well as by selling to other companies such as steel manufacturing firms for remanufacturing the metal wastes (scrap). The companies that buy the metal waste are also benefiting from buying the metal wastes in bulky number and sustainable way since they consider these metal wastes as main input resources for manufacturing steel bars. In fact, the companies that are involving in buying the metal waste may not be interested in metal waste reduction since they may face shortage of input resources as a result, they may be face scarcity of input materials. So generally, the company that manages metal products will be beneficial more, and also the residents as whole the nations.

Everyone can contribute his or her own contribution for the metal waste management and minimization. The contribution may vary as the degree of responsibility, awareness, education level and economic level they want to be benefited from.

The future frameworks for Waste Management in this case company, Kaliti Metal Products Factory was reported to use the continuous improvement method called Kaizen as improvement tool for a metal wastes management using lean management only.

4.2.4. Questionnaires Data analysis regarding production workers

The questionnaires were distributed to 15 production workers. Among the distributed questionnaires only 10 production workers have returned back, that is about 67 % of the production workers have returned the questionnaires. The production workers gender distributions were all males. No females were involved with the participation of production workers.

Age distribution of Respondents of production workers were analyzed. Production workers age distribution for the questionnaire's respondents were 50 % of the respondents of production workers' ages distribution were between the 40 years and 50 years old; 30 % of the respondents of production workers' ages distribution were between 30 and 40 years old and; 20 % of the respondents of production workers' ages distribution were between 18 and 30 years old.

The respondents of production workers relevant work experience distribution were 50% of the respondents of production workers relevant work experience distribution were laid between 1 year and 10 years; 30% of the respondents of the production workers relevant work experience were laid between 11years and 20 years; 20% of the respondents of the production workers relevant work experiences were between 21 and 30 years.

The responsibility of production workers varies from one manufacturing workshop to the other manufacturing workshop. The production workers in this case all are machine operators.

Responses for the questionnaires prepared for production workers, part II *were discussed below.*

I. Tubular Products

The tubular products include such as Square, Rectangular and Circular Hollow sections and also sometimes called as standard products. Poor machine and equipment break down maintenance handling was responded as the very significant cause of metal wastes averagely scored 75 %; Defects in products due to the process sudden interruption and Poor material & product handling techniques were considered as moderately significant for the cause of metal wastes and scored 50 % averagely. Excessive dimensions allowances of the tubular, use of poor tools and equipment, poor operations leading to rework, poor production process controlling systems, Negligence or lack of awareness, operators' poor relationship with managers, Poor preventive maintenance of machine were considered as slightly significant for the cause of metal wastes in the case company and averagely scored 25%.

II. Galvanized corrugated Iron sheet (Engineered Products Manufacturing)

Defects in products due to the process sudden interruption were considered as very significant for the cause of metal wastes and averagely scored 75 %; excessive dimensional allowances of the designs, poor performance leading to rework, and poor machine and equipment maintenance skill, old machines were considered as moderately significant for the cause of metal wastes in the case company and scored averagely 50 %; operators lack of skill or negligence, poor material and product handling system, poor production process controlling systems, and frequent cutting tools wearing out were considered as slightly significant for the cause of metal wastes in the case company and averagely scored 25%; poor machine and equipment installation, and operators poor relationship with managers were considered as has no significance to the cause of metal wastes and scored averagely 0 %.

III. Truck (Welding and Assembly Workshop)

Defects in products due to poor welding system was considered as very significant for the cause of metal wastes averagely scored 75 %; Poor electric power setting for the required work, Poor equipment operating skill, old machines, and Poor performance leading to rework were considered as moderately significant for the cause of metal wastes source, averagely scored about 50 %; Operators lack of skill or negligence, use of poor welding and cutting tools and equipment, lack material and product handling, poor production process controlling system, and excessive dimensional allowances of the designs were considered as has slightly significance for the cause of metal waste sources, averagely scored about 25% by the respondents; Machine and equipment poor installations were considered as has no significance to the cause of metal waste sources in the case company, averagely scored about 0%.

Responses for the open-end questions prepared for production workers, part III were also included. wastes generated from metal products manufacturing as in the case of Kaliti metal products factory (KMPF) have the following disadvantages as reported by the respondents: metal wastes consume significant amount of financial resource, human efforts, handling equipment and storage sites(land); Can create health problems and unsafe conditions for workers; and can create environmental pollution.

The company was beneficiary from wastes management especially by the lean tool called Kaizen for continual improvement. Some of the benefits were work place proper arrangement and cleanliness, saving time, reductions of workers and materials movement, economic benefits and mental satisfactions of employees.

Managers, production workers and other stake holders can take action to reduce metal wastes in the manufacturing factory. Most of the responses were to strictly and properly use continual improvement tool called Kaizen for metal wastes management methods.

4.2.5. Analysis Results for Interview, Observations and data collected

As discussed during interview about waste management of the case company, Kaliti Metal Products Factory has been making encourageable efforts to minimize metal wastes. One of the remarkable waste management efforts was to apply and use one of the lean manufacturing principle (continual improvement) tools called Kaizen. The following lean wastes were discussed as shown below in table 4.8.

Table 4. 8 Lean wastes

S. No.	***Type of waste***	***Data Collection***	***Results***
1	Defect or reject	Number. of good parts made, Scrap and rework during processing	See table 4.13 for detail analysis
2	Inventory	Total raw material in store, WIP and Finished goods in stock	A small amount of raw materials, WIP and Finished goods were observed due to material scarcities.
3	Transportation and motion	Distance between machines, Distance operators travel	Distance between machines and operator motion were very small.
4	Waiting	Idle time of the machineries due to operational, technical and other reasons	Down time (waiting) is very high in the case company.
5	Overproduction	Total number of parts manufactured beyond the demand needed.	No significant over production observed
6	Over processing	Using wrong set of tools, procedures or systems	No significant over processed was observed.

Table 4. 9 Down time factors for the waiting lean wastes of standard products **in the case company for the budget year 2019/2020**

Machine Name	working time (hours)		Down time (waiting time) due to (in hours)								
	Plan	Actual	Die change	Products setup& trial	Lack of raw material	No job order	Mechanical problems	Electrical problems	Power interruption	Others	Total down time
OME	6,440.00	550.75	58.21	7.25	3540.95	115	125	308.25	164.8	1569.79	5889.25
MTM1	6,440.00	2088.8	484.37	88.00	1157.500	168	448.75	1265.65	159.05	579.88	4351.2
MTM2	6,440.00	2105.97	288.41	45.50	884.25	168	277.98	1960.00	101.3	608.59	4334.03
Slitt.2	6,440.00	1526.5	33.09	0	2263.00	509.96	498.96	428.25	68.05	1112.20	4913.5
slitt.1	6,440.00	1639.5	29.09	0	1941.00	339	873.00	561.91	69.80	986.70	4800.50
Total hours	32200.00	7911.52	893.17	140.75	9786.70	1299.96	2223.69	4524.06	563.00	4857.16	24288.5
Total hours (%)	100.00	25	3	0	30	4	7	14.05	1.75	15	***75***

Total down time (waiting time) for standard products in percentage is about 75% of the total production time planned. This is wasted time or nonproductive time. Table 4.9 shows total production plan, actual performance and down times (waiting times) with the main downtime drivers (factors). So, the case company must take measures to minimize downtime wastes.

Table 4. 10 Causes of waiting for standard products (the time is in hours)

Factors	Waiting time in hrs.	Waiting time in percentage
Die change	893.17	4%
Products setup &trial	140.75	1%
Lack of raw material	9786.70	40%
Lack of job order	1299.96	5%
Mechanical problems	2223.69	9%
Electrical problems	4524.06	19%
Power interruption	563.00	2%
Others	4857.16	20%
Total waiting time	24288.5	100%

The major causes of the down time (waiting) for standard products were: -Causes of down times (waiting time) due to lack of raw material contributes about 40% of the total down times (waiting times); downtimes due to different factors categorized as others were contributed about 20% of the total downtimes, down times (waiting time) due to electrical problems contributes about 19 % of the total down times (waiting times), Causes of down times (waiting time) due to mechanical problems contributes about 9 % of the total down times (waiting times), lack of job orders contributes about 5 % of the total down times (waiting times), die change activity contributes about 4%, electrical power interruption contributes about 2 % of the total down times (waiting times) and products set up and trial contributes about 1 % of the total down times (waiting times).

Table 4. 11 Waiting time factors for the waiting lean wastes for the other engineered **products for the Ethiopian budget year 2019/2020**

Machineries Name	Working time(hours)		Down times due to (in hours)								total down time
	plan	actual	Die change	set up & trial	Lack of raw material	Lack of job order	Mechanical problem	Electrical problem	Power interruption	others	
EGA 300	2527.00	283.00	128.54	0	2115.46	0	0	0	0	0	2244
Press	7942.00	3241.22	262.37	0	2578.5	249.5	120	100	0	310	4701
Cutting	7942.00	3953.50	413.73	95.38	1683	200	130	152	0	144.4	3988
Ribtile RF	2527.00	1615.50	523	147.82	0	21	10	19.68	0	100	911
Versatile RF	2527.00	1850.50	500	148.5	0	28	0	0	0	0	677
Arctile RF	2527.00	1877.47	111.6	25.93	0	312	100	100	0	0	950
Ridge cap RF	2527.00	1551.50	286.83	72.79	0	91	500	24.88	0	0	975
Normal R.C	7942.00	1511.75	207.84	39.26	0	3636	786	199	0	1562.2	6430
Total Hours	***36461.00***	***15884.44***	***2433.91***	***529.67***	***6376.96***	***4537.5***	***3986***	***595.56***	***0***	***2116.9***	***20577***
Total Hours (%)	100.00	43.6	7	1	17	12	11	1.63	0	6	***56***

Total down time (waiting time) in percentage is about 56% of the total production time planned for other engineered products. This is wasted time or nonproductive time. Table 4.11.shows total production plan, actual performance and down times (waiting times) with the main downtime drivers (factors) for the engineered products. So, the case company must take measures to minimize downtime wastes.

Table 4. 12 causes of waiting times for the other engineered products

Factors	Waiting time in hrs.	Waiting time in percentage
Die change	2433.91	12%
Products setup &trial	5,29.67	3%
Lack of raw material	6,376.96	31 %
Lack of job order	4,537.5	22%
Mechanical problems	3,986	19%
Electrical problems	595.56	3%
Others	4,857.16	10%
Total waiting time	20,577	100%

As can be seen from the table 4.12 cause of downtimes for the other engineered products were causes of downtime (waiting times) due to lack of raw materials were contributing about 31% of the total down time (waiting times) for other engineered products, lack of job order contributes about 22 % , mechanical problems encountered contributed about 19 % ,die change contributed about 12 %, electrical problems encountered contributed about 3% , products set up& trial were about 2% of the total downtimes and others factors were contributed about 10% of the total downtimes (waiting times).

Sample Defected or rejected products from the standard products production seen below. These products are rejected because they were not meeting customers design specifications but can be sold for other purposes with low price when compared to the normal product price.

Figure 4. 6 Sample of rejected parts defects

Defects or rejected products or scraps were shown in the table 4.6 below for standard products. From the table 4.6 as can be seen, out of 10066.43 tons of standard products of production, 86.546 ton of rejected products that covers (0.86%) were rejects or defects and classified as second and third grade according to the case company's own classification to identify from the main product called first grade and the scrap that cannot be further used in the case company. Out of 10066.43 tons of standard products, 12.87 tons were considered as scraps that cover about 0.13 %. Out of 9711.1 tons of coils of slitting operation, 231.789 tons of side trims that cover about 2.4 % were classified as side trim scraps. Rejected products for standard metal products were sold 78.6 ton for 2,361,000(two million three hundred sixty-one thousand). This price (2361000 birr) was less by 30% of the main products for the same ton of products according to the sales data from marketing and sales department. Scraps were sold 245 tons for 4,512,000 (four million five hundred twelve thousand) Birr.

Table 4. 13 Rejected products and scrap from standard products production process for the Ethiopian budget year 2019/2020

Standard products Production line						Slitting operation		
Month	production (ton)	Rejected products (2nd grade) (ton)	Rejected products (3rd grade) (ton)	total rejected products (2nd &3rd grade) (ton)	scrap(ton)	No. of coil(kg)	No. of coil(ton)	side trim scrap(ton)
July	646.033	17.01	0.83	17.84	0.7	959858	959.86	20.674
August	849.982	1.617	0.099	1.716	1.592	1207363	1207.4	31.545
September	834.394	6.422	0.412	6.834	0	794770	794.77	14.997
October	1436.707	8.44	0.263	8.703	1.3	1229096	1229.1	22.086
November	1443.577	21.697	0.098	21.795	1.16	1178105	1178.1	25.623
December	1414.303	8.531	1.722	10.253	0.4	1302630	1302.6	26.431
January	850.294	6.316	0.56	6.876	4.52	1302630	1302.6	21.896
February	543.061	2.654	0.978	3.632	0	300402	300.4	5.513
March	1.352	0	0	0	0	0	0	0
April	454.686	3.37	0.167	3.537	0	655136	655.14	14.413
May	792.044	1.929	0.841	2.77	1.6	781069	781.07	17.361
June	800	1.8	0.79	2.59	1.598	0	0	31.25
total	10066.43	79.786	6.76	86.546	12.87	9711059	9711.1	231.789
Total (%)	100	0.79	0.07	**0.86**	**0.13**	100.00	100	**2.4**

Defects or rejected products and scraps from other engineered products production processes are metal wastes. Table 4.14 shows rejected products and scraps from other engineered products production processes. About 11.551 tons of rejected products (second grade) and about 11.599 tons of scraps were recorded almost within a year time.

Table 4. 14 Defects or rejected products and scraps from other engineered products production for the budget year 2019/2020

Rejected parts and scraps from other engineered products production			
S. No.	Month	rejected products (2^{nd} grade) (tons)	scraps(tons)
1	July 2019	1.044	0.36
2	August 2019	1.932	0.446
3	September 2019	2.539	0.32
4	October2019	1.618	0
5	November 2019	0.73	0
6	December 2019	0.61	1.26
7	January 2020	0.886	0.83
8	February 2020	0.155	2.513
9	March 2020	0.828	0.55
10	April 2020	0.37	0.65
11	June 2020	0.839	4.67
Total		**11.551**	**11.599**

Rejected products for other engineered metal products sold 78.6 ton for 2,361,000(two million three hundred sixty-one thousand as well as scraps were sold 245 tons for 4,512,000(four million five hundred twelve thousand) Birr.

Metal wastes become a global issue facing by practitioners and researchers around the world. Metal Wastes can affect success of metal products manufacturing industries significantly. More specifically, it has major impact on company profitability, production time, and productivity and sustainability aspects. The highest environmental impact of metal waste is believed in terms of contamination. Although, metal wastes pollute the soil, the main areas of concern are air, water and noise pollution. Sources of water pollution in metal products manufacturing include diesel and oils, paints, solvents, cleaners and other harmful chemicals.

The impact of metal products wastes described as spoiling attractiveness of the manufacturing compound related to green production and environmental issues, needs additional financial, human resource, material handling equipment as well as the precious time for collecting, sorting, transporting and selling. The waste products occupy large amount of land that can be used other valuable investment since land is the very important and scarce resource in Ethiopia especially in Addis Ababa. The area of the site for the metal waste products storage is about 500 square meters within the factory compound.

The metal manufacturing factories can be beneficiary by managing metal products wastes as it can increase profitability by reducing downtime waste and rejected products, reducing human resource cost, material handling equipment cost and the precious time saving. The precious time saving was described as the time taken for collecting, sorting, transporting to the required site, and the process of selecting bidders for selling the metal waste. Minimizing significant amount of metal products waste can lead to increase the life time of the expensive cutting tools and at same time can increase the products quality. The site for metal products waste storage, about 500 square meters, can be save and considered as profit for the case company under investigation. Health and safety benefits also were considered as potential gains from managing and minimizing the metal products waste in addition to economical and environment concerns.

The response for the question “actions to reduce metal wastes”? was presented and discussed. Government policy makers, Industrial managers and experts, researchers, factory experts, environment and health experts and researchers, global policy makers as well as political parties can take actions to reduce metal wastes. Frame work for future metal waste management was asked to the respondents. 86% of the respondents had not stated the future frame work for metal waste management, but 14% of the respondents were stated as to use the continuous improvement method called Kaizen as improvement tool for a metal wastes management.

4.3. Discussion

The general objective of the study is to investigate the current situation of waste management in the metal manufacturing industry in the case company, Kaliti Metal Products Factory and propose waste free metal manufacturing strategies accompanying with some research questions to address the research problems.

This study shows the main sources(causes) of wastes such as technology constraints and products design out of standard were the main sources of wastes from the design issues perspectives were similar with the study done by (Shahbazi, Kurdve, Bjelkemyr, Jönsson, & Wiktorsson, 2013),and (Singh, Laurenti, Sinha, & Frostell, 2014).But there is some difference with the study results with respect to selecting the lowest price bidder suppliers and sub-suppliers that were scored highest point averagely (75%) by the manager's respondents as causes of wastes in the case company with regard to procurement issues.

Moreover the study confirmed that Poor time management, damage of output products and poor technology of machines and equipment were sources of wastes in the manufacturing processes perspectives which matches with the research study of (Singh, Laurenti, Sinha, & Frostell, 2014), (Womack & Jones, 2003),and (Pavnaskar, Gershenson, & Jambekar, 2003).

The study also showed that Waste management issues results that encompasses, Lack of Contribution of the Management System aiming at waste minimization, Lack of Transformed Industrial Design, Lack of 100% Recycling and Recovery, and New infrastructure & system thinking(includes new infrastructure, New technologies, and zero waste Governance) were considered the extreme significant(100%) averagely by the respondents for the cause of wastes in the case company ; Lack of proper waste management plan and control, Lack of availability of strategy to waste minimization, lack of provision of information to participants in the Factory, ineffective planning and scheduling of the Production byproducts, Lack of Awareness, education and Research includes Zero waste programs, Transformative education and zero waste research were considered as very significant averagely scored 75% for the cause of wastes in the case company were supported in the literature reviews by (Zaman & Lehmann, 2013), (Singh, Laurenti, Sinha, & Frostell, 2014), (Mekonnen &

Gokcekus, 2019) that supports the analyses results but with some difference with the analyzed results such as prioritization missing.

The findings from the analysis for the secondary data shows that 75 % of the total production time for standard products and 56 % of the total production time for other engineered products were found as wastes called waiting time waste according to lean principle; rejected products as waste from the standard products departments were somehow related to the literature review of lean wastes such as waiting time and rejected products/ materials according to (Womack & Jones, 2003),and (Pavnaskar, Gershenson, & Jambekar, 2003), but differ from the study results of (Zaman & Lehmann, 2013).

The major findings of this research are very important to the metal manufacturing industry particularly to the case company, KMPF to handle the poor waste management so that the company can be benefited from implementing good waste management practices and also gives adequate knowledge and understanding to the broad knowledge of metal manufacturing industry waste management.

CHAPTER FIVE

5. PROPOSED WASTE MANAGEMENT STRATEGY

The integration of the concepts of the zero- waste and lean management as shown in figure 5.1 below it is clear that waste free metal manufacturing industry can be created. The zero-waste concept majorly concerns about avoiding waste landfill and incineration around the city but lean concerns about eliminating of wastes or non-value adding processes to the manufacturing of the product that cannot increase satisfaction of the customer. The main elements of the Zero waste management are described below.

1. Awareness, Education and Research

Awareness, education and research include zero waste programs, transformative education and waste research. They are set at the very being because they are very important for creation new mind set up to wards the new transformation of current industries to zero waste industries. creating awareness to the society through different initiative programs can lead to zero waste such as the polluters pay more or non-polluters get incentives. Promoting zero waste management through education and training to the manufacturing industry as well as to the community can lead to effective waste management. Research on the topic zero waste management can improve the waste management system by indicating improvement strategies.

2. New infrastructure and system thinking

New infrastructure and System thinking include three very important elements, new infrastructure, new technologies and the zero-waste governance. New infrastructure includes waste separation and collecting systems, machineries and equipment, and equipped waste plant areas. The new technology and system thinking are very important in reducing wastes specially for metal wastes in order to recycle or recover material and energy by reducing the negative effect on the health of nations and pollution of the environment.

3. Hundred percent recycling and recovery

Implementing 100% recycling and recovery leads to zero waste metal manufacturing system. The Ethiopian the metal manufacturing industry has to reach to the capacity of circular manufacturing system to 100% recycling and recovery, and use the energy produced in converting metal wastes to useful metal products. But the case company sales the metal wastes to other steel manufacturing companies using tendering system. The company should also investigate the feasibility to establish waste recycling and recovery plant.

4. Sustainable consumption and behaviour change

Sustainable consumption and behaviour change include collaborative consumption, behaviour change and sustainable living. They are very important enablers of zero waste management by having sustainable product consumption and behaviour change. Sustainable living contributes to waste reduction. Behaviour change to the traditional way of waste management leads to the zero-waste management such as waste collecting in a proper way and location, having the idea the metal wastes are valuable resources that can generate money. Metal Wastes have also negative impacts on human being heath and on the environmental pollution.

5. Transformed industrial design

Transformed industrial design includes cradle to cradle design, cleaner production and producer's responsibility. Cradle to cradle design covers the whole product development and manufacturing system chain to avoid wastes. When waste is observed in some place in the product manufacturing, the whole system should be reconsidered to avoid the wastes from the source so that sustainable system can function well. Cleaner production is very useful in improving manufacturing productivity by avoiding wastes that have negative impact on the environment and people living nearby. Producers responsibility is the responsibility of the manufacturing firms that they have to take care of the wastes not to harm the health and environment knowingly. Producers have the responsibility to create awareness to the community and his employees about hazard wastes disadvantages and their protection methods if any.

6. The zero-depletion legislation and policies

The zero-depletion legislation and policies include the zero landfill, zero incineration and incentives that are very important to eliminate wastes. In Ethiopia there is no forcing legislations and policies to bring wastes to zero level. Wastes are disposed in around the cities in landfill strategies. In incineration wastes are burned and energy is recovered but there are harmful emissions during incineration that must be avoided. Incentives have the power to reduce wastes to zero. Different incentive mechanisms can be initiated by the concerned government and non-government bodies.

In the lean management concept, some waste that are not physical (material) wastes that are considered as wastes such as transportation or motion, loss of potentials. There is also confusion in defining 'waste' and applying approaches.

7. Eliminating wastes from the Lean manufacturing systems perspective

7.1.Over production

Over production is producing more than essential by the subsequent process. Many numbers of production managers and supervisors assumes that metal waste is caused by quality issues but surplus manufactured items possibly will be sold with cheap prices at the end of the fiscal year to match the finances for the subsequent year's inventory. The cost of overproduction for firms may be different dimension. Hence the management always fixes the production schedule to the customer demands in order to avoid overproduction that can hold money-ties.

7.2.Waiting

Waste of waiting is directly relevant to flow and it is probably the most important waste. It occurs when time is not being used effectively. In a factory, this type of waste occurs when goods are not moving and it affects both the goods and workers.

7.3. Excess Motion

Any unnecessary motion that does not add value to the product is waste. Unwanted motion of worker in metal manufacturing factories will result in time lag, waste of human effort and increased cost of the finished products. Excessive motions in the manufacturing environment will cause delays of manufacturing time and can be exposed to sudden products and machines damage.

7.4.Transportation

Moving manufactured products from one place to another place does not add value of the product to the customer. Transportation is defined as dispatch to and from outside the firm. Transportation of completed metal products normally made by an appropriate factory process in some of the manufacturing industries facing major impact of lean.

7.5. Inventory

This is the classic waste. All inventories are waste unless the inventory translates directly in to sales. It makes no difference whether the inventory is raw materials, work in process (WIP) or finished goods. The level of equipment support should be given attention in lean manufacturing because some manufacturing processes rely heavily on their equipment to produce products. This inventory reduction not only save money but also tolerates the minimum manufacturing lead time. Poor record keeping, miscommunication with suppliers and clients and irregular management decisions will result in elevated inventory levels. In the case company no inventories were observed due to shortage of foreign currency for a long time.

7.6. Over-processing

Extra processing not essential to value-added from the customer point of view is waste. Many research articles point out to the over processing is more important to reduce the wastages in factories. As a result, it is important to focus at all operations in factories to identify and avoid the potential waste. Incorrect processing results from the wrong set of tools, low standard machines, lack of communications and unnecessary information regarding product changes without process changes.

7.7.Producing defective products

Defective products impede material flow and lead to wasteful handling, time, and effort. These wastes appear in every manufacturing activity. The most important tasks of factories are to identify, manage, and minimize these wastes in order to become more profitable and competitive.

7.8. Loss of potential (underutilization of employees)

The loss of potential is considered as waste in the lean management philosophy. In the case company, employees without work engagement or little engagement were observed during the study process in it.

So, integrating the zero-waste and lean management waste concepts can give clarity to the definition of waste, types of waste and their scope. In this thesis paper the scope of waste concept includes both the zero- waste and the lean management waste concepts to fill the research gap to metal manufacturing industry waste management.

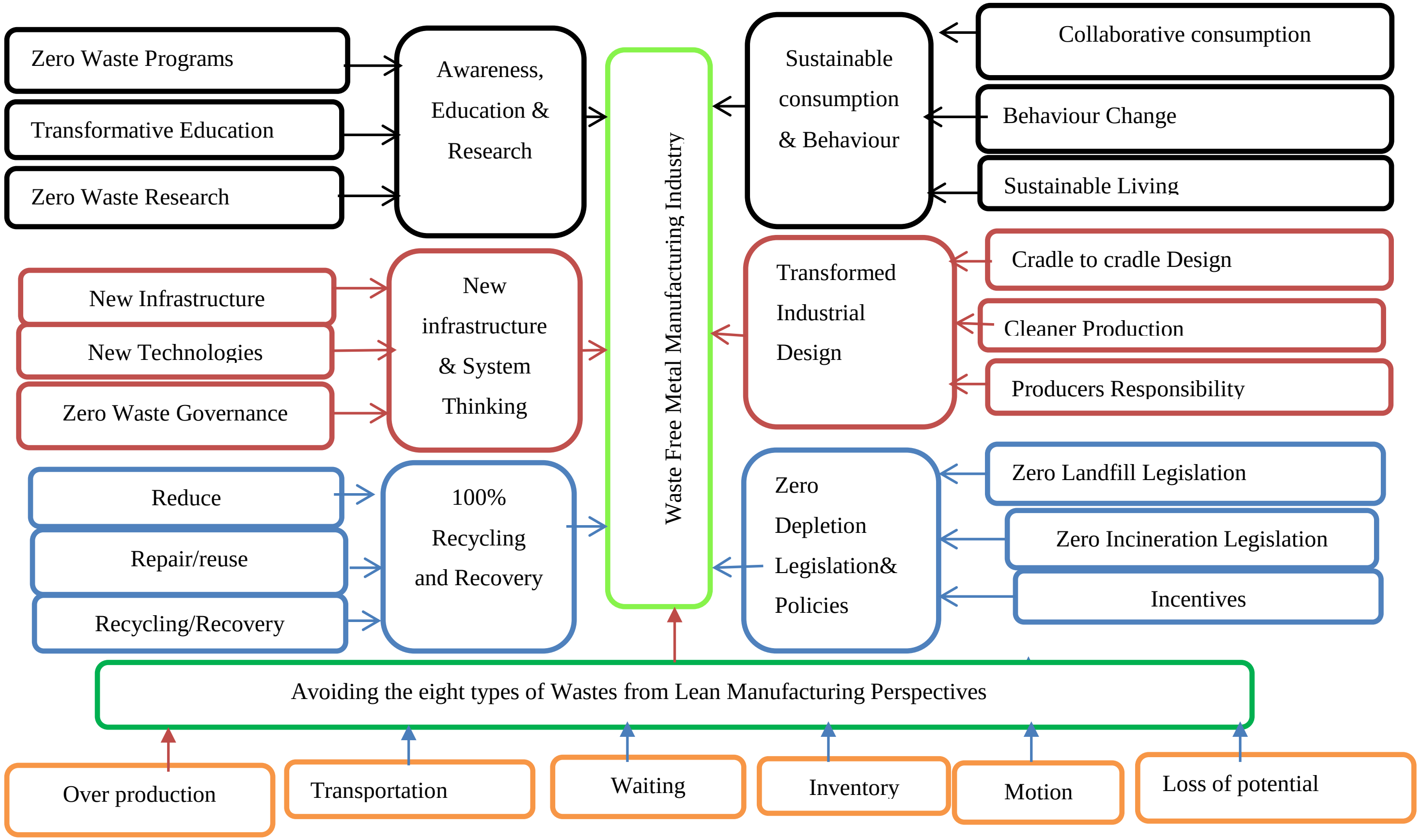

Figure 5. 1 Proposed plan for Waste free metal manufacturing industry (Own contribution)

CHAPTER SIX

6. CONCLUSIONS AND RECOMMENDATIONS

6.1. Conclusion

This study has focused on Waste Management in Metal Manufacturing Industry using the integration of Lean and the Zero Waste Management Strategy through a case company called Kaliti Metal Products Factory (KMPF) in Addis Ababa. The major causes of waste in the metal products factory was identified and presented in a comprehensive analysis of these causes in chapter four. The questionnaires of this study considered 84 factors which were causes or sources of wastes in metal products manufacturing industry, and those factors were distributed into three groups namely, Managers (executive officers), Marketing and sales executive officers and Production workers.

Therefore, the results from the analysis shows that seventy-five percent (75 %) of the total production time for standard products and fifty-six percent (56 %) of the total production time for other engineered products were found as wastes called waiting time(down time) waste according to lean principle; rejected products as waste from the standard products departments were found to be , 86.546 ton of rejected products that covers (0.86%) out of 10066.43 tons of standard products of production were rejects or defects and classified as second grade according to the case company's own classification to identify from the main product called first grade and the scrap that cannot be further used in the case company and out of 10066.43 tons of standard products, 12.87 tons were classified as scraps that cover about 0.13 %. Out of 9711.1 tons of coils of slitting operation, 231.789 tons of side trims that cover about 2.4 % were classified as side trim scraps; and rejected products from other engineered products about 11.551 tons of rejected products (second grade) were recorded almost within a year time and 11.599 tons of scraps were recorded to be considered as wastes.

The main sources(causes) of wastes were technology constraints and products design out of standard were the main sources of wastes from the design issues perspectives, selecting the lowest price bidder suppliers and sub-suppliers were scored highest point averagely (75%) by the manager's respondents as causes of wastes in the case company with regard to procurement issues, Poor time management, damage of output products and poor technology of machines and equipment were sources of wastes in the manufacturing processes perspectives; waste management and minimization issues encompasses Lack of Contribution of the Management System aiming at waste minimization, Lack of Transformed Industrial Design, Lack of 100% Recycling and Recovery, and New infrastructure & system thinking(includes new infrastructure, New technologies, and zero waste Governance) were considered the extreme significant(100%) averagely by the respondents for the cause of wastes in the case company ; Lack of proper waste management plan and control, Lack of availability of strategy to waste minimization, lack of provision of information to participants in the Factory, ineffective planning and scheduling of the Production byproducts, Lack of Awareness, education and Research includes Zero waste programs, Transformative education and zero waste research were considered as very significant averagely scored 75% for the cause of wastes in the case company.

The major causes (sources) of downtimes (waiting) for standard and engineered products were lack of raw materials, electrical and mechanical failures, lack of job orders, die change activity, electrical power interruption, and products set up and trial. The highest environmental impact of metal products wastes is believed in terms of contamination. Although, metal products wastes pollute the soil, the main areas of concern are also air, water and noise pollution. Metal Products Manufacturing Factories are generating high level of noise and dust particles. Sources of water pollution in metal manufacturing industry include diesel and oils, paints, solvents, cleaners and other harmful chemicals.

The mitigation measures to practice for reducing metal products wastes in Metal Manufacturing Industry are, Giving training for metal products manufacturing personnel on Transformed Industrial Design(such as cradle –to- cradle design, cleaner production, producer responsibility), 100% Recycling and Recovery (such as reduce, repair/reuse and Recycling/recovery),and New infrastructure & system thinking(includes new infrastructure, New technologies, and zero waste Governance) , changing attitude of managements and workers towards the zero waste and lean management by proper training, improving supervision, good coordination between managements and production workers to avoid material or products wastages of the metal products manufacturing industry particularly for the case company, Kaliti Metal Products Factory(KMPF) and also to encourage to use circular economy concept.

6.2. Recommendations

The following recommendations have been made to improve the application of principles to manage metal products wastages in metal products manufacturing industry particularly for the case company.

- Government Should establish waste management implementation strategies with mandatory rules, regulations and incentives.
- Factory Owners can use the proposed new waste free metal manufacturing industry to reduce their wastes to zero.
- Implementation of the new proposed waste free metal manufacturing industry strategies or model in Ethiopia manufacturing Industry can be further investigated.

References

Abdullah, F. (2003). *Lean Manufacturing Tools and Techniques in the Process Industry with a Focus on Steel.* Pittsburgh: University of Pittsburg.

Aibinu, & Jagboro. (2002). The effects of construction delays on project delivery in Nigerian construction industry . *International Journal of Project Management*, 595.

Al-Khatib, I. A., B, H. A., Basheer, T., Shawahneh, H., Salahat, A., Eid, J., & Ali, W. (2007). Trends and problems of solid waste management in developing countries:A case study in seven Palestinian districts. *Waste Management, 27*, 1910-1919.

Al-Kindi, L. A., & Alghabban, W. K. (2019). Framework for Solid Waste Management in Steel Fabrication. *Fourth International Scientific Conference on Environment and Sustainable Development (4th ISCESD). 37 , part C, No.2*, pp. 227-236. Cairo(Egypt): Engineering and Technology Journal.

Bello, I. A., Ismail, M. N., & Kabbashi, N. A. (2016). Solid Waste Management in Africa: A Review. *International Journal of Waste Resources*, 1-4.

Castrejón-Godínez, M. L., Sánchez-Salinas, E., Rodríguez, A., & Ortiz-Hernández, M. L. (2015). Analysis of Solid Waste Management and Greenhouse Gas Emissions in México: A Study Case in the Central Region. *Journal of Environmental Protection, 6*, 146-159.

Chahala, V., & Narwalb, M. (2017). An empirical review of lean manufacturing and their strategies. *Management Science Letters*, *7*, 321-336.

Cheru, M. (2016). *Solid Waste Management in Addis Ababa: A new approach to improving the waste management system.* Heinsinki Metropolia Unversity Applied Sciences.

Chroneer, D., & Wallstrom, P. (2016). Exploring Waste and Value in a Lean Context. *International Journal of Business and Management, 11*(10), 282-297.

Coelho, L. M., Coelho, L. C., & MG, a. H. (2016). Multi-criteria decision making to support waste management: A critical review of current practices and methods. *Waste Management & Research,* 1-26.

Creswell, J. W. (2014). Research Design: Qualiative, Quantitative, and Mixed Methods Approaches (4th ed.). *California :SAGE publications, Inc.*

Demirbas, A. (2010). Waste Management, waste resource facilities and waste conversion processes. *Energy Conversion and Management*, 1280-1287.

Dijkema, G., Reuter, M., & Verhoef, E. (2000). A new paradigm for waste management. *Waste Management, 20,* 633-638.

Dixit, A., Dave, V., & Singh, A. P. (2015). Lean Manufacturing: An Approach for Waste Elimination. *International Journal of Engineering Research & Technology (IJERT), 4*(4), 532-536.

Duke, L. D. (1994). Hazardous waste minimization: is it taking root in U. S. Industry?Waste Minimization in Metal Finishing Facilities of the San Francisco Bay Area, California . *Waste Management, 14*(1), 49-59.

E.Marshal, R., & Farahbakahsh, K. (2013). Systems approaches to integrated solid waste management in developing countries. *Waste Management*, 988-1003.

Elgizawy, S. M., El-Haggar, S. M., & Nassar, K. (2016). Approaching Sustainability of Construction and Demolition Waste Using Zero Waste Concep. *Low carbon Economy, 7,* 1-11.

Eshetie, T. (2018). Ethiopia's Manufacturing Industry Opportunities, Challenges and Way Forward: A Sectoral Overview. *Novel Techniques in Food and Nutrition Science, 2*(2), 1-7.

FDRE Ministry of Industry . (2014). *ENVIRONMENTAL AND SOCIAL MANAGEMENT FRAMEWORK.* FDRE Ministry of Industry. Addia Ababa: The Federal Democratic Republic of Ethiopia MINISTRY OF INDUSTRY.

Generowicz, A., Kowalski, Z., & Kulczycka, J. (2011). Planning of Waste Management Systems in Urban Area Using Multi-criteria Analysis. *Journal of Environmental Protection, 2*, 736-743.

Gilles, D. G., Loehr, R. C., & Fellow, A. (1994). Waste Generation and Minimization in Semiconductor Industry. *Environmental Engngineering, 120*(1), 72-86.

Guerrero, L. A., Maas, G., & Hogland, W. (2012). Solid waste management challenges in developing countries. *Waste Management*, 220-232.

Hailemariam, M., & Ajeme, A. (2014). Solid Waste Management in Adama, Ethiopia: Aspects and Challenges. *World Academy of Science, Engineering and Technology International Journal of Environmental and Ecological Engineering, 8*(9), 670-676.

Hannon, J., & Zaman, A. U. (2018). Exploring the Phenomenon of Zero Waste and Future Cities. *Urban Science, 2*(90), 1-25.

Hollins, O., & Institute, W. (2017). Towards a circular economy -Waste Managemnt in the European Union. *STOA - Science and Technology Options Assessment* (pp. 1-140). Brussels: European Union.

Jamaludin, A. H., Karim, N. A., Husna, R. N., Noor, R. M., Othman, N., & Malik, S. A. (2017). Preliminary Study on Enhancing Waste Management Best Practice Model in Malaysia Construction Industry. *International Conference on Applied Physics and Engineering (ICAPE2017)* (pp. 030008-1–030008-6). Mara,Malaysia: AIP.

Johansson, G., & Winroth, M. (2014). Lean vs. Green manufacturing: Similarities and differences. *https://www.researchgate.net/publication/257492917* (pp. 1-11). Göteborg, Sweden: Research Gate.

Joshi, A., Kale, S., Chande, S., & Pal, D. K. (2015). Likert Scale: Explored and Explained. *British Journal of Applied Science & Technology, 7*(4), 396-403.

K.Henry, R., Yongsheng, Z., & Jun, D. (2006). Municipal Solid Waste Management challenges in developing countries – Kenyan case study. *Waste Management, 26*, 92-100.

Karak, T., Bhagat, R. M., & Bhattacharyya, P. (2012). Municipal Solid Waste Generation, Composition, and Management: The World Scenario. *Critical Reviews in Environmental Science and Technology, 42*(15), 1509-1630.

Karlson, C. N. (1995). Model for Lean Production. *Institute for management of Innovation and Technology*. Goteborg.

Kitaw(Dr.-Ing.), D. (2009). *Industrial Management and Engineering Econmomy :An Introduction to Industrial Engineering Textbook.* Addis Ababa, Addis Ababa, Ethiopia: Addis Ababa University Press.

Kouloughli, S., & Kanfoud, S. (2017). Municipal Solid Waste Management in Constantine, Algeria. *Journal of Geoscience and Environment Protection, 5*, 85-93.

Kumar, A., & Kumar, B. (2018). Recent Advances in Solid Waste Minimization using Nanotechnology. *International Journal for Research in Applied Science & Engineering Technology (IJRASET), 6*(VI), 759-764.

Kumar, S., & A.N.Balaji, R. (2014). Productivity improvement of an industry by implementing Lean Manufacturing principles. *International Journal of Innovative Research in Science, Engineering and Technology*(Special Issue 3), 3.

Lema, G., Mesfin, M. G., Eshete, A., & Abdeta, G. (2019). Assessment of status of solid waste management in Asella town, Ethiopia. *BMC Public Health*, 1-7.

Lewis, F. (2003). Design Issues. In J. Ritchie and J. Lewis (ed), Qualitative Research Practice. A Guide for Social Science Students and Researchers. (p.66-67).

Lilija, R. (2009). From waste prevention to promotion of material efficiency :Changeof discourse of in the waste police in Finland. *Journal of Cleaner Production, 17*, 129-136.

M.C.Monte, E.Fuente, A.Blanco, & C.Negro. (2009). Waste management from pulp and paper production in the European Union. *Waste Management*, 293-308.

Mallak, S. K., Elfghi, F., Rajagopal, P., Vaezzadeh, V., & Fallah, M. (2016). Overview of Waste Management Performance of Industrial Sectors by Selected Asian Countries: Current Practices and Issues. *99 No.8*, pp. 66-75. Selangor Darul Ehsan(Malaysia): Chemical, Biological and Environmental Engineering.

Mallak, S. K., Ishak, M. B., Kasim, M. M., & Samah, M. A. (2015). Assessing the Effectiveness of Waste Minimization Methods in Solid Waste Reduction at the Source by Manufacturing Firms in Malaysia. *Environmental Study*, 2063-2071.

Mbuligwe, S. E., & Kaseva, M. E. (2006). Assessment of industrial solid waste management and resource recovery practices in Tanzania. *Resources, Conservation and Recycling, 47*, 260–276.

Mekonnen, Y. A., & Gokcekus, P. H. (2019). Urbanization and Solid Waste Management Challenges, in Addis Ababa City, Ethiopia. *Civil and Environmental Research*, 6-15.

Moreira, F., Alves, A. C., & Sousa, R. M. (2010). Towards Eco-efficient Lean Production Systems. *IFIP International Federation for Information Processing*, 100-108.

Muleya, F., & Kamalondo, H. (2017). An Investigation of Waste Management Practices in the Zambian Construction Industry. *Journal of Building Construction and Planning Research, 5*, 1-13.

Owolabi, S. A., Mmereki, D., Baldwin, A., & Li, B. (2016). A comparative analysis of solid waste management in developed, developing and lesser developed countries. *Environmental Technology Reviews, 5*(1), 120-141.

Pattanaik, L. N., & Sharma, B. P. (2009). Implementing lean manufacturing with cellular layout:a case study. *International Journal for Advanced Manufacturing Technology, 42*, 772-779.

Pavnaskar, S. J., Gershenson, J. K., & Jambekar, A. B. (2003). Classification scheme for lean manufacturing tools. *International Journal of Production Research, 41*(13), 3075-3090.

Prasad, S., & S.K.Sharma. (2014). Lean and Green Manufacturing: Concept and its Implementation in Operations Management. *International Journal of Advanced Mechanical Engineering. Volume 4, Number 5 (2014), pp. 509-514, 4*(5), 509-514.

Regassa, N., D.Sundaraa, R., & Seboka, B. B. (2011). Challenges and Opportunities in Municipal Solid Waste Management: The Case of Addis Ababa City, Central Ethiopia. *Journal of Human Ecology, 33*(3), 179-190.

Rushton, L. (2003). Health hazards and waste management. *British Medical Bulletin, 68*, pp. 183-197.

Saidou, H., & Aminou, S. (2015). Solid Waste Management in the Town of Maradi in Niger Republic. *Journal of Environmental Protection, 6*, 359-373.

Shah, R., & T.Ward, P. (2007). Defining and developing measures of lean production. *Journal of Operations Management, 25*, 785-805.

Shahbazi, S., Kurdve, M., Bjelkemyr, M., Jönsson, C., & Wiktorsson, M. (2013). Industrial waste management within manufacturing: a comparative study of tools, policies, visions and concepts. *Proceedings of the 11th International Conference on Manufacturing Research (ICMR2013)* (pp. 1-8). Stockholm, Sweden: https://www.researchgate.net/publication/267209102.

Singh, J., Laurenti, R., Sinha, R., & Frostell, B. (2014). Progress and challenges to the global waste management system. *Waste Management & Research*, 800-812.

Solisio, C., Lodi, A., & Veglio, F. (2002). Bioleaching of zinc and aluminium from industrial waste sludges by means of Thiobacillus ferrooxidans. *Waste Management*, *22*, 667-675.

Starovoytova, D., & Namango, S. (2018). Solid Waste Management at a University Campus (Part 3/10): Waste Generators, Current Practices, and Compliance with relevant-law-provisions. *Journal of Environment and Earth Science, 8 No.6*, 140-170.

Tiwari, B. P., & SC.Tiwari. (2012). An overview of Solid Waste Management System in Debre Markos Town of Ethiopia. *Global Journal of Current Research*, 1-8.

Tortorella, G., Silva, G., Campos, L. M., Pizzeta, C., Latosinski, A., & Soares, A. (2018). Productivity improvement in solid waste recycling centres through lean. *Benchmarking: An International Journal*, 1-37.

Ulfik, A., & Nowak, S. (2014). Determinants of Municipal Waste Management in Sustainable Development of Regions in Poland. *Poland Journal of Environmental Studies, 23*(3), 1039-1044.

Wee, S. T., Abas, M. A., Chen, G. K., & Mohamed, S. (2017). The Constraints of Good Governance Practice in National Solid Waste Management Policy (NSWMP) Implementation: A Case Study of Malaysia. *AIP Conference Proceedings*, (pp. 020127-1 to 020127-6). Johor, Malaysia.

Womack, J. P., & Jones, D. T. (2003). *Lean Thinking, Banish Waste and Creat Wealth in Your Corporation.* New York: FREE PRESS a division of Simon & Schuster, Inc. 1230 Avenue of the Americas, Ny 10020, ISBN 0-7432-4927-5.

Womack, J., & Jones, D. (2003). Lean Thinking. *Simon &Schuster.* London.

Yilmaz, O., Anctil, A., & Karanfil, T. (2014). LCA as a decision support tool for evaluation of best available techniques (BATs) for cleaner production of Iron casting. *Journal of Cleaner Production, xxx*, 1-11.

Yin, R. (2003). Case study research: design and methods. *Sage Publications, Thousand Oaks, CA.*

Young, T. K. (2004). Using industrial processes to improve patient care. *British Medical Journal, 328*(7432), 162-164.

Zaman, A. U. (2015). A comprehensive review of the development of zero waste management : lessons learned and guidelines. *Journal of Cleaner Production, 91*, 12-25.

Zaman, A. U., & Lehmann, S. (2013). The zero waste index: a performance measurement tool for waste. *Journal of Cleaner Production, 50*, 123-132.

Zulkipli, F., Nopiah, Z. M., Basri, N. E., & Kie, C. J. (2016). Stock Flow Diagram Analysis on Solid Waste Management in Malaysia. *The 4th International Conference on Quantitative Sciences and Its Applications (ICOQSIA 2016)* (pp. 040023-1-6). Pahang,Malaysia: AIP Publishing.

APPENDICES

APPENDIX –A

Questionnaire Survey for the Managers for Thesis paper on

Waste Management and Minimization in metal products manufacturing industry: a case study on Kaliti Metal Products Factory.

ADDIS ABABA UNVERSITY

ADDIS ABABA INSTITUTE OF TECHNOLOGY

SCHOOL OF MECHANICAL AND INDUSTRIAL ENGINEERING

Questionnaire Survey for thesis paper *entitled:* Waste Management and Minimization for Metal Products Manufacturing Industry: A case Study on Kaliti Metal Products Factory.

I am presently pursing a Master of Science Degree in Mechanical Engineering (Industrial Engineering Stream) in Addis Ababa Institute of Technology (AAiT) in the school of Mechanical and Industrial Engineering.

The aim of these questionnaires is to study the Waste Management and Minimization in the case company, Kaliti Metal Products Factory. Please answer all questions as possible as you can. All the information gathered will be kept strictly confidential and will be used only for academic research and analysis without mentioning the names of individual participants involved.

Thank you in advancing for your time and kind cooperation

Yours Faithfully,

Moges Hagos (Mobile. +251-911865343)

Supervised by Dr. Kassu Jilcha.

June 2020, Addis Ababa, Ethiopia.

Questionnaires for Managers (executive officers) only

Part I: General Information

Please circle the appropriate alternatives.

1. Sex

   A) Male B) Female

2. Age (in years)

   A) 18-30 B) 31-40 C) 41-50 D) above 50

3. Relevant work experience in years

   A) 1-10 B) 11-20 C) 21-30 D) More than 30

4. Your work Position in the company

   A) Production manager B) Marketing Manager C) worker D) Procurement Manager E) administration worker F) other

Part II. Sources and causes of wastes in Kaliti Metal Manufacturing Products Factory

The given numbers below are sources and causes of wastes on Metal Manufacturing Products. Please indicate the significance of each factor by ticking the appropriate boxes. Add any remarks relating to each factor on the last column e.g. as to the reasons, the critical factors or the solutions.

E.S. = extremely significant [100%], V.S. = very significant [75%] M.S. = moderately significant [50%], S.S. = slightly significant [25%], N.S. = not significant [0%]

Cause of wastes in the case company	E.S 100%	V.S 75%	M.S 50%	S.S 25%	N.S 0%	Remarks
Group I. Design Issues						
1. Design changes and revisions						
2. Technology constraints						
3. The increment of engineered products (designing of Products out of standard or as customer desired)						
4. Lack of information in the drawings						
5. Shortage of time for urgent design activities						
6. Big estimation of specification tolerances (allowances)						
7. Poor communication with stakeholders leads to mistakes and errors						
8. Selection of low-quality input materials during the design process						
Group II. Materials and Products						

Cause of wastes in the case company	E.S 100%	V.S 75%	M.S 50%	S.S 25%	N.S 0%	Remarks
A: Procurement						
1. Poor schedule to procure materials						
2. Selecting the lowest bidder suppliers and sub-supplier						
3. Over ordering or under ordering due to mistakes in quantity surveys [Inventory is regarded as waste in Lean principle]						
4. Purchased materials that don't comply with specifications						
5. Poor storage system						
6. Damage of materials in the store						
B: Manufacturing processes						
1. Damage of input materials arrival						
2. Damage of output materials(products)						
3. Lack of Product controlling systems						
4. Lack of understanding the design or drawings given to operators						
5. Lack of production methods clarity						
6. Operators negligence or lack of skill						

Cause of wastes in the case company	E.S 100%	V.S 75%	M.S 50%	S.S 25%	N.S 0%	Remarks
7. Design change of customers or order change.						
8. Machine and equipment depreciation						
9. Poor product handling system						
10. Lack of employee’s motivation and incentives						
11. Poor workmen relation in the company						
12. Reworks due to mistakes [Reworks are wastes with regard to Lean principles]						
13. High product rejection rate [Rejected products are wastes with regard to Lean principles]						
14. Over production [Over productions are wastes with regard to Lean principle]						
15. Over processing [with regard to Lean principle]						
16. Poor time management [Downtime is waste with regard to Lean principles]						
17. Unnecessary movement of products (materials) and workers [Motion is waste with regard to Lean principles]						
18. Frequent accidents						
19. Shortage of manpower						
20. Using untrained(new) workers						

Cause of wastes in the case company	E.S 100%	V.S 75%	M.S 50%	S.S 25%	N.S 0%	Remarks
21. Machines and equipment frequently breakdown						
22. Poor technology of machines and equipment						
23. Shortage of tools and equipment required						
24. Poor floor plan layout						
Group III. Waste Management						
1. Lack of proper waste management plan and control						
2. Contribution of the Management System aiming at waste minimization						
3. unavailability of strategy to waste minimization						
4. Lack of Material or product transportation system [unnecessary transportation is waste with regard to Lean Principle]						
5. Qualification of the operators, technical staff assigned to the Factory						
6. provision of information to participants in the Factory						
7. ineffective control of the quality controllers and inspectors						
8. unavailability of technical senior professionals in the Factory						
9. ineffective planning and scheduling of the Production						

Cause of wastes in the case company	E.S 100%	V.S 75%	M.S 50%	S.S 25%	N.S 0%	Remarks
byproducts						
10. Lack Waste Separation system in the Factory						
11. Lack of Awareness, education and Research includes Zero waste programs, Transformative education and zero waste research						
12. Lack of Transformed Industrial design (such as cradle –to- cradle design, cleaner production, producer responsibility)						
13. Lack of Zero depletion legislation and policies (such as zero landfill legislation, Zero –incineration legislation and Incentives)						
14. Lack of 100% Recycling and Recovery (such as reduce, repair/reuse and Recycling/recovery)						
15. New infrastructure and system thinking (includes new infrastructure, New technologies, and zero waste Governance)						
16. Lack of Sustainable consumption and behavior (includes collaborative consumption, behavioral change and sustainable living)						

Part III: Causes/sources of metal wastes for the key products of the case company

Please indicate the significance of each factor by ticking the appropriate boxes. Add any remarks relating to each factor on the last column e.g. as to the reasons, the critical factors or the solutions. E.S. = extremely significant [100%], V.S. = very significant [75%], M.S. = moderately significant [50%], S.S. = slightly significant [25%], N.S. = not significant [0%].

Cause of product /material wastes in the case company	E.S 100%	V.S 75%	M.S 50%	S.S 25%	N.S 0%	Remarks
I. Tubular [Rectangular and Circular Hollow sections (Standard Products)]						
1. Defects in products due to the process sudden interruption						
2. Excessive dimensions allowances of the tubular						
3. Use of poor tools and equipment						
4. Poor material and product handling						
5. Poor production process managing						
6. Poor performance leading to rework						
7. Poor machine and equipment installation						
8. Poor machine and equipment maintenance skill						
9. Poor shifts managing style						
10. Operators lack of skill or negligence						
II. Galvanized corrugated Iron sheet (Engineered Products Manufacturing)						
1. Defects in products due to the process sudden interruption						
2. Excessive dimensions of the designs						
3. use of poor cutting tools and equipment						
4. Poor material and product handling						
5. Poor production process managing						

Cause of product /material wastes in the case company	E.S 100%	V.S 75%	M.S 50%	S.S 25%	N.S 0%	Remarks
6. Poor performance leading to rework						
7. Poor machine and equipment installation						
8. Poor machine and equipment maintenance skill, old machines						
9. Poor shifts managing style						
10. Operators lack of skill or negligence						
III. ***Truck (Welding and Assembly Workshop)***						
1. Defects in products due to poor welding						
2. Excessive dimensions of the designs						
3. use of poor welding and cutting tools and equipment						
4. Lack material and product handling						
5. Poor production process managing						
6. Poor performance leading to rework						
7. Poor machine and equipment installation						
8. Poor equipment operating skill, old machines						
9. Poor electric power setting for the required work						
10. Operators lack of skill or negligence						

Part IV: Open ended Questions

1. What are the major impacts of metal products waste?

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2. Which company is beneficial by managing and minimizing waste of metals in the Metal Manufacturing Industry or other sector? and how?

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3. Who should take actions to reduce metal wastes?

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4. What are the future frameworks for Waste Management and Minimization in this case company, Kaliti Metal Products Factory?

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THANK YOU!!

APPENDIX_B

Questionnaire Survey for the **marketing and sales personnel** for Thesis paper on Waste Management and Minimization in metal products manufacturing industry: a case study on Kaliti Metal Products Factory.

ADDIS ABABA UNVERSITY

ADDIS ABABA INSTITUTE OF TECHNOLOGY

SCHOOL OF MECHANICAL AND INDUSTRIAL ENGINEERING

Questionnaire Survey for thesis paper *entitled:* Waste Management and Minimization for Metal Products Manufacturing Industry: A case Study on Kaliti Metal Products Factory.

I am presently pursing a Master of Science Degree in Mechanical Engineering (Industrial Engineering Stream) in Addis Ababa Institute of Technology (AAiT) in the school of Mechanical and Industrial Engineering.

The aim of these questionnaires is to study the Waste Management and Minimization in the case company, Kaliti Metal Products Factory. Please answer all questions as possible as you can. All the information gathered will be kept strictly confidential and will be used only for academic research and analysis without mentioning the names of individual participants involved.

Thank you in advancing for your time and kind cooperation

Yours Faithfully,

Moges Hagos (Mobile. +251-911865343)

Supervised by Dr. Kassu Jilcha.

June 2020, Addis Ababa, Ethiopia.

Questionnaires prepared for marketing and sales personnel only

Part I: General Information

Please circle the appropriate alternatives.

5. Sex

   A) Male B) Female

6. Age (in years)

   A) 18-30 B) 30-40 C) 40-50 D) above 50

7. Relevant Experience in years

   A) 1-10 B) 11-20 C) 21-30 D) More than 30

8. Your Position in the company

   A) Production manager B) Marketing Manager C) worker D) Procurement Manager E) administration worker F) other

Part II. Sources and causes of wastes in Kaliti Metal Manufacturing Products Factory

The given numbers below are sources and causes of wastes on Metal Manufacturing Products. Please indicate the significance of each factor by ticking the appropriate boxes. Add any remarks relating to each factor on the last column e.g. as to the reasons, the critical factors or the solutions.

E.S. = extremely significant [100%], V.S. = very significant [75%] M.S. = moderately significant [50%], S.S. = slightly significant [25%], N.S. = not significant [0%]

Source & Cause of wastes in the case company	E.S 100%	V.S 75%	M.S 50%	S.S 25%	N.S 0%	Remarks
Group. Materials and Products (For Marketing and sales Departments)						
1. Poor schedule to procure materials						
2. Selecting the lowest bidder suppliers and sub-suppliers that lead to poor quality						
3. Purchased materials that don't comply with specifications						
4. Damage of materials in the store						
5. Change of customer orders and designs						
6. Scarcity of raw materials						
7. Lack of incentives						
8. Lack of rules and regulations						
9. Shortage of foreign currency						
10. Technological constraints						

Part III: Open Questions

1. What are the major impacts of metal products waste?

2. Which company is beneficial by managing and minimizing waste of metals in the Metal Manufacturing Industry or other sector? and how?

3. Who should take actions to reduce metal wastes?

4. What are the future frameworks for Waste Management and Minimization in this case company, Kaliti Metal Products Factory?

THANK YOU!!

APPENDIX –C

Questionnaire Survey for the Production workers for Thesis paper on

Waste Management and Minimization in metal products manufacturing industry: a case study on Kaliti Metal Products Factory.

ADDIS ABABA UNVERSITY

ADDIS ABABA INSTITUTE OF TECHNOLOGY

SCHOOL OF MECHANICAL AND INDUSTRIAL ENGINEERING

Questionnaire Survey for thesis paper *entitled:* Waste Management and Minimization for Metal Products Manufacturing Industry: A case Study on Kaliti Metal Products Factory.

I am presently pursing a Master of Science Degree in Mechanical Engineering (Industrial Engineering Stream) in Addis Ababa Institute of Technology (AAiT) in the school of Mechanical and Industrial Engineering.

The aim of these questionnaires is to study the Waste Management and Minimization in the case company, Kaliti Metal Products Factory. Please answer all questions as possible as you can. All the information gathered will be kept strictly confidential and will be used only for academic research and analysis without mentioning the names of individual participants involved.

Thank you in advancing for your time and kind cooperation

Yours Faithfully,

Moges Hagos (Mobile. +251-911865343)

Supervised by Dr. Kassu Jilcha.

June 2020, Addis Ababa, Ethiopia.

Questionnaires for Production workers (operators) only

Part I: General Information

Please circle the appropriate alternatives.

9. Sex

   A) Male B) Female

10. Age (in years)

    A) 18-30 B) 30-40 C) 40-50 D) above 50

11. Relevant Experience in years

    A) 1-10 B) 11-20 C) 21-30 D) More than 30

12. Your Position in the company

    A) Production manager B) Marketing Manager C) worker D) Procurement Manager E) administration worker F) other

Part II: Causes/sources of metal wastes for the key products of the case company

Please indicate the significance of each factor by ticking the appropriate boxes. Add any remarks relating to each factor on the last column e.g. as to the reasons, the critical factors or the solutions. E.S. = extremely significant [100%], V.S. = very significant [75%], M.S. = moderately significant [50%], S.S. = slightly significant [25%], N.S. = not significant [0%].

Cause of product /material wastes in the case company	E.S 100%	V.S 75%	M.S 50%	S.S 25%	N.S 0%	Remarks
IV. Tubular [Rectangular and Circular Hollow sections (Standard Products)]						
11. Defects in products due to the process sudden interruption						
12. Excessive dimensions allowances of the tubular						
13. Use of poor tools and equipment						
14. Poor material and product handling techniques						
15. Poor production process controlling systems						
16. Poor operations leading to rework						
17. Poor preventive maintenance of machines						
18. Poor machine and equipment break down maintenance handling						
19. Operators poor relationship with managers						
20. Negligence or lack of awareness						
V. Galvanized corrugated Iron sheet (Engineered Products Manufacturing)						
11. Defects in products due to the process sudden interruption						
12. Excessive dimensional allowances of the designs						
13. Frequent cutting tools wearing out						
14. Poor material and product handling system						
15. Poor production process controlling systems						
16. Poor performance leading to rework						
17. Poor machine and equipment installation						
18. Poor machine and equipment maintenance skill,						

old machines						
19. Operators poor relationship with managers						
20. Operators lack of skill or negligence						
VI. ***Truck (Welding and Assembly Workshop)***						
11. Defects in products due to poor welding system						
12. Excessive dimensional allowances of the designs						
13. use of poor welding and cutting tools and equipment						
14. Lack material and product handling						
15. Poor production process controlling system						
16. Poor performance leading to rework						
17. Machine and equipment poor installation						
18. Poor equipment operating skill, old machines						
19. Poor electric power setting for the required work						
20. Operators lack of skill or negligence						

Part III: Open ended Questions

1. List the disadvantages of wastes generated from metal products manufacturing.

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2. Is your company beneficial from metal wastes management and minimization? If your answer is 'yes', please list some of the benefits.

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3. Who should take actions to reduce metal wastes?

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5. Please, write your own methods for metal Waste Management and Minimization in this case company, Kaliti Metal Products Factory?

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THANK YOU

APPENDIX - D

Table 2.3 **Summary of Literature review on Waste Management and Minimization in Metal Products Manufacturing Industry**

S. No.	author	Title	Problem	Methodology	Result	Tools used	Research gap	Country
1	(Al-Kindi & Alghabban, 2019)	Framework for Solid Waste Management in Steel Fabrication	Waste disposal problem	Qualitative study	Proposal on waste minimization strategies	No specific tool used	No specific tool is used for analyzing the data	Egypt
2	(Starovoytova & Namango, 2018)	Solid Waste Management at a University Campus: Waste Generators, Current Practices, and Compliance with relevant-law-provisions.	The open and uncontrolled waste dumpsite, at the-university	the-study adopted qualitative case-study-framework	It is necessary to maximize strengths and opportunities; minimize the external threats, transform the identified weaknesses into strengths.	The Strength, Weakness, Opportunities and Threats (SWOT) analysis	Doesn't address the metal products manufacturing industry or the industrial waste management problems	Kenya
3	(Mekonnen & Gokcekus, 2019)	Urbanization and Solid Waste Management Challenges, in Addis Ababa City, Ethiopia	Improper management of infrastructures like solid waste	The study reviews the major influences of urbanization on solid	Solid waste has impacts on socio- economic and environmental impacts.	Only tables, figures and charts used with qualitative	Industrial waste management especially Metal Products manufacturing is not dealt in detail;	Ethiopia (Addis A.)

				waste management		analysis.		
4	(Wee, Abas, Chen, & Mohamed, 2017)	The Constraints of Good Governance Practice in National Solid Waste Management Policy (NSWMP) Implementation : A Case Study of Malaysia	Constraints of good governance practices	An exploratory research approach through in-depth interviews	The findings are inadequate fund, poor competency of staffs, and vagueness of policy implementation system	Purposive sampling, the analysis was run using the NVIVO software version 10.	Lacks quantitative analysis; Industrial waste governance or management isn't addressed.	Malaysia
5	(Demirbas, 2010)	Waste Management, waste resource facilities and waste conversion processes	Amount of waste increasing almost constantly	Exploratory method by reviewing literatures on waste management	Reviewing: Waste management concept, system, Biomass and bio-waste resources, classification and Methods	No particular tool is used.	Waste Management in Metal Manufacturing industry lacks proper analyses & particular tool	Turkey
6	(Singh, Laurenti, Sinha, & Frostell, 2014)	Progress and challenges to the global waste management system	the release of large amounts of waste to the environment	Exploratory method by reviewing literatures on waste	The study concludes economic growth and resource	Charts, tables and figures were used.	no specific tools were used for data analyzing for Metal Products manufacturing	Sweden

				management	consumption and wastes is a vital challenge throughout the world		Industry	
7	(Guerrero, Maas, & Hogland, 2012)	Solid waste management challenges in developing countries	Increasing generation of wastes in developing country cities	Literature structured reviews, observations and visits and questionnaires with descriptive and inferential statistic methods	List of stakeholders and set of factors that reveal the most important causes for the systems' failure.	Descriptive and inferential statistic methods.	Metal Products Manufacturing Industry especially factories that manufacture different variety of products were not specifically addressed yet.	The Netherlands
8	(E.Marshal & Farahbakahsh, 2013)	Systems approaches to integrated solid waste management in developing countries	Lack of Solid Waste Management (SWM) affects health and environment	the reviewing the literature and contrasting on the history and current paradigms of SWM	the reviewing and contrasting on the history and current paradigms of SWM	Tables and figures were used for illustration	No clear data collection and analyzing methods; and Metal Products Manufacturing Industries in Ethiopia.	Canada

9	(M.C.Monte, E.Fuente, A.Blanco, & C.Negro, 2009)	Waste management from pulp and paper production in the European Union	11 million ton of wastes were produced from pulp and paper production	Review of literatures	Giving suggestions and conclusions on the subject matter.	Use tables and figures were used	No specific data analyzing tools were used.	Spain
10	(Bello, Ismail, & Kabbashi, 2016)	Solid Waste Management in Africa: A Review	the quantity and generation rate of solid waste in Africa are increasing tremendously	Literature Review and qualitative analysis	Recommendations were proposed	tables	No specific data analyzing tools were applied and not specific for a Metal Manufacturing Industry	Malaysia
11	(Tiwari & SC.Tiwari, 2012)	An overview of Solid Waste Management System in Debre Markos Town of Ethiopia	Solid waste poor management	Primary and Secondary were collected through field survey observation, questionnaires and interviews	Gaps were identified and accordingly proposed new sanitary landfill	Tables and figures were used but no data analyzing tool was used	There is deficiency to address waste management in industrial sector especially to Metal Products Manufacturing Industry.	Ethiopia (Debre-Markos)
12	(Mallak, Ishak, Kasim, & Samah, 2015)	Assessing the Effectiveness of Waste Minimization	Poor waste minimization methods in manufacturin	Both primary and secondary data were	the results show that there was a significant positive	IBM-SPSS 20 software and the	From the bar graph of Mean of waste generation for industrial solid	Malaysia

		Methods in Solid Waste Reduction at the Source by Manufacturing Firms in Malaysia	g firms	used; Sampling and data collection • Data analysis: the quantitative data was analyzed using IBM-SPSS 20 software,	relationship between waste minimization methods and quantity of waste reduction ($p<0.05$).	statistical techniques that were used include descriptive statistics	waste in Malaysia, more than 50 ton per year waste generation was from scrapped metals but they were not addressed in detail in the rest of the world, like Ethiopia.	
13	(Hailemariam & Ajeme, 2014)	Solid Waste Management (SWM) in Adama, Ethiopia: Aspects and Challenges	lack of proper waste management system growing	Field observation, Interview and self-administered questionnaires analyzing with the Statistical package for Social Science (SPSS) software	The current SWM practice couldn't cope with the fast urbanizing needs and the rapid population growth	Statistical Package for Social Science (SPSS) software	Industrial or Manufacturing Industries waste management techniques not addressed even in the Adama City.	Ethiopia (Adama)
14	(Gilles, Loehr, & Fellow, 1994)	Waste Generation and	Increasing cost of	Summarizing method	Chemical recovery and	Tables and figures	There is a deficiency in	U.S.

		Minimization in Semiconductor Industry	disposal and strict regulations		recycling techniques recommended		fulfilling Waste Management aspect of Metal Industries	
15	(Regassa, D.Sundaraa, & Seboka, 2011)	Challenges and Opportunities in Municipal Solid Waste Management: The Case of Addis Ababa City, Central Ethiopia	A.A faces problems associated with poorly managed solid waste operations	Qualitative and quantitative data with purposive sampling	Geographical and urban structure inaccessibility, Improperly designed collection route system, etc.	Check lists	Metal products Manufacturing industry not addressed.	Ethiopia (Addis Ababa)
16	(Mallak, Elfghi, Rajagopal, Vaezzadeh, & Fallah, 2016)	Overview of Waste Management Performance of Industrial Sectors by Selected Asian Countries: Current Practices and Issues	Challenges with waste management	Qualitative analysis using tables and figures	comparing the current practicing of different waste management options by industries	Tables and figures were used	Not addressed to the Ethiopian Industrial Sector waste management case	Malaysia
17	(Kumar & Kumar, 2018)	Recent Advances in Solid Waste Minimization using Nanotechnolog	Increasing world population with increasing solid wastes	Review	Reviewing the nanotechnology and discussion	Figures were used	Not addressed to the Ethiopian Industrial Sectors waste management case	India

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18	(Lema, Mesfin, Eshete, & Abdeta, 2019)	Assessment of status of solid waste management in Asella town, Ethiopia	Improper solid waste management affects health and environment	A community-based cross-sectional study designed, SPSS version 21 software, and descriptive data analyzing method were used	332 (82.8%), had improper solid waste management practices and Lack of awareness	SPSS version 21 software	Not addressed the Industrial waste management in Ethiopia.	Ethiopia (Asella)
19	(Mbuligwe & Kaseva, 2006)	Assessment of industrial solid waste management and resource recovery practices in Tanzania	Solid waste problem	questionnaire surveys and interviews; Waste quantificatio n and characterizati on	Solid waste sources and generation listed	Tables and figures were used	Not specifically addressed about Metal Products Manufacturing Industry	Tanzania
20	(Duke, 1994)	Hazardous waste minimization: is it taking root in U. S. Industry? Waste	Availability of hazardous wastes	Data are collected from annual reports analyses were done	The research study concludes that hazardous waste minimization has not fully	Annual reports	There are no comparative data analyses with other countries or cities to draw the effectiveness of the	U.S. A

		Minimization in Metal Finishing Facilities of the San Francisco Bay Area, California		using tables and figures	entered the industry,		method	
21	(K.Henry, Yongsheng, & Jun, 2006)	Municipal Solid Waste Management challenges in developing countries – Kenyan case study	Solid waste amount growth	Interviews, reports and documents, field visit and observation	The growth of solid waste generation has been increased but the capacity to collect and disposing was declining.	Tables and figures for demonstrat ion only	The strength and weakness of the waste management in Metal Manufacturing Industry	Kenya
22	(Dijkema, Reuter, & Verhoef, 2000)	A new paradigm for waste management	Waste definition	review	Suggests to improve the decision process	Tables and figures	Lean waste not dealt.	The Netherlan ds
23	(Chroneer & Wallstrom, 2016)	Exploring Waste and Value in a Lean Context	Definition of waste and value problems in a lean context	Literature Review with Case studies	applying the concept of waste and value in separate projects are difficult	Tables and figure	'Waste 'impact in the context of Metal Manufacturing industry	Sweden
24	(Jamaludin, et al., 2017)	Preliminary Study on Enhancing Waste Management	Poor waste management in the construction sector	Interview and questionnaire s, with Analytical	Determined the factors of waste generation in construction and their	Analytical Hierarchy Process (AHP)	Not dealt with related to the manufacturing sector with lean aspect	Malaysia

		Best Practice Model in Malaysia Construction Industry		Hierarchy Process (AHP) method	effectiveness.			
25	(Ulfik & Nowak, 2014)	Determinants of Municipal Waste Management in Sustainable Development of Regions in Poland	Cost related problems to pay for the municipality	Qualitative study	Impact on the local resident's ad on the environment	No tool was used	Waste Management in manufacturing industry is not dealt	Poland
26	(Solisio, Lodi, & Veglio, 2002)	Bioleaching of zinc and aluminum from industrial waste sludges by means of Thiobacillus ferrooxidans	Bulk industrial wastes accumulating in many countries will not be disposed without prior special treatments	Chemical Analysis Atomic Adsorption Spectrophoto meter	A bioleaching process using a savage microbial strain mainly containing T. Ferro-oxidants	Chemical Analyzers to analyze industrial wastes	the metal products waste economic and environmental impacts were not addressed	Italy
27	(Zulkipli, Nopiah, Basri, & Kie, 2016)	Stock Flow Diagram Analysis on Solid Waste Management in	Waste increment	Qualitative method	Increase in the number of population and practicing 3R (reduce, reuse	Vensim software package.	Manufacturing industry contribution to the waste amount is not addressed.	Malaysia

		Malaysia			&recycle) will increase the amount of recycled waste.			
28	(Coelho, Coelho, & MG, 2016)	Multi-criteria decision making to support waste management: A critical review of current practices and methods	Determination of factors of waste sources and generators	Critical Literature Review	67% of the articles analyzed were addressed to Municipal Solid Waste (MSW)	normalization, weighting, and sensitivity analysis	Did not address the waste management with respect to lean management	Brazil
29	(Castrejón-Godínez, Sánchez-Salinas, Rodríguez, & Ortiz-Hernández, 2015)	Analysis of Solid Waste Management and Greenhouse Gas Emissions in México: **A** Study Case in the Central Region	Environmental waste growth	Data collected from different literature articles, informal interview	the development of mechanisms and regulations for managing the waste, strengthening education and raising awareness	Tables, figures and bar graphs but no specific analyzing tools	There is a deficiency in addressing the manufacturing sector in Ethiopia even in Africa.	Mexico
30	(Generowicz, Kowalski, & Kulczycka, 2011)	Planning of Waste Management Systems in Urban Area Using Multi-	Planning problem in waste management operation	Literature Review, qualitative and multi-criteria Analysis	The proposed Methodology allows to carry out system evaluation systematically	Multi-criteria Analysis	It was not considering the metal manufacturing industry with respect lean	Poland

		criteria Analysis					production	
31	(Elgizawy, El-Haggar, & Nassar, 2016)	Approaching Sustainability of Construction and Demolition Waste Using Zero Waste Concept	Amount of waste rapid increment	Qualitative study with literature review analyzing using the Zero Waste concept	Applying zero waste concept	Tables and, figures were used for illustration purpose	impacts of the various manufacturing industries on the construction sector were not included	Egypt
32	(Kouloughli & Kanfoud, 2017)	Municipal Solid Waste Management in Constantine, Algeria	Waste increment due to population growth	Qualitative analyzing with field survey data	to reduce the amount of waste generated through public awareness as recycling and re-use practices are the most important issues	Tables and figures were used for data demonstration but no specific tool is used.	the separation of MSW at the source as this activity is largely neglected.	Algeria
33	(Saidou & Aminou, 2015)	Solid Waste Management in the Town of Maradi in Niger Republic	Waste management	Literature review, Interview, household survey and field visit	Insufficient Collection Capacity, Lack of Effective Awareness of Population, Uncontrolled and Badly Managed Landfills and	Tables and figures for the qualitative analysis	There is deficiency in addressing manufacturing industry waste management with regard to lean or zero waste management	Niger Republic

					Inadequate Human Resources Capacities			
34	(Muleya & Kamalondo, 2017)	An Investigation of Waste Management Practices in the Zambian Construction Industry	Waste problem	questionnaires, interviews and site surveys with descriptive statistics tools such as mean	the construction industry in Zambia has poor practice of waste management through disposal which is not environmentally friendly	Mean score (descriptive Statistics	Not addressed related to manufacturing industry in Ethiopia.	Zambia
35	(Zaman, 2015)	A comprehensive review of the development of zero waste management: lessons learned and guidelines	Waste management problem	Qualitative Study; Literature review, interview &observation	The principle is applied in both production and waste management systems; identify priority areas and guidelines	Tables and figures	Not dealt with respect to lean management in the manufacturing industry with current situation in Ethiopia.	Australia
36	(Shahbazi, Kurdve, Bjelkemyr, Jönsson, & Wiktorsson,	Industrial waste management within manufacturing: a comparative	Sustainability problem in in manufacturing industry	Qualitative study approach; structured literature	In many cases the waste management approaches have similar	Tables and figures	a more detailed organization level, improvement processes and direct and indirect effect	Sweden

	2013)	study of tools, policies, visions and concepts		review on waste management that are applicable to manufacturing and analyzing these literatures	goals and approaches, which cause confusion and disorientation for companies aiming to synthesize their management systems to fit their waste management strategy		on product life cycle phases were not addressed well.	
37	(Yilmaz, Anctil, & Karanfil, 2014)	LCA as a decision support tool for evaluation of best available techniques (BATs) for cleaner production of Iron casting	Lack of support tools for Evaluation of available techniques	Qualitative study; data collecting was done from literature review and analyzed and interpreted	On site recovery and external reuse of waste sand were capable of overall environmental impact of casting by 60% to90%; created revenue and savings	Life cycle approach (LCA) to evaluate the performance	There is gap in the impact of casting wastes on environment in Ethiopia.	USA
38	(Prasad & S.K.Sharma, 2014)	Lean and Green Manufacturing: Concept and its Implementation	Confusion of concepts of Lean and Green	Literature review	Explanation and discussion on the subject matter	Tools were not used	Not detailed well	India

		in Operations Management	Manufacturing					
39	(Tortorella, et al., 2018)	Productivity improvement in solid waste recycling centers through lean implementation aided by multi-criteria decision analysis	Solid waste Recycling problems	Workers participation in the decision making	The integration of a multi-criteria decision-making tool to the lean practices	AHP was used as analyzing tool.	Not addressed the 2Rs (Reduce and Reuse strategies)	Brazil
40	(Johansson & Winroth, 2014)	Lean vs. Green manufacturing: Similarities and differences	Confusion between Lean and Green Manufacturing	qualitative study; Literature review and analyzing by comparisons	The analysis indicates that the concepts shows similarities at the level of source reduction	No specific tool was applied	It didn't indicate why they have similar purpose with different names	Sweden