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COLLEGE OF DEVELOPMENT STUDY, CENTRE FOR ENVIRONMENT AND DEVELOPMENT STUDIES

MSc Thesis

WATER EFFICIENT TECHNOLOGY USE OF FIRMS AND ITS EFFECT ON TECHNICAL EFFICIENCY:

EMPIRICAL EVIDENCES FROM INDUSTRIAL FIRMS FUNDED BY THE DEVELOPMENT BANK OF ETHIOPIA

BY

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A THESIS

WATER EFFICIENT TECHNOLOGY USE OF FIRMS AND ITS EFFECT ON TECHNICAL EFFICIENCY: EMPIRICAL EVIDENCES FROM INDUSTRIAL FIRMS FUNDED BY THE DEVELOPMENT BANK OF ETHIOPIA:

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A THESIS SUBMITTED TO CENTER FOR ENVIRONMENT AND DEVELOPMENT STUDIES AS A PARTIAL FULFILLMENT TO THE REQUIREMENTS DEGREE OF MASTER OF SCIENCE **(MSc)** SPECIALIZATION IN WATER RESOURCES MANAGEMENT.

ABSTRACT

*Industrialization plays an important role in economic development. Of which, the manufacturing and agro processing sub sectors role in growth is immense. Cognizant to; the government of Ethiopia has given an attention to the industry sector under the Growth and Transformation Plans to create a foundation for the sector to take a leading role in the economy. Industrial firms are top priority for the government in developing the export sector; and the Development Bank of Ethiopia is mandated to provide finance. This study was conducted on 153 sample industrial firms which were funded by Development Bank of Ethiopia. The study applied a parametric stochastic frontier approach **(SFA)** in estimating the technical efficiency of industrial firms situated in Addis Ababa & its surrounding those financed by DBE. In this study translog frontier model was specified to represent the frontier function. The parameter estimates by industrial groups are obtained using Maximum-likelihood method.*

*Water is critical for industries hence it can be taken as the essential input. It is also realized that industrial water use is increasing rapidly thereby requiring water management and further efforts shall be made. The technical efficiency of firms most of the time was analyzed using labor, capital and intermediate materials only; without giving due attention to the water input used in production. This implies there is a gap in studies conducted on technical efficiency analysis in taking in to account the water input as a factor of production. Water input was so well thought-out in this study. The study result reveals that the estimated coefficients for the water inputs are positive across all industrial firms, but its significant level differ with different industrial groups. For example in industries such as food and beverages, tanning & leather industries, paper & printings, and rubber & plastics industries; the estimated coefficient for the water input is positive and significant at 1 percent. Whereas in industries; like chemicals and furniture's; the coefficients for the water input is positive and significant at 5 percent. The study result reveals variations in efficiency exist among firms within the industrial group, indicating that there is room for improving efficiency levels if firms use the water input in a more efficient manner. Common to some industrial firms would be inability to operate at their optimum production capacity. The study result also reveals the aggregate mean technical efficiency of operational industrial firms funded by DBE was **43.8** percent during the study period. The study findings provide evidence that water efficient technology usage in combination with other variables reinforce each others have significant effects on technical efficiency. The findings of this study have also recommendations in that; it primarily support for decision making by firm owners, funding institutions and the policy makers. Hence, national and regional policies that promote water efficient technology use are likely to enhance efficient utilization of the water resources; ensure sustainable use of the water resources and increase productivity of industrial firms.*

Keywords: Water input, stochastic frontier Approach, Industrial firms, Water efficient technology use, Technical efficiency

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Dedication

To my parents, and my colleagues

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List of Acronyms

ADB	African Development Bank
CE	Consumed Embedded water
CIP	Cleaning in-Place optimization systems
CL	Consumed Lost water
CRS	Constant return to scale
DBE	Development Bank of Ethiopia
DEA	Data Envelopment Analysis
DNR	Discharged Non Renewable Water
DPSIR	Driver Pressure State Impact and Response
DR	Discharged Renewable Water
DW	Discharge Water
FDI	Foreign direct investment
ETB	Ethiopian Birr
GDP	Growth Domestic Product
GTP	Growth and transformation plan
MPP	Marginal physical product
NPW	Non Production Water
PDW	Production Water
SFA	Stochastic frontier Approach
SPSS	Statistical package for social sciences
SW	System Water
SDGs	Sustainable Development Goals
TE	Technical Efficiency
TPP	Total physical product
UN	United Nations
UNIDO	United Nation Industrial Development Organization
USA	United States of America
VRS	Variable returns to scale

CHAPTER ONE

1. INTRODUCTION

1.1. Background of the study

Now days, world is stance under an era of sustainable development goals. The SDGs cover the three dimensions of sustainable development goals; the economic, social and environmental issue with water is their core connector. SDG **6** is dedicated to water and sanitation. Target **6.4** on Sustainable development goals, illustrates that "By 2030, substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity and substantially reduce the number of people suffering from water scarcity"(UN, 2013). Industrial water use is critical; hence it can be taken as the essential input in the sector. It is also realized that the industrial water use is increasing rapidly thereby requiring water management and further efforts shall be made.

The industry sector is considered to be a special deriver of economic transformation because it has the potential to impact the economy via various channels. First, industrial output is characterized by value addition and higher productivity, and hence it has the potential to create job opportunities for both skilled and unskilled workforce by producing wage increases. Second, technical skills obtained from manufacturing jobs can be transferred into the economy and reinforce increases in general productivity levels, thereby raising wages in other sectors (UNIDO, 2009).

The East Asian experience, which has passed the virtuous circle in a manufacturing sectors were able to rapidly and successfully retrain their farmers as manufacturing workers. However, it seems that Africa has thus far failed to bring about the structural change that has recently been seen in East Asian countries (UNIDO, 2009). The development of the sector in most African countries has virtually stagnated in the last two decades. The declining performance of the sector is manifested in terms of its contribution to GDP and its share of global manufacturing. A report by (UNIDO, 2009) showed that the contribution of manufacturing to GDP has seen a significant decline from 15.3 percent in 1990 to 12.8 percent in 2000 and 10.5 percent in 2008.

The absence of well-functioning markets, poor infrastructure facilities, and poor managerial and technological capabilities coupled with unfavorable government policies in the manufacturing sector are often considered to be the main stumbling blocks of the manufacturing sector in Africa (UNIDO, 2009). Nevertheless, it is believed that Africa has the potential to develop its manufacturing sector and can become competitive in the global market. Particularly, Ethiopia has great potential to revitalize its manufacturing sector. Notwithstanding the fact that Ethiopia has been one of the fastest growing economies in the world in the past decade, the performance of the industrial sector has been disappointing. Its share of GDP has remained relatively static, amounting to between 13 and 14 percent (ADB, 2010); in particular, the share of the manufacturing sub-sector, a crucial sector in transforming an economy, remained stagnant.

The government of Ethiopia aspires to sustainably raise growth to reach middle income levels via maintaining macroeconomic stability. Industrialization plays an important role in economic development of which the manufacturing sub sector's role in growth is also immense. Subject up on this fact, the government gives due attention to the industry sector under the Growth and Transformation plans (GTPs) to create a foundation for the industrial sector to take a leading role in the economy. To realize this objective, in the past three years of GTP II implementation, the government of Ethiopia has been exerting concerted efforts toward improving the general investment climate to attract FDI. Beyond improving the general investment climate, it has also made customized negotiations targeting such well-known foreign manufacturers as George shoe, and H & M, whose presence could attract more foreign firms and improve Ethiopia's reputation among others. Indeed, the country has made considerable progress in the industry sectors over the last few years. In an effort to promote industrial development, the government recognizes the establishment of industrial zones. Thus, the government allocated demand-based industrial zones in different parts of the country like; Addis Ababa, Kombolcha, Dire Dawa and Hawassa are the major ones. Other privately-owned industrial zones include the Eastern Industrial Zone around Dukem (owned by a Chinese investor) and the Sendafa Industry Zone around Finfine area (owned by Turkish investors).

Under the export-led industrialization strategy that Ethiopia is pursuing, labor-intensive light manufacturing industries such as textile and garment, leather and leather products and agro-processing are the sectors to which foreign investor are attracted. The potential competitiveness of the sectors can be justified on two grounds. First is the labor cost advantage: while labor productivity in some of the sectors in Ethiopia can approach that of China and Vietnam, Ethiopia's wages are a quarter of those in China and half of wages in Vietnam (Dinh et al, 2012). The second reason is Ethiopia's abundance of natural resources to be used as raw materials in these sectors. For example, Ethiopia is endowed with cotton resources that can be used as inputs in the textile and garment industries. Moreover, in the leather and leather products industry, Ethiopia's hides and skins are known for their high quality. These advantages can give Ethiopia a comparative advantage in the export market (Dinh et al, 2012). Ethiopia's preferential duty-free trade access to USA and Europe markets also provides strategic opportunities to further enhance its industry sector. Mindful of this potential, since 2002 Ethiopia has been undergoing significant policy changes in the industry sector to create a favorable environment to attract foreign direct investment (FDI) and encourage domestic investment. To exploit this opportunity, a number of foreign companies from China, India, Turkey, and Japan are currently exploring opportunities in the country, which has led to a sudden upsurge in FDI inflow in the last two to three years.

Efficiency occupies a central place in production of a firm. One of the objectives of an economic unit (firm) is to avoid waste by producing the maximum possible output from a given vector of inputs (output-oriented) or by minimizing input usage to produce a given level of output vector (input-oriented). Such a concept in production is what we call technical efficiency and firms can attain a high degree of technical efficiency by pursuing the waste avoidance objective (Krumbhakar & Lovell, 2000). Notwithstanding, the water input in the industry sector is not studied in incidence so far to technical efficiency analysis for the case of Ethiopia; and limited number of researches has been conducted as can been seen from literature review in chapter two. Thus, the study analyzes the technical efficiencies of industrial firms using stochastic frontier approach. Moreover, the study has examined firm's use of water efficient technology via three parameters of measurements i.e. Efficiency technical solutions, Reuse - recycling, and effluent reduction & treatments. Thus, cognizant to the current economic direction of the country for industrialization and the contribution of water to the sector; this study is important and timely.

1.2. Statement of the Problem

The current development policy i.e. agricultural development led industrialization is the fundamental building block of industrial development in Ethiopia. To support this key policy, the industry sector has to be promoted so that it can play a more significant role in sustaining economic growth. Despite the policy changes and the enormous potential that could boost the industrialization process in the country, the sector still remains underdeveloped (ADB, 2010). Development financial institutions and other Development agencies face challenge to achieve success in funded industrial projects in Africa (ADB, 2010). Thus, it calls to improve the technical efficiency of firms funded with Banks.

Water, as economic good faces competition among users; such as agriculture (the major water user), domestic use, industries, and other sectors. It is realized that the industrial water use is increasing rapidly in contrast to slight growth of the sector; thereby requiring water management and further efforts shall be made. It is also observed that slight growth of the industry sector has imposed a risk to the water resources. Unless the way the water utilized is being dealt in its use is seriously acted upon to catapult the prevailing poor water use efficiency. Technical efficiency of firms most of the time was analyzed using labor, intermediate materials and capital only; without giving due attention to the water input used in production process. This implies there is a gap in studies conducted on technical efficiency analysis in taking to account the water input as a factor of production.

Harron and Chelakumar (2012), Ghahula (2012) and Sudarin & Haung (2013) are similar to this study on the choice of independent variables but differ in that the water input is considered in this study; moreover, in the method of estimation whereby they used DEA while this study used SFA. In these studies a Cobb-Douglas production function was specified to represent the frontier function. But, this study motivated on the choice of the translog production function in favor of the Cobb-Douglas. The Cobb-Douglas imposes a prior restriction on the firm's technology by restricting the production elasticity to be constant and the elasticity of input substitution to unity. Moreover, in those studies; the non-parametric approach which includes DEA is mostly used to measure performance of each producer relative to the best practice in the sample of producers.

However, DEA is characterized by the assumptions that it does not impose a functional form of the production frontier; it does not make assumptions about the error term so that all the unexplained variations are taken to represent the inefficiency. It also defines the frontier as the most efficient. Therefore, the, non-parametric approach has criticized in its assumption to determine the efficiency level of industrial firms. To take in to custody the parametric stochastic frontier approach was functioned in this study. Previous empirical studies have also overlooked the issue of estimating technical efficiency of industrial firms in Ethiopia. Therefore, this study contributes towards filling this gap. Indeed, with consideration of the problems and limitations of researches in our case specifically to industrial firms; this study opts to focus and estimate the technical efficiencies of industrial firms with stochastic frontier parametric approach.

1.3. OBJECTIVES OF THE STUDY

1.3.1 General Objective of the Study

The general objective of the study is to examine the effect of water efficient technology use on technical efficiency of industrial firms which were financed by the Development Bank of Ethiopia.

1.3.2. Specific Objective of the Study

- To assess the water consumptions status of industrial firms which introduced water efficient technologies.
- To estimate the technical efficiency of water efficient technology use industrial firms.
- To examine the effect of water efficient technology use on technical efficiency of industrial firms.

1.4. Significance of the study

The study analyzes the technical efficiencies of industrial firms while applying stochastic frontier approach. Measuring technical efficiency of firms is particularly important in that it helps to identify the sources of inefficiency and thus allow further investigation of how firms can utilize resources optimally to enhance their efficiency.

Technical efficiency analysis is important for managing resource use at factory gate level, preserve the resource from upset, and increase the productivity of industrial investment projects. The relevance of technical efficiency analysis is also leads to improve operational performances in that firms ensure their establish objective to achieve and in turn to attend the socio - economic responsibility.

Furthermore, the result of this study is important because it support to decisions making for proper resource allocations and so as to improve firms' performance. it also offer valuable inputs and directions for investors to consolidate their investment firm status, through solicitation of the findings and the study is believed to benefit both academicians and other practitioners as a documented study on the subject area. Cognizant to the current economic direction of the country for industrialization and the contribution of water to the sector; this study is timely and important.

1.5. Scope of the Study

The study was conducted to industrial firms funded by the Development Bank of Ethiopia. Though, the Bank has different districts and Branches, that are responsible to provide funds for industrial investment firms, with limited time, and budget constraint, the scope of this study dealt with firms delimited in Addis Ababa & its surroundings.

The study conducted was limited to assess the water consumptions and estimating the technical efficiency of industrial firms using the four input variables; labor, capital and intermediate inputs and the water input. The study has tried to control the relevant variables those directly or indirectly have effect on the production amount of industrial firms. Nonetheless, in previous empirical studies; the concept of technical efficiency analysis was conducted both with non-parametric (DEA) and the parametric approaches (SFA). However, in this study the technical efficiency of industrial firms was estimated using the parametric approach (SFA) only. In any case firms' implementation stages are the key issue; and in this study only on on-going firms were assessed.

1.6. Limitation of the study

Data on inputs and outputs of the firms is confidential and was not easy to collect and this was a major challenge to obtain data. Most manufacturing firms especially the small and medium sized firms do not publish their financial statements especially on the value added; this was attributed to fear of the taxation authorities and fear of competitions from other firms in the industry. These challenges could have been addressed only by collecting primary data from the firms, and this was not possible due to time and financial resource constraints.

The study would like to suggest some future research directions. In the efficiency analysis Cobb-Douglas imposes a prior restriction on the firm's technology by restricting the production elasticity to be constant and the elasticity of input substitution to unity. One direction for future research is, therefore, to somehow incorporate flexibility in the models.

In the efficiency analysis, noted that despite the ability of the model to distinguish firm-specific unobserved heterogeneity from inefficiency, the inefficiency term can still capture any possible time-invariant structural inefficiency, which leads the another model to underestimate overall inefficiency and in turn overestimate technical efficiency. The other direction for future research is, therefore, to somehow incorporate persistent inefficiency in the models in order to examine the impact of possible time-invariant structural inefficiency. Future research should also look into the effect of observable heterogeneity of firms on efficiency estimates

1.7. Organization of the paper

This research is presented in five chapters. Chapter one provides a background to the study while chapter two presents a review of theoretical and empirical relevant literatures. Chapter three deals with methodology that the study followed for empirical modeling of efficiency estimations, variables & measurements, data type used & the model used for analysis. Chapters four presents the descriptive statistics of the data, analysis and discuss the research findings chapter five derive conclusions, recommendation and finally derive policy implications.

CHAPTER TWO

2. REVIEW LITERATURE

This section reviews the literature written by different authors and researches conducted by different scholars in relation to the study and present a summary of literatures to theories, definition & concepts, and the empirical works. Finally, conceptual model for this study is developed.

2.1. The Concept and definitions

Technical efficiency is the ability of the firm to maximize outputs given inputs, (output-oriented) or minimize inputs used in the production of a given outputs (input-oriented). The Economic efficiency reflects the production of given outputs at minimum cost or, the utilization of given inputs to maximize revenues or the allocation of inputs and outputs to maximize profits (Kumbhakar, 2011).

A firm is an organization owned by one or jointly by a few or many individuals which is engaged in productive activity of any kind for the sake of profit or some other well defined aim. Most of the firms owned by private individuals in merchandise and services are aspire for profits but there may be some other such as government companies where profit motivation is be secondary or missing altogether (Kumbhakar, 2011).

Investment Projects: are defined as discrete investment activities in which resources are capitalized to priority area development programs of the government; such as manufacturing industries, agro-processing industries, mining or extractive industries, and commercial agricultural projects; with a specific starting and ending points, intended to achieve specific objectives (UNIDO, 2009).

On-going or operational Firms: as part of project implementation phases; ongoing firms are defined as those already commenced production and fully entered to operations after contentment of all required inputs and resources (UNIDO, 2009). Thus, industrial firms which reached at this stage of implementation phase had been studied.

Firms' performance: - refers to the enhancement of project standing in strong position to meet target objectives, in terms of yield or productivity, revenue generation, creation of job opportunities, meeting government tax obligation, and concern to the wider environment.

2.2. Theoretical Literature Review

Production economics theory is microeconomics theory, which deals with production of a given output using a set of specified inputs. A production function is used to formalize this relationship. Equation 2.1 is specification of a production function.

$$Y = f(K, L, R) ----------------------------(\mathbf{2.1})$$

Where Y represents firms' output, this output is the final processed products. L represents the amount of labor (people and skills), and R represents the quantity of raw materials used in the production of the Y. The raw materials for the agro-processing industry are the fresh produce from the agricultural sector. K represents the amount of capital employed in the production process; this could be the property, land, equipment and stocks (Varian, 2006).

The objective of the firm is to maximize profit, either by increasing the quantity of Y produced or by reducing the cost of producing Y. The production function shows the maximum amount of the good that can be produced using alternative combinations of labor (L), raw materials (R) and capital (K). Y is also referred to as the total physical product (TPP). The marginal physical product (MPP) of an input is the additional output that can be produced by employing one more unit of that input while holding all other inputs constant. The concept of returns to scale shows how output responds to increase in all inputs together. Returns to scale can either be constant, decreasing or increasing (Varian, 2006).

The production relationship can be expressed in several forms such as linear functional forms, polynomial functional forms and Cobb-Douglas functional form. The Cobb-Douglas functional form is modified into the transcendental and translog functional forms.

The production frontier refers to a fixed state of technology. If the technology changes, the frontier production function also moves. Positive technological change is a movement towards the origin whereby a given quantity of output can be achieved by utilizing lesser amounts of inputs. Negative technological change is a movement away from the origin (Farell, 1957).

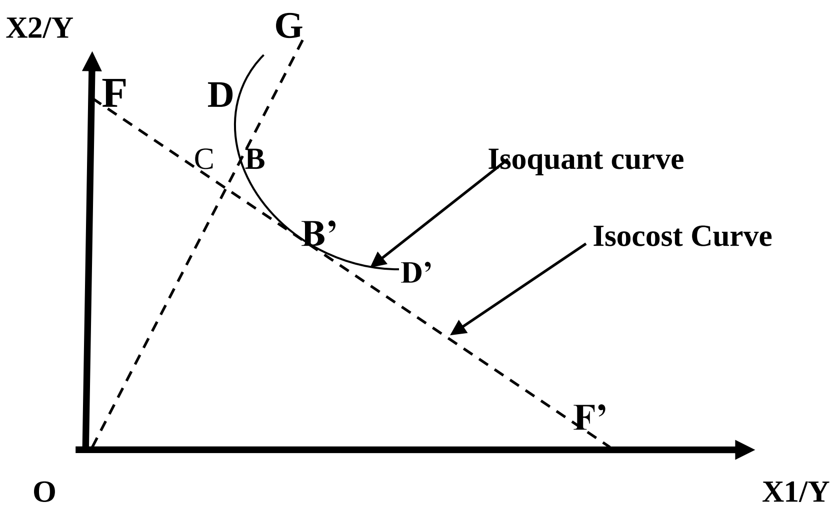


Figure 2.1: input –oriented efficiency measure.

Source: Coelli*et al.* (2005)

The production function of the input-oriented measure was presented as assuming a constant return to scale production function, so that the efficient frontier can be presented as the isoquant that shows the most efficient combination of the two factors 1 and 2 used to produce a particular level of a product. Any deviations from the frontier DD' causes inefficiency in the factor use. The line FF' is referred to as the isocost curve if a given firm uses quantities of inputs defined by point G. To produce a unit of output the technical inefficiency of the firm could be presented by the distance BG (Coelli, 2005).

Technical inefficiency is usually expressed in percentage terms by the ratio BG/OG while the technical efficiency of a firm is measured by the ratio OB/OG=1-(BG/OG).

2.2.1. The concept of efficiency

The core of an economic activity is to strive for the maximum possible efficiency or performance. Efficiency is a relative concept, which requires a standard of performance be established against which the success of economics units is assessed (Forsund, 1979).

The concept of efficiency involves a comparison between optimal values and expected values of output and input of a production line. The comparison can take the form of the ratio of minimum potential to observed input required to produce a given output or, the comparison can take the form of the ratio of observed to maximum potential output obtainable from given set of inputs. In these two comparisons, the optimum was defined in terms of production possibilities and efficiency was technical. Technical efficiency reflects the ability of the firm to maximize outputs given inputs, (output-oriented) or minimize inputs used in the production of a given outputs. Economic efficiency reflects the production of given outputs at minimum cost or, the utilization of given inputs to maximize revenues or the allocation of inputs and outputs to maximize profits (Kumbahakar and Lovell, 2000).

2.2.2. Approaches of efficiency level measurements

Non- Parametric Approach

The non-parametric approach includes DEA; the objective of the DEA is to measure performance of each producer relative to the best practice in the sample of producers. The main objective is to determine which of the set of producers, as represented by observed data, form an empirical production function or envelopment surface. The producers that lie on the empirical production frontier or surface are deemed efficient, otherwise inefficient (Meesun, 1977). DEA is characterized by the assumptions that it does not impose a functional form of the production frontier, it does not make assumptions about the error term, and it defines the frontier as the most efficient. It also assumes that the random error is zero so that all the unexplained variations are taken to represent the inefficiency. There are two types of the DEA models referred to as constant returns to scale (CRS) and variable returns to scale (VRS). The appropriateness of either CRS or VRS is determined by economic and other assumptions about the data to be analyzed (Meeusen and Broeck, 1977).

Parametric approach

The parametric approach imposes a functional form of the production function. The functional forms include: the Cobb – Douglas, translog function, constant elasticity function. This approach makes an allowance for stochastic error due to statistical noise or measurement errors.

The error term in the model consist of two components as shown by equation (2.2) one that captures the randomness outside control of the firm and the other part is the inefficiency (Schmidt and Lovell, 1979). The deterministic frontier can be specified, in natural logarithms as:

$$lnyi = lnX_i; \boldsymbol{\beta} + \boldsymbol{V}_i - \boldsymbol{U}_i = \text{i=1, 2 …..N} \text{---} (2.2)$$

Where lnY_i is the logarithm of the output of the i^th firm, xi is a K+1 vector whose first element is value 1 and the remaining elements are the logarithms of K input quantities used by i^th firm, $\boldsymbol{\beta i}$ is a K+1 vector of unknown parameters to be estimated, $\boldsymbol{ui}$ is a non- negative one-sided error term associated with technical inefficiency (Coelli*et al.*, 2005).

Using equation (2.3), the technical efficiency (TE) is given as a ratio of the observed output relative to potential output defined by the frontier function.

$$TE = \frac{Y_i}{\exp X_i \boldsymbol{\beta}_i} = \exp(-\text{ui}) ------------------------ (2.3)$$

The ratio (2.3) gives an output-oriented measure of technical efficiency, and its value lies between 0 and 1. The parameters of the model could then be computed via linear or quadratic programming. Linear programming approach entails minimizing the sum of the absolute values of residuals subject to the constraint that this sum is greater or equal to zero. However, the quadratic programming involves minimizing the sum of squared residuals subject to the constraint the sum of squared residuals is greater or equal to zero. Alternatively, the ordinary least squares or maximum likelihood could also be used to estimate the model (Coelliet al., 2005).

The major limitation of the deterministic parametric approach is that it does not take into consideration the influence of errors of measurement and other errors on the frontier. All the deviations from the frontier are considered to be as a result of technical inefficiency.

The SFA approach constructs a frontier from efficient firms that envelopes relatively inefficient firms. The SFA and the inefficiency effects model estimates are subject to the specification of the inefficiency effects modeled showing the inefficiency effects arising from the main effects of relevant variable inputs, and the interaction effects of the technology use as well.

The followings are some of relevant variables that affect the efficiency results and all are should be controlled in the case of technical efficiency analysis.

Age of firms: This is a firm-specific characteristic with ambiguous effects on efficiency. A positive relation may occur due to learning-by-doing arising from cumulative experience in production. Notwithstanding, a negative relation may arise from use of old capital equipment and inefficient production practices (Dermiyagala, 2001)

Firm Size: The effect of firm size on technical efficiency is ambiguous (Niringive, 2010). It can be analyzed through the number of full-time employees in the last fiscal year.

Finance: financing that is obtained from the bank boosts efficiency by facilitating a firm's day-to-day operations (Nickel, 1999).

Managerial experience: Firms with experienced managers have been found to be more technically efficient. Managerial experience as the number of years that a top manager or business owner has worked in a given sector.

Technology: Industry dummies are used as explanatory variables for the variance in the idiosyncratic error component of the inefficiency effects model to account for differences between industries (Belotti, 2012).

Ownership structure: It is argued that private ownership of enterprises enhances their efficiency for the reason that privatization changes the incentive structure of the enterprises. Hence, we expect privatization in Ethiopian manufacturing to positively affect technical efficiency.

2.3. Empirical Literature Review

Schmidt (1979), investigated the relationship between stochastic production, factor demand and cost frontiers. He used a sample of 150 U.S. steam electric generating plants constructed in the period between 1947 and 1965. He obtained data on output, total cost, and prices of inputs. Capital input was measured in terms of the actual cost of the plant, and labor input was measured in employee man-hours. They estimated a cost function and used the results of the parameters to derive estimates of production function, which was then used to estimate inefficiency. This study is similar to this project on the choice of input and output variables and such that a Cobb-Douglas functional form of cost frontier was used in the estimation while the current study tested a stochastic translog production function for efficiency estimation. Maximum likelihood method of estimation of this study is similar to the method of estimation adopted by this project.

Ludvall (2000), using an unbalanced panel data for period 1993-1995, estimated a translog production function for the Kenya manufacturing sector. The output variable used in the empirical analysis was the value added of all output produced by the firm in a given year. The input variables consisted of capital which was defined as the replacement cost of existing machinery and other equipment employed in the production process, multiplied by the degree of capacity utilization, Wages which included the total wage bill including all allowances for the firm in one year. This study is similar to this project on test of the translog production function as a best fit for the data using SFA but different on the choice of the subsectors.

Muslesh (2007), Estimate the efficiency of the large-scale manufacturing sector of Pakistan, using parametric as well as non-parametric frontier techniques. Production frontiers were estimated for two periods─1995-96 and 2000-01─for 101 industries where output of the firms was taken as the dependent variable which was a function of capital used, labor input and industrial costs. The results showed that there had been some improvement in the efficiency of the large-scale manufacturing sector, though the magnitude of improvement remained small.

The results were mixed at the disaggregated level: whereas a majority of industrial groups had gained in terms of technical efficiency, some industries had shown deterioration in their efficiency levels. Musleh-Ud*et al*. (2007) is different since it compared the results of DEA and SFA for two time periods, 1995-96 and 2000-01 while the current study used only SFA in the estimation for the period 2011-2013.

Nigui (2012), empirically investigated technical efficiency of firms in the Kenyan manufacturing food, metal and textile sub-sectors using data covering two periods: 1992/1993 - 1994/1995, and 2000/2001 - 2002/2003.The stochastic frontier approach was used in the analysis.
The likelihood ratio test for specification of technology indicated that with an exception of the textile sub-sector in both periods, the Cobb-Douglas specification was rejected given the translog specification for both food and metal sub-sectors. The dependent variable (output) was measured by value-added in Kenyan shillings. The output was calculated as the difference between gross output and raw materials and indirect inputs in a given period. The results showed that the technical efficiency point varied among the sampled firms in each period. The average technical efficiency of 52 percent, 58 percent, and 60 percent for the food, metal and textile sub-sectors, respectively, imply that nearly 48 percent, 42 percent, and 40 percent technical potentialities were not achieved in the 1992/1993 - 1994/1995 period. On the other hand, the average technical efficiency of 48 percent, 42 percent, and 68 percent for the food, metal and textile sub-sectors, respectively, imply that nearly 52 percent, 58 percent, and 32 percent technical potentialities were not achieved in the 2000/2001 - 2002/2003 periods.

Gahalua (2012), employs Data Envelopment Analysis (DEA) to estimate the relative efficiency of selected 58 commercial banks operating within the East African Community, namely Tanzania, Kenya, Uganda, Rwanda and Burundi from 2008 to 2011. The estimated results shows sharp decline of Technical efficiency. The findings show that most commercial banks in east Africa are operating under a decreasing return to scale. Therefore inefficient utilization of input resources (technical inefficiency) could be one of the reasons for the inefficiency of commercial banks in East Africa; therefore banks should make use of underutilized resources and reduce operating expenses to be relatively efficient in the production frontier.

Haronn (2012); determined the efficiency performance of the Kenya manufacturing companies over the period of 2009 to 2011. The study also suggested appropriate policies to be employed by the manufacturing companies in Kenya based on the findings of the study. Three critical inputs variables (raw materials, staff expenses and plant and machinery) and two output variables (net sale and earnings after tax) were used to evaluate the relative efficiency of 30 manufacturing companies in Kenya. Data was gathered from Kenya Association of Manufacturers (KAM) database. The results indicated that small-sized company has the highest relative efficiency compared to medium-sized and large size company. In addition, the study finds that 1 large-sized company, 2 medium-sized companies and 3 small-sized companies operate under the most productive scale size throughout the three-year period.

Sudarin (2013), estimated the efficiency of the food and beverage subsector of Thailand companies, an application of relational two-stage data envelopment analysis. The study used a relational two-stage data envelopment analysis (DEA) to evaluate the efficiency of 23 food and beverage companies in Thailand in 2011.The inputs were cost of sales and services (X_1) and other expenses (X_2). The outputs were the net profit (Y_1) and other comprehensive income (Y_2). The conclusion showed that the low efficiency score of the profit generation process leads to the low overall efficiency score of the companies.

Harron and Chelakumar (2012), Sudarin and Haung (2013) and Ghahula (2012) are similar to this project on the choice independent variables but differ in the method of estimation whereby they used DEA while this project used SFA. These studies specified a Cobb-Douglas production function to represent the frontier function. These studies did not motivate on the choice of rejecting the translog production function in favor of the Cobb-Douglas. The Cobb-Douglas imposes a prior restriction on the firm’s technology by restricting the production elasticity to be constant and the elasticity of input substitution to unity.

Moreover, a study was conducted at Tamil Nadu of India in 2014; to determine the technical efficiency of turmeric Production using a stochastic frontier model. Turmeric (*Curcuma longa*) is an important commercial spice crop. The stochastic frontier production function used in the study was given by Equation (2.4)

$$lnY_i = \beta o + \beta_1 \ln(X_1) + \beta_2 \ln(X_2) + \beta_3 \ln(X_3) + \beta_4 \ln(X_4) + \beta_5 \ln(X_5) + \beta_6 \ln(X_6) + \beta_7 \ln(X_7) + V_i - U_i \text{ -------------- } (2.4)$$

Where, lnYi is the logarithm of the output of the i^{th} farm, βo is constant $\beta 1, \beta 2, \beta 3, \beta 4, \beta 5, \beta 6$ and $\beta 7$ are coefficients of the input variables. Whereas, X_1, X_2, X_3, X_4, X_5, X_6 and X_7 are the input variables used for turmeric production for the study includes; Planting material (kg/ha), Nitrogen (kg/ha), Phosphorous (kg/ha), Potash (kg/ha), Harvesting and curing (`/ha), Machine hours (hours/ha) and Irrigation (No/ha) respectively. Except Phosphorous all other inputs have positive effect on the technical efficiency of turmeric Production. Other determinant factors for technical inefficiency effects had also assessed. Both farmers educational level and farming experience (years) have both negative effect on the technical inefficiency of production or improve the technical efficiencies. Whereas; farm size (ha) has positive effect on technical inefficiency; mean that it has negative effect on technical efficiency and it can be interpreted small farms are more efficient than large farms.

The model for assessing technical inefficiency is given by Eq. (2.5)

$$U_i = b_0 + b_1 Z_1 + b_2 Z_2 + b_3 Z_3 \text{ ------------- } (2.5)$$

Where, U_i is the technical inefficiency in the i^{th} farm, Z_1 is the experience in turmeric farming (in years), Z_2 is the education of a farmer (in years), Z_3 is the farm size (in ha), and $b1$, b_2, b_3 are the inefficiency parameters.

For the output- input orient; the technical efficiency of individual farm was worked out using formula (2.6)

$$TE = Y_i/Y_i^* \dots \dots (2.6)$$

Where, Y_i^* is the frontier yield and Y_i is the actual yield.

2.4. Methodological Review

Though it has been given a little attention in most activities and businesses firms, the water input is the most significant ingredient in the process of producing the output in industrial firms. In production process of industry sector, the water used might be defined at each production processes accordingly. The Production Water (PDW), which; is the direct use of water by or in products, production processes, production equipment, and production areas. The collection of all water flows in a plant is named "Factory Water", and the water used during production is referred to as "Production Water" (PDW). Non-production water (NPW) is typically the initial focus of water-saving efforts such as awareness campaigns, automatic taps for washrooms, and use of grey water for washing vehicles. According to (Gleik.p.H & Palaniappan.m, 2010) the input water can be considered as either consumed or discharged as wastewater. Whereas, the Production Water (PDW**)** is defined as the water used in production processes that is essential to convert raw materials into intermediate and final products for example, water used as an ingredient in products, as a solvent, as a coolant or lubricant, or as a cleaning agent to wash products.

Production water is further subdivided into number of flow types: Consumed Embedded water (CE): water that is embedded into the product as an ingredient. This type of and consumption is beneficial and adds value to the product. Examples are beverage manufacturing processes, where water is used as a main ingredient.

Consumed Lost water (CL) is defined as the water lost in the process through evaporation or spillage that cannot be recovered. This type of consumption is non-beneficial and occurs due to system inefficiencies and errors. Discharged Renewable water is that fraction of discharged water which is of a quality allowing reuse either directly or after treatment. Examples are water from washing. Discharged Nonrenewable water (DNR) is the proportion of discharged water that is unfit for reuse, because of higher levels of contamination, and is discharged as trade effluent. With the definitions above, the full production system can be represented as a factory water model as shown on. **Figure 2.4.1**

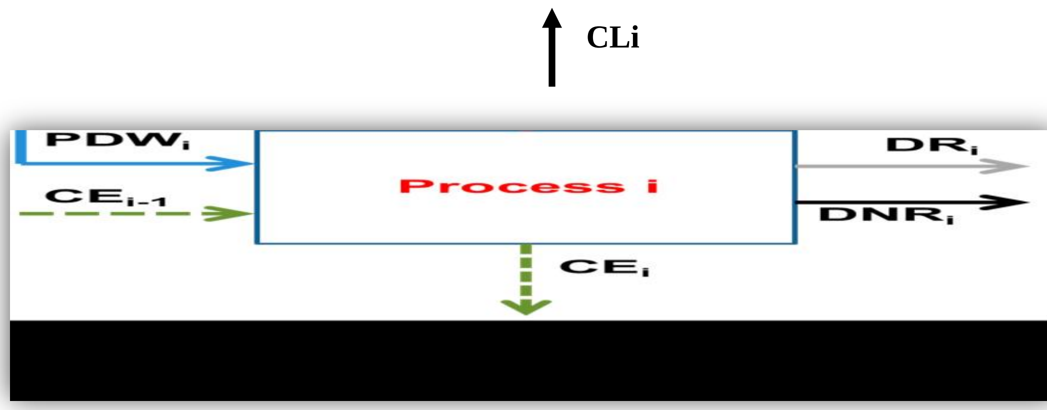


Figure 2.4.1. Water flow input and outputs for unit process *i* in a manufacturing process chain

Source: Gleik.p.H & Palaniappan.m, (2010)

To investigate the performance of firms in utilizing the water input (Gleik.p.H & Palaniappan.m, 2010); are proposed the following steps;

1. Obtain Data for the amount of total water that is available for production purpose:
2. Calculate the amount of consumed embedded water; that is embedded into the product as an ingredient;
3. Calculate the amount of discharged renewable water which is of a quality allowing reuse either directly or after treatment;
4. Add the amount of consumed embedded water and discharged renewable water
5. Change into percentage : $\frac{(\mathbf{CEW+DRW})}{\mathbf{PDW}}$ *** 100%**
6. Calculate the amount of consumed lost water in the process through evaporation or spillage that cannot be recovered.
7. Calculate the amount of discharged nonrenewable water that is unfit for reuse, because of higher levels of contamination, and is discharged as trade effluent;
8. Add the amount of consumed lost water and discharged nonrenewable water
9. Change into percentage : $\frac{(\mathbf{CLW+DNRW})}{\mathbf{PDW}}$ *** 100%**
10. Compare the results on **5** and 9
11. Decision; if result the $\frac{(CEW+DRW)}{PDW}$ * 100% **greater than** result $\frac{(\mathbf{CLW+DNRW})}{\mathbf{PDW}}$ *** 100%;** then a firm is effective in utilizing the water input; otherwise not.

2.4.1. Overview of the literatures

The theoretical literature reviewed has given a detailed analysis of the approaches for measuring technical efficiencies of industry sectors using, DEA and SFA approaches. It is evident that the approaches that are currently being used in the estimation of frontiers are broadly classified as parametric and non-parametric. The parametric approach consists of the deterministic and stochastic frontier models while the non-parametric approach is dominated by the data envelopment analysis (DEA). Besides, there is evidence that both approaches seem to converge on the level of average efficiency, but diverge on scoring individual producers. Schmidt and Lovell (1979) recommended that both approaches be applied to the same set of data on the basis of the strengths and weaknesses of the two approaches, to improve the reliability of the results of efficiency analysis.

The Empirical literature reviewed, indicated that technical efficiency of firms can be estimated by either estimating a stochastic production frontier or a stochastic cost function. In the estimation of the production frontiers empirical literature revealed that, both ordinary least squares and maximum likelihood methods were used. Empirical literature reviewed also revealed that the inputs variables used in the estimation of the stochastic production function are mostly labor, capital, and cost of raw materials while the output variables used can be value added and/or return on investments. Apart from Lundvall and Battese (2000) most of the studies reviewed estimated a Cobb- Douglas production function.

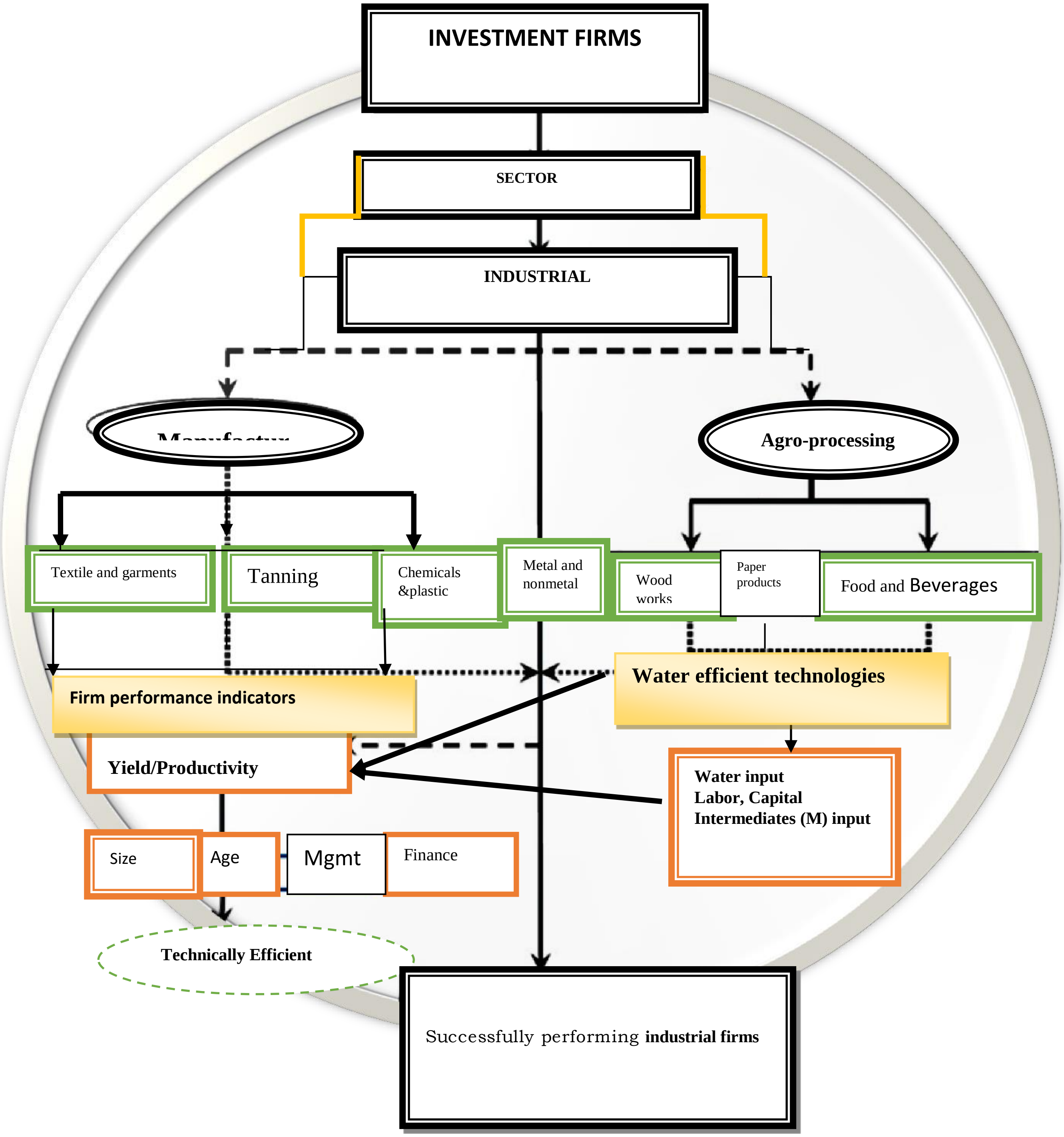
2.5. Conceptual framework of the study

The study has interested in analyzing the technical efficiency of industrial firms' via captivating the water input, labor, capital (the value of fixed assets) and costs of intermediate inputs. To realize the study; all operational industrial investment firms (the manufacturing, and Agro processing industries) financed by Development Bank of Ethiopia delimited to Addis Ababa and its surrounding are critically identified and analyzed. The manufacturing and Agro processing industrial firms are the major water users; and call for the overview of the water use in order to enhance better water management practice and improve project performance.

Thus, the study has assessed firms' execution the inputs so as to augment the level of technical efficiency and firms' performance. Indeed, firms' performance is measured by the net output sales or value addition. However, firms' output gain is not only affected by the above mentioned input variables only; there are also other relevant variables those ought to affect the production status of a given firm. Therefore, the study has identified the relevant variables that have effect on the technical efficiency of firms and had controlled them. The controlled variables include; firm size, age of firms, finance / working capital adequacy /, ownership structure of a firm, management, and the technology a firm uses.

Thereby, water efficient technology use of firms can boost the technical efficiency; as well saves the water input from upset to ensure its sustainability of use. Firms have to properly execute all factors of production to improve their technical efficiency, to maximize their profit, to enhance better water management practice; guarantee successful performance; and to ensure sustainability.

Figure 2.5 Conceptual frame work of the study developed through DPSIR techniques



CHAPTER THREE

3. STUDY AREA AND RESEARCH METHODS

3.1. Study Area

This study was conducted in Addis Ababa and its surrounding areas where the Development Bank of Ethiopia had financed the firms so as to support firms' capability to run-through maximum level of production capacity in order to realize their purpose of establishments. Thus, the coverage area of the study is delimited to Addis Ababa and its surroundings; hence the area is identified as strategic area where industrial firms exist.

3.2. Methods and Materials

3.2.1. Research Design

The research design that was used for the study is a cross-sectional research design. In cross-sectional types of research design either the entire population or a subset thereof is selected, and from these individuals, data are collected to help answer research questions of interest. It is called cross-sectional because the information gathered from the single represents what is going on at only one point in time. Whereas, evaluative or experimental research design had been used to examine how the water use consumption flow is effective and enhance the productivity of firms. The study design incorporated the quantitative research methods.

3.2.2. Target Population

The target populations (N) for this study are operational industrial firms. The study analyzes the technical efficiency of industrial firms which are introduced water efficient technologies using a stochastic frontier approach and examines the performances of industrial firms delimited to Addis Ababa and its surroundings that are funded by the Development Bank if Ethiopia.

3.2.3. Data Sources

Both primary and secondary sources of data are used in this study. The primary data was collected from eligible respondents (Project owners, Project managers, and technical staffs). Whereas secondary data was obtained through review of firms monthly and annual reports, advices, firms websites etc.

3.2.4. Sample size determination and Sampling techniques

3.2.4.1. Sample size determination

The total numbers (N) of operational industrial firms financed by the Bank and which situate in Addis Ababa are identified. Then, the researcher is determining the samples (n) which are representative for the total population. (Umar, 2003); Provide a simplified formula to calculate sample sizes of finite population, which is used to determine the sample size for this particular study. A 95% confidence level is assumed for this formula to determine the sample size, at$e = 0.05$and the sample size is determined by the following formula.

$$n = \frac{N}{1+N(e)2} \text{------------(3.1)}$$

where; 'n' is the required sample size,

'N' is the population size and

'e' is the level of percision at 5%

Adding contingency for expected non-response rate, the final sample size was determined. As per data obtained from the Bank the total numbers of operational industrial firms that are financed by the bank within the study areas are 227 in number. Applying the above formula with A 95% confidence level assumed for this formula; the determined sample size, at $e = 0.05$ was determined by the following formula.

$$\mathbf{n = \frac{227}{1+227(0.05)2} \approx 145}$$

Adding contingency for expected non-response rate, the final sample size determined is **153**

3.2.4.2. Sampling Techniques

The study area is selected with non-probability sampling technique; that is purposively. Industries such as manufacturing and agro processing projects situated in Addis Ababa and Surrounding areas funded by Development Bank of Ethiopia are deliberately selected. Then the calculated sample size is distributed with probability sampling technique using proportionate stratified sampling method. The number of sampling units drawn from each stratum is in proportion to the population size of that stratum.

$$ni = \frac{Ni}{N} . n \quad ------------- (3.2)$$

Where, ni = Sample size for i th stratum

Ni = Population size in i th strata

N= Total Population

n =the sample size required

The following table depicts the population size of industrial firms and with applying proportionate stratified sampling technique; the determined sample size is distributed accordingly. In each stratum; attempt to coat drawn sample sizes that is be distributed proportionally.

Table 3.1: Sample size determination and proportional distribution

S.No	List Firms	Ni	ni
1	Food & beverage	60	38
2	Textile	39	28
3	Wearing apparel	21	13
4	Tanning, leather & footwear	18	12
5	Wood works	21	13
6	Paper & printing	7	6
7	Chemicals	6	6
8	Rubber & Plastics	3	2
9	Non-metals	29	18
10	Fabricated Metals	8	7
11	Furniture	15	10
	Total	**227**	**153**

Source Own computation based on DBE data, (2018)

3.2.5. Tools of Data Collection

In this study; the research design incorporated the quantitative research method. Both primary and secondary sources of data are used in this study. To collect data, the primary data was obtained through structured questionnaire that was organized and distributed to each individual firms enclosed for this study. And the structured questionnaire supported with eligible documents & guidelines was filled by eligible respondents (Project owners, Project managers, technical staffs). Whereas; secondary data was obtained through review of firms monthly and annual reports, advices, firms websites etc.

3.2.6. Methods of Data analysis

In this study both descriptive and inferential or econometric methods of data analysis was utilized.

3.2.6.1. Descriptive Analysis

The study applied tables to analyze the descriptive results and has also used descriptive statistics such as sum values, means, standard deviations, and minimum and maxim values of study variables. The study key variables include the output produced by firms, labor (salary payments), capital (value of fixed assets), the water consumption and intermediate material.

3.2.6.2. Econometric Analysis

In technical efficiency estimation; empirical literature revealed that, stochastic Cobb-Douglas, translog cost function, and maximum likelihood methods were used. Similarly, this study also used the methods to estimate the level of technical efficiency of the industrial firms. Harron and Chelakumar (2012), Sudarin and Haung (2013) and Ghahula (2012) are similar to this study on the choice independent variables but differ in that water input is considered in this study.

3.2.7. Techniques of Data Analysis

The obtained quantitative data was entered into computer for analysis using Statistical Packages for Social Sciences (SPSS) software. Then, the data was edited, coded, and cleaned. Some consistency checks have been verified by running the validity and reliability confidence measures. The validity of the instrument is be finding by running the Cranach's alpha; it is the most commonly accepted measures of reliability.

In estimating the technical efficiency level of firms, one should further investigate the relationship between the efficiency determinant variables and technical efficiency of individual firms. This is to give insight the inefficiency result may occur due to disturbance effect of variables. To do so, the study pursues a two-stage estimation procedure. In the first stage, we estimate the efficiency levels of each firms using Equation 2.6. In the second stage, we run a regression of the estimated technical efficiency level of firms that is to observe the relationship between the determinant variables and technical efficiency. The effect of each relevant controlled variable was analyzed using the maximum likely hood estimation method.

3.2.7.1. Model Specification

The empirical literatures reviewed, indicated that technical efficiency of firms can be estimated by either estimating a stochastic production frontier or a stochastic cost function.

$$\ln Y_i = \beta_0 + \beta_1 ln(W_i) + \beta_2 ln(L_i) + \beta_3 ln(K_i) + \beta_4 ln(M_i) + V_i - U_i \text{------ (3.3)}$$

Where, $\ln Y_i$ = natural logarithm of output of firm i

W$_i$= Industrial water input of firm i

L$_i$ = Labor (No. /salary of employees) of firm i

K$_i$ = Capital (the value of net productive fixed assets) of firm i

M$_i$= the amount of Intermediate inputs of firm i

V$_i$ =Two-sided normal error, and

U$_i$= One-sided non-negative inefficiency term.

β_0 = the constant parameter.

β_1 = Coefficient for Industrial water input

β_2 = Coefficient of Labor

β_3 = Coefficient of Net productive fixed assets

β_4 = Coefficient for Intermediate inputs.

For the output – input, technical efficiency of individual firm is worked out using formula

$$\mathbf{TE_i = Y_i / Y_i^*} \text{ --------------------------------- (3.4)}$$

Where, Y_i^* is the frontier yield and Y_i is the actual yield.

3.2.8. Study key Variables

Independent Variables

- ✓ **Capital**

Capital is one of the essential inputs in measuring efficiency and productivity. As discussed in Coelli et al. (2005), a proper measurement and treatment of capital input is needed to explain efficiency and productivity variations across firms as well as the changes in the structure of industry.

It is not easy to measure the quantity and price of capital input, because unlike material or labor inputs which are consumed in the production process within an accounting period, capital is a durable input used throughout the life of the asset.

- ✓ **Labor**

Labor is also one of the important inputs in a firm's production and hence constitutes a considerable share of a firm's expenditure on inputs. The proxy variables used to measure labor input include; (i) number of employees; (ii) numbers of hours worked; (iii) total wages and salaries bill. Labor input can further be classified as skilled and unskilled workers, and production and non-production workers (Coelli et al., 2005).

- ✓ **Water input**

Accoridng to (Gleik.p.H & Palaniappan.m, 2010); Production Water (PDW**)** is defined as the water used in production processes that is essential to convert raw materials into intermediate and final products for example, water used as an ingredient in products, as a solvent, as a coolant or lubricant, or as a cleaning agent to wash products. According to (Gleik.p.H & Palaniappan.m, 2010); Production water is further subdivided into number of flow types: Consumed Embedded (CE); water that is embedded into the product as an ingredient. This type of consumption is beneficial and adds value to the product. Examples are beverage manufacturing processes, where water is used as a main ingredient. Consumed Lost water (CL) is defined as the water lost in the process through evaporation or spillage that cannot be recovered. This type of consumption is non-beneficial and occurs due to system inefficiencies and errors.

Discharged Renewable water is that fraction of discharged water which is of a quality allowing reuse either directly or after treatment. Examples are water from washing. Discharged Nonrenewable water (DNR) is the proportion of discharged water that is unfit for reuse, because of higher levels of contamination, and is discharged as trade effluent. System Water (SW) is defined as the water used in the production processes to maintain the production equipment, apparatus, and environment for example, water used in clean-in-place (CIP) systems or other general cleaning activities to sanitize production equipment and material-handling systems.

- ✓ **Intermediate inputs**

Intermediate inputs are another important category of inputs in efficiency and productivity analysis which mainly includes energy and raw material inputs. Energy and material inputs constitute the largest share in input costs of an enterprise and are often considered to be intermediate input.

Dependent Variable: The measure of output commonly used in the study is the value-added or gross output as a measure of output.

3.2.8.1. Control variables

In addition to estimating the technical efficiency level of firms, this study also further investigated the relationship between other relevant variables and the technical efficiency of firms. This is to give insight to the inefficiency result may occur due to disturbance effect of the variables. The variables included in this study are age of firms, firm sizes, adequacy of working capital, managerial experiences, water efficient technology use and ownership structure of firms are estimated:

The effect of each relevant controlled variable is analyzed using maximum-likelihood methods for the regression coefficients of the SFA.

The models to be estimated can be represented

$$TEi = \beta 0 + \beta 1\, ln(Agei) + \beta 2\, ln(Sizei) + \beta 3\, ln(Finacei) + \beta 4\, ln(Techi) + \beta 5\, ln(Owneri) + \beta 6\, ln(Mgmti) \text{---}(3.5)$$

Where TE_i is the technical efficiency score for firm i

Age_i = the number of years counted for firm i since its establishment

szei = The number of full-time employees in the last fiscal year of firm i

Finacei = Access to finance for firm i

techi = The technology level used by firm i

Owneri = the ownership structure of firm i

Mgmti = the numbers of year for relevant experience of the general manager of firm i

$\boldsymbol{\beta_0}$ is the constant parameter and $\boldsymbol{\beta_1, \beta_2, \beta_3, \beta_4, \beta_5}$, ***and*** $\boldsymbol{\beta_6}$ are Coefficients of the variables respectively.

3.2.9. Data Validity and Reliability

To have a valid and reliable data well developed questionnaires was established. Close and on spot observation to firm site is held by the researcher for the whole data collections. The Completed questionnaire was checked up daily and if any corrections the data were amended. Moreover, during analysis, the validity of the instrument was found by running the Cranach's alpha; the most commonly accepted measures of reliability. It measures the internal consistency of the items in a scale. Many literatures propose the result of 0.7 and above implies an acceptable level of internal reliability.

Table 3.2: Reliability test result for the data.

Item	Cranach's Alpha
Cost of Labor(L)	0.72
The value of fixed assets (K)	0.79
Water consumption (W)	0.87
The Intermediate materials (M)	0.89
Output (Y)	0.83

Source: Survey result 2019

CHAPTER FOUR

4. RESULT AND DISCUSSION

4.1. Descriptive Statistics of key variables

The overall data description for the research has been adjusted according to the models used in particular. Four key input variables; capital, labor, water and intermediate inputs; and a single output; are used to estimate technical efficiency of firms. The descriptive statistics result for the key variables give insights in to the actual costs incurred for the inputs variables by firms to produce a given output that is to realize the net sales from the output produced. The input and output data were measured to the amount of the input variables avail for the last 12 months that firms had in order to realize the outputs. The unit measurement for the output and input variables were in ETB (Birr.) The figures show that for the outputs and inputs under consideration where the standard deviation higher than the mean; implies that firms had a high level of heterogeneity, since the variations were on inputs and outputs; the high standard deviation suggested heterogeneity in the scale of operations by the firms. The measure of output in this study was measured by net output sales.

Table 4.1.1: Output Produced by firms for the last 12 months (2017/2018)

Industry	Mean	Std. Dev.	Min	Max	No of Firms
Food and beverages	24,011,453.53	30,720,986.05	156,224.00	107,313,170.65	38
Textiles	241,626,930.2	406,517,068.9	1,142,450.6	1,104,322,516.3	28
Wearing apparel	478,731,594.01	107,585,206.80	301,688,956.64	646,486,077.50	13
Tanning, leather & footwear	347,824,036.35	159,934,913.82	165,277,768.73	626,392,751.28	12
Wood	431,843,322.41	282,953,740.92	140,291,386.55	828,273,629.41	13
Paper and printing	150,236,497.67	94,854,106.77	4,980,794.25	259,031,352.08	6
Chemicals	278,604,192.98	167,058,161.52	98,563,600.18	525,817,738.02	6
Rubber and plastics	25,204,976.80	14,737,375.10	11,329,309.56	45,868,415.25	2
Non-metals	101,865,853.56	124,330,639.03	30,016,580.60	288,055,380.30	18
Fabricated metal	188,795,037.00	119,528,978.13	126,148,982.35	367,997,190.52	7
Furniture	188,007,581.08	89,132,330.91	125,522,052.66	290,075,774.82	10

Sources: Own Survey result 2019

Labor is also one of the important inputs in a firm's production and hence constitutes a considerable share of a firm's expenditure on inputs. The proxy variables used to measure labor input included in this study is total wages and salaries bill.

Table 4.1.2: labor cost incurred by firms for the last 12 months (2017/2018)

Industrial firms	Mean	Std. Dev.	Min	Max	No of Firms
Food and beverages	558,691.11	542,155.04	45,976.00	3,400,612.00	**38**
Textiles	2,523,206.0	6,945,035.1	200,256.0	35,415,235.0	**28**
Wearing apparel	1,920,236.17	2,911,696.48	250,756.00	9,444,258.00	**13**
Tanning, leather & footwear	2,618,055.23	2,718,218.14	320,756.00	6,812,586.00	**12**
Wood	3,503,687.23	3,475,837.72	153,568.00	9,481,414.00	**13**
Paper and printing	657,913.08	477,017.23	123,158.00	1,508,000.00	**6**
Chemicals	2,812,879.60	2,552,656.35	107,867.00	6,538,592.00	**6**
Rubber and plastics	499,677.00	312,020.13	253,132.00	955,586.00	**2**
Non-metals	2,790,309.50	4,482,833.35	369,346.00	9,511,820.00	**18**
Fabricated metal	2,998,531.25	4,451,015.41	663,356.00	9,672,346.00	**7**
Furniture	2,859,400.67	2,922,880.47	842,523.00	6,211,423.00	**10**

Sources: Own Survey result 2019

The next one is capital that is essential input in measuring efficiency and productivity. As discussed by Coelli et al. (2005), a proper measurement and treatment of capital input is needed to explain efficiency and productivity variations across firms as well as the changes in the structure of industry. Capital is a durable input used throughout the life of the asset. The value of all fixed assets of a firm as of the study period are measured and validated for the study.

Table 4.1.3: The value of fixed assets (Capital (K))

Industrial firms	Mean	Std. Dev.	Min	Max	No of Firms
Food and beverages	26,532,815.27	35,293,489.11	559,689.00	120,874,652.00	38
Textiles	271,784,273.5	457,451,457.9	1,202,300.0	1,237,504,801.3	28
Wearing apparel	539,084,898.56	120,932,610.58	339,882,769.20	726,848,553.98	13
Tanning, leather & footwear	391,433,994.52	179,969,320.42	185,737,045.80	704,517,769.49	12
Wood	485,939,517.90	318,419,600.17	158,056,361.63	932,645,896.48	13
Paper and printing	186,261,195.75	94,030,220.82	29,210,723.25	291,832,549.92	6
Chemicals	320,291,163.26	194,271,484.19	112,199,762.81	608,010,572.64	6
Rubber and plastics	29,124,431.99	17,033,318.96	13,071,939.00	52,998,822.88	2
Non-metals	117,641,886.26	143,491,318.05	34,679,704.10	332,522,472.10	18
Fabricated metal	218,230,585.63	137,927,294.02	145,936,888.03	425,016,030.34	7
Furniture	217,336,917.85	102,894,245.01	145,200,917.13	335,163,854.77	10

Sources: Own Survey result 2019

Water used in production that is essential to convert raw materials into intermediate and final products for example, water used as an ingredient in products, as a solvent, as a coolant or lubricant, or as a cleaning agent to wash products was measured in meter cubes and then; the cost incurred by firm owners for the utility of water consumption to their firms was validated. Table 4.1.4, reveals; the standard deviation of water consumption amount is higher than the mean value at each industrial firm; implying that firms had a high level of heterogeneity in consuming the water input for different purposes rather than production.

Table 4.1.4: **Water consumption (W) by firms**

Industrial firms	Mean	Median	Std. Dev.	Min	Max	No of Firms
Food and beverages	5,284.26	1,768.00	8,928.95	223.00	48,697.00	38
Textiles	7,777.3	4,523.0	9,958.8	423.00	47,856.0	28
Wearing apparel	4,902.83	1,450.00	5,786.06	159.00	14,526.00	13
Tanning, leather & footwear	13,362.92	4,758.00	22,693.75	258.00	65,899.00	12
Wood Works	8,302.62	4,253.00	11,071.70	156.00	36,541.00	13
Paper and printing	370,264.50	25,868.50	579,938.96	158.00	1,523,546.00	6
Chemicals	170,633.50	8,145.00	460,539.66	1,523.00	1,475,623.00	6
Rubber and plastics	3,527.00	1,559.00	3,960.10	1,523.00	9,467.00	2
Non-metals	5,059.50	1,678.00	6,858.97	1,536.00	15,346.00	18
Fabricated metal	46,531.25	16,178.00	70,953.91	1,423.00	152,346.00	7
Furniture	2,400.67	1,523.00	1,607.54	1,423.00	4,256.00	10

Sources: Own Survey result 2019

Intermediate materials (Mi)

Intermediate materials are another important category of inputs in efficiency and productivity analysis which mainly includes energy and raw material inputs. Energy and material inputs constitute the largest share in input costs of an enterprise and are often considered to be intermediate input. Similarly in this study, the raw material input costs and overhead are considered measured and has validated for this study. As of conducting this study; the researcher has noticed the major challenge to firms not operate at full capacity.

Raw material is the major ingredient especially for the manufacturing sector that is to produce the output, but firms exist confront to it due to that the materials are mostly imported and problem of hard currency is the challenge thereby. Both in its availability as well as inadequacy of working capital for intermediated material are still the challenge. Table 4.1.5 has summarized the descriptive statistics of costs incurred by firms as of utilizing intermediate materials during their production phases.

Table 4.1.5: **Intermediate materials (Mi) by firms**

Industrial firms	Mean	Median	Std. Dev.	Min	Max	No of Firms
Food and beverages	7,191,894.92	3,718,797.25	8,719,891.08	464,922.25	30,474,663.00	38
Textiles	70,469,274.4	4,496,815.0	117,771,105.0	722,895.0	190,151,792.50	28
Wearing apparel	136,691,460.81	137,877,401.87	31,866,040.39	85,357,117.30	14,526.00	13
Tanning, leather & footwear	100,476,553.86	85,907,110.75	46,350,439.69	49,026,114.45	182,942,028.37	12
Wood Works	124,988,566.71	111,287,150.21	81,847,554.33	39,667,658.41	237,893,564.44	13
Paper and printing	47,223,212.02	56,324,717.27	23,339,679.47	8,097,136.81	73,240,889.48	6
Chemicals	50,856,554.09	48,310,103.05	30,979,008.70	17,085,087.42	97,443,121.90	6
Rubber and plastics	4,868,341.80	4,092,321.95	2,820,928.02	2,383,313.85	8,905,409.43	2
Non-metals	20,436,592.44	8,251,343.66	25,994,347.57	5,853,491.61	59,390,190.81	18
Fabricated metal	57,556,177.66	38,553,567.52	38,932,752.11	37,191,222.01	115,926,353.59	7
Furniture	57,193,630.13	44,435,751.42	28,646,253.50	37,142,752.28	90,002,386.69	10

Sources: Own Survey result 2019

4.2. Water Efficient Technology Use of Firms

The study has examined firms' status to water efficient technology use via three parameters of measurements: - (1) Efficiency technical solutions, (2) Reuse & recycling water, and (3) effluent reduction & treatments methods. The study result reveals that of the total samples only 4.6% or 7 of them use water efficient technical methods during production phases, and; 53.6% or 82 of them use reuse – recycling water via captivating recycling technologies. This implies that of the total samples; 50% and above take advantage of reuse the water input via captivating recycling technologies i.e water harvesting technologies, concurrent rinsing and membrane separation technologies are the widely used ones by firms. The remaining 41.8% or 64 of them use water effluent & treatment technologies that includes; pigging, drying, dosing equipment and UV/Ozone system. However, the study result reveals that, still there is a gap firms' in utilizing water efficient technologies. So, introduction of water efficient technologies for industrial firms have to be promoted.

The remaining 41.8% of them use water effluent & treatment technologies that includes; pigging, drying, dosing equipment and UV/Ozone system. Table 4.2.1 can summarizes the results revealed based on the relevant data congregated to industry firms. Moreover, list of the technologies that are categorized to each parameter of measurements are also attached as annex to this paper.

Table 4.2.1: Water Efficient Technology use by industrial groups

Descriptives	Food & Beverage	Textile	Wearing apparel	Tanning, leather & Footwear	Wood	Paper & printing	Chemicals	Rubber & Plastics	Non-metals	Fabricated Metals	Furniture	Total
(A) Efficiency-Technical solutions												
Observations (ni)	1	2	0	1	1	0	0	0	1	0	1	7
commmulatives	1	3	3	4	5	5	5	5	6	6	7	
No. firms (Ni)	38	28	13	12	13	6	6	2	18	7	10	153
Relative frequency (ni/Ni)	3%	7%	0%	8%	8%	0%	0%	0%	6%	0%	10%	4.6%
(B) Re-use and recycling												
Observations (ni)	22	18	9	5	5	5	4	1	10	1	2	82
commmulatives	22	40	49	54	59	64	68	69	79	80	82	
No. firms (Ni)	38	28	13	12	13	6	6	2	18	7	10	153
Relative frequency (ni/Ni)	58%	64%	69%	42%	38%	83%	67%	50%	56%	14%	20%	53.6%
(C) Effluent Reduction and Treatment												
Observations (ni)	14	16	4	5	4	4	5	2	9	0	1	64
commmulatives	14	30	34	39	43	47	52	54	63	63	64	
No. firms (Ni)	38	28	13	12	13	6	6	2	18	7	10	153
Relative frequency (ni/Ni)	37%	57%	31%	42%	31%	67%	83%	100%	50%	0%	10%	41.8%

Sources: Survey result 2019

Though it has given a little attention in most activities and businesses firms, the water input is the most significant ingredient in the process of producing the output in industrial firms. The study has also assessed the levels and flow types of water consumed by industrial firms. In production process of industry sector, the water input might be defined at each production processes. As discussed on the methodological review part of the literatures; (Gleik.p.H & Palaniappan.m, 2010) had described the water consumption flows at each production process. Similarly, this study has also assessed the water consumption levels and water flows by industrial firms.

In accord; this study has assessed firms' water consumption levels and flow types of the water realized by industrial firms while producing the outputs and the study assessed all important water flows at each production processes and it includes; the consumed embedded water, discharged renewable water, discharged none renewable water and consumed lost water measured in meter cubes at each production.

The study findings reveal that food and beverage industries, wood work enterprises, paper & printing industries and chemical manufacturing are effective in utilizing the water. This implies that of the total available water 80%, 60% and 55% and 62% respectively had effectively utilized either as consumed in the form of consumed embedded or discharged and renewed water. Whereas; industries such as textiles, tanning & leather industries, rubber & plastic industries, none metallic industries, metallic industries and furniture manufacturing are not effective in utilizing the water.; meaning that from the total available water for production purpose, the major share of the water is either discharged none renewable or consumed lost water. This is the logic behind for the need to technology based water resources management in order to preserve the resource from upset; ensure sustainable use and increase productivity of industrial firms. Table 4.2.2 summarizes the study result.

Table 4.2.2 Water consumption level and flow types of industrial groups

Sector	Descriptive Statistics	Firms' Water Consumption for the last 12 months			
		(CEW + DRW)	Percentage(%)	(CLW + DNRW)	Percentage(%)
FOOD & BEVERAGES	Total	1,825,960.86	80%	481,128.02	20%
	Mean	**48,051.60**	**80%**	12,661.26	**20%**
	No. Firms	38	38	38	38
TEXTILES	Total	232,587.13	40%	354,280.87	60%
	Mean	**9,303.49**	**40%**	14,171.23	**60%**
	No. Firms	28	28	28	28
WEARING APPAREL	Total	**170,665.27**	44%	217,828.73	56%
	Mean	**9,481.40**	**44%**	12,101.60	**56%**
	No. Firms	13	13	13	13
TANNING ,LEATHER & FOOTWEAR	Total	168,970.51	33%	350,722.69	67%
	Mean	**12,997.73**	**33%**	26,978.67	**67%**
	No. Firms	12	12	12	12
WOOD WORKS & WOOD PRODUCTS	Total	320,833.58	60%	216,459.67	40%
	Mean	**24,679.51**	60%	16,650.74	40%
	No. Firms	13	13	13	13
PAPER & PRINTINGS	Total	449,882.43	55%	365,951.27	45%
	Mean	**37,490.20**	**55%**	30,495.94	**45%**
	No. Firms	6	6	6	6
CHEMEICALS	Total	8,837,473.09	62%	4,492,048.91	38%
	Mean	**16,685,744.00**	**62%**	10,166,106.88	**38%**
	No. Firms	6	6	6	6
RUBBER& PLASTICS	Total	183.05	17%	875.05	83%
	Mean	**80.91**	**17%**	386.79	**83%**
	No. Firms	2	2	2	2
NON-METALS	Total	2,314,723.91	17%	11,065,183.09	83%
	Mean	**578,680.98**	**17%**	2,766,295.77	83%
	No. Firms	18	18	18	18
FABRICATED METALS	Total	8,431.46	15%	47,406.04	85%
	Mean	**2,107.87**	**15%**	11,851.51	**85%**
	No. Firms	7	7	7	7
FURNITURE	Total	13,932.39	27%	37,745.61	73%
	Mean	**4,644.13**	**27%**	12,581.87	**73%**
	No. Firms	10	10	10	10

Sources: Own calculation based on Survey data 2019

4.3. Results of the Econometric Model

4.3.1. Technical efficiency estimates by industrial group

So far the study has been describing the descriptive statistics of the key variables used in estimating the technical efficiency of industrial firms. Now; turn to econometric analysis of the data to estimate the technical efficiency by industrial group. In this study the parameters of coefficients were estimated by SFA approach. The parameter estimates by industrial group obtained using the Cobb-Douglas and translog functions frontier model; we can see similar approaches in other studies (Lundvall & Battese, 2003,) for Kenyan manufacturing plants. The coefficient of parameters estimated in this study stand for industrial water input, labor costs, the value of productive fixed assets; and value of intermediate inputs; that are $\beta_1, \beta_2, \beta_3$ *and* β_4 respectively; β_0 is the constant parameter. The main advantage of the Cobb-Douglas functional form is its simplicity of application. The Maximum likelihood random effect model was used to estimate the parameters for the efficiency level.

Table4.3.1. Estimated Parameters of the Stochastic Frontier Function by Industrial Group

Coefficients of Parameters	Food & Beverage	Textile	Wearing apparel	Tanning, leather &footwear	Wood products	Paper & printing	Chemicals	Rubber & Plastics	Non-metals	Fabricated Metals	Furniture
β_1 Water (W_i)	0.168***	0.0674	0.0420	0.208***	0.238	0.453***	0.305**	0.118***	0.0291	0.0807	0.211**
β_2 Labor(L_i)	0.0904***	0.0127	0.0190	0.0843**	0.151	0.0278	0.0413	0.0159	0.125***	0.00746	0.119***
β_3 Capital (K_i)	0.881***	0.931***	0.895***	0.783***	0.742***	0.649***	0.721***	0.886***	0.825***	0.853***	0.622***
β_4 Intermediates(M_i)	0.0217	0.0782*	-0.0152	-0.0287	0.0161	-0.00409	0.208	0.0179	0.166**	-0.0615	0.219**
$\beta 0$ Constant	-0.289***	0.363***	-0.378**	-0.475***	0.328	-0.360**	-0.657***	-0.166	-0.251**	-0.631***	-0.731***
δV Error term	0.2471	0.1262	0.1636	0.1981	0.1279	0.4885	0.3387	0.2208	0 .2149	0.5337	0.2021
δU Inefficiency	0.2089	0.2859	0.3175	0.2703	0 .3744	0.2261	0.2675	0.3041	0 .3002	0.2016	0 .2683
No. firms	**38**	**28**	**13**	**12**	**13**	**6**	**6**	**2**	**18**	**7**	**10**

Note: Robust standard errors in parentheses. *** Significant at 1 percent significance level, ** significant at 5 percent significance level, * significant at 10 percent significance

The signs of the coefficients of the models are consistent with expectations. The study result reveals that the estimated coefficient for the water consumption is positive across all industrial firms, but its significant level is differ with different industrial groups. For example in industries such as food and beverages, tanning & leather industries, paper & printings, and rubber & plastics industries; the estimated coefficient for the water input is positive and significant at 1 percent. Whereas in industries; like chemicals and furniture industries; the coefficient for the water input is positive and significant at 5 percent. Moreover, the study result reveals that the estimated coefficients of inputs are positive except for the intermediate inputs which had a negative coefficient for some industry groups. The result implies that there is a positive effect by water input, capital, labor and the output. But the significance of their effect is different from industry to the industry group as described on table 4.3.1. The result also implies that increasing the intermediate inputs and holding the other entire inputs constant the marginal physical product will be less or equal to zero. The results also imply water, capital and labor are significant inputs in production in order to firms to increase their outputs. Table 4.3.1 revealed that, if all the inputs were to change by the same proportion the output would decrease. This is because the sum of the elasticity of cost of intermediate inputs, capital, labor, and water input were less than one. In particular, the study result reveals to non-negligible variations in efficiency level exist among firms within the industrial group, indicating that there is room for improving efficiency levels if firms use the water resource in a more efficient manner. Table 4.3.2 presents efficiency estimates for the firms under consideration.

The study reveals that the aggregate mean technical efficiency of operational industrial investment firms financed by the DBE was **43.8** percent during the study period. This implies that firms are operating below their optimum capabilities. So the technical inefficiency can be easily calculated as 1-technical efficiency. Therefore, the technical inefficiency for operational industrial investment firms financed by the Bank was **56.2** percent. The finding suggested that the industry's efficiency level of firms is below the average level for the study period under consideration. Efficiency estimates vary considerably among firms in any given industry, with some firms achieving very low efficiency and others achieving high levels of efficiency. Perhaps the major problem, common to some the industries, which might have greatly contributed to inefficiency and that, are inability of firms to work at optimum production capacity.

Table 4.3.2 Technical Efficiency Estimates by Industrial Group

Industry	Mean	Std. Dev.	Min	Max	Number of Firms	Models
Food and beverages	0.71	0.122	0.011	1.000	38	SFA Random Effect
Textiles	0.63	0.165	0.308	1.000	28	SFA Random Effect
Wearing apparel	0.14	0.156	0.287	1.000	13	SFA Random Effect
Tanning, leather & footwear	0.41	0.181	0.244	1.000	12	SFA Random Effect
Wood	0.69	0.216	0.173	1.000	13	SFA Random Effect
Paper and printing	0.57	0.174	0.094	1.000	6	SFA Random Effect
Chemicals	0.24	0.220	0.056	1.000	6	SFA Random Effect
Rubber and plastics	0.16	0.168	0.154	1.000	2	SFA Random Effect
Non-metals	0.40	0.135	0.023	1.000	18	SFA Random Effect
Fabricated metal	0.29	0.201	0.054	1.000	7	SFA Random Effect
Furniture	0.58	0.113	0.063	1.000	10 **153**	SFA Random Effect
Aggregate mean technical efficiency	**0 .438**					

Sources: Survey result 2019

So far the study is discussed the technical efficiency of industrial firms' in the context of wider sense of aggregate mean technical efficiency level for the industry sector. However, the study result reveals that the mean technical efficiency of some industrial firms such as food & beverages, (0.71) textiles (0.63), wood works (0.69), Paper & printing (0.57) and furniture manufacturing (0.58) are scored above the average level of efficiency; though the efficiency variation is still exists within the industry group itself. Whereas; in contrast, for the remains industry groups; the mean efficiency level results reveal below average the efficiency variation is still exists within the industry group itself. This implies firms to have improved their levels of efficiency by optimizing utilization of resources in wise manner.

4.3.2. Other Variables that Determine technical inefficiency

In addition to estimating the technical efficiency of firms, this study also further examined the relationship between other relevant variables and technical efficiency of individual firms. This is to give insight the inefficiency result may occur duet to disturbance effect of the variables. In keeping with the tradition of reporting SFA coefficients, the interpretation provided for a positive sign on a coefficient in the inefficiency effects model is that the coefficient reflects increased firm inefficiency. Positive coefficient is reported as having a negative effect on technical efficiency. Contrastingly, a negative sign on a coefficient is interpreted as the coefficient having a decreasing effect firm inefficiency. Thus, a negative coefficient is interpreted as having a positive effect on technical efficiency. The parameters of coefficients for each relevant controlled variable were estimated using the Maximum-likelihood regression model. Table 4.3.2.1 Maximum-likelihood results for the regression coefficients

Determinants of inefficiency	Coefficients
Age	-0.438** (0.188)
Size	2.347*** (0.376)
Financing (Working Capital)	-0.725* (0.383)
Managerial experience	-0.020 (0.316)
Ownership structure	-0.347 (0.309)
Water efficient technology use	-0.503* (0.274)
Constant	0.660** (0.281)

Sources: Survey result 2019

- **Notes:** *n*=153. Robust standard errors in parentheses. *$p<0.10$; **$p<0.05$; ***$p<0.01$

The coefficients in determining to the effects of the variables have meaning in analyzing the result. The coefficients to each variable are interpreted as follows.

Age of Firms

It is a firm-specific characteristic with ambiguous effects on efficiency. A positive relation may occur due to learning-by-doing arising from cumulative experience in production.

Notwithstanding, a negative relation may arise from use of old capital equipment and inefficient production practices. However, the result reveals that age has significant negative effect on firm's technical inefficiency; meaning it is interpreted as having a positive effect on technical efficiency due to learning-by-doing arising from cumulative experience in production.

Size of Firm

The effect of firm size on technical efficiency is ambiguous (Niringive, 2010). Firm size is determined based on the number of full-time employees in the last fiscal year. In this study; firm Size is a dummy variable taking a value of "1" where a firm has registered capital of 7.5 million and above; "0" if otherwise. Firms with a registered capital in between 500,000 (inclusive) and bellow 7.5 million (exclusive) are categorized as small and medium enterprises otherwise they are large scale. The study result reveals that firm size has positive and significant effect on technical inefficiency, and this implies that small scale firms are more efficient than large scales.

Working capital

Finance pertains to working capital that is obtained from the banks or other lending institutions could boost efficiency by facilitating a firm's day-to-day operations ((Nickel, 1999). Financing is measured using a dummy variable taking a value of "1" if ample working capitals "0" if otherwise. The study result reveals firms with having adequate working capitals are more efficient than having working capital insufficient.

Managerial experience

Firms with experienced managers have been found more technically efficient. The result reveals also supports the argument same. Managerial experience as the number of years that a top manager or business owner has worked in a given sector.

Ownership structure:

The study result reveals solely owned firms are more efficient than privately limited companies and it positively affects technical efficiency. It is argued that privately owned enterprises enhances their efficiency for the reason that privatization changes the incentive structure of the enterprises. Private firms motivate their workers by providing reward associated with higher level of performance.

Water efficient technology use

Previous studies argue that there exists a degree of complementarity between the variables and water efficient technology use since successful water efficient technology use depends on the degree absorptive capacity of a firm, which in turn depends on internal firms capabilities to use the technology. Industry dummies are used as explanatory variables for the variance in the idiosyncratic error component of the inefficiency effects model to account for differences between industries (Belotti, 2012). Similarly, the study result reveals that industrial groups which were reuse - recycling water efficient technology use firms have more technical efficiency, than those effluent reduction & treatments water technology used. Table 4.3.2.2 presents the technical efficiency distribution of firms for water efficient technology use group i.e reuse & recycling water technology use , effluent reduction & treatments tech use, and water use technical solutions

Table 4.3.2.2: Technical Efficiency Distribution of water efficient technology use by industrial groups

INDUSTRY GROUPS

Water Efficient Technology use Group	**Food and beverages**	**Textile**	**Wearing apparel**	**Tanning, leather & footwear**	**Wood products**	**Paper & printing**	**Chemicals**	**Rubber & plastics**	**Non-metals**	**Fabricated metals**	**Furniture**
Reuse & recycling water technology	0.790	0.780	0.730	0.680	0.630	0.640	0.650	0.660	0.670	0.680	0.690
Effluent reduction & treatments tech.	0.560	0.550	0.500	0.450	0.400	0.410	0.420	0.430	0.440	0.450	0.460
Technical Solution	0.440	0.430	0.380	0.330	0.280	0.290	0.300	0.310	0.320	0.330	0.340

Survey result 2019

CHAPTER FIVE

5. CONCLUSION AND RECOMMENDATIONS

5.1. Conclusion

Water is critical input element in production for industrial firms. The water used in production processes convert raw materials into intermediate and final products for example, water used as an ingredient in products, as a solvent, as a coolant or lubricant, or as a cleaning agent to wash products. Though it has given a little attention in most activities and businesses firms, the water input is the most significant ingredient in the process of producing the output in industrial firms. The study has also assessed the levels and flow types of water consumed by industrial firms. The study findings reveal that food and beverage industries, wood work enterprises, paper & printing industries and chemical manufacturing are effective in utilizing the water. This implies that of the total available water 80%, 60% and 55% and 62% respectively had effectively utilized either as consumed in the form of consumed embedded or discharged and renewed water. Whereas industries such as textiles, tanning & leather industries, rubber & plastic industries, none metallic industries, metallic industries and furniture manufacturing are not effective in utilizing the water.; meaning that from the total available water for production purpose, the major share of the water is either discharged none renewable or consumed lost water.

The study has analyzed the technical efficiency of industrial firms funded by the Development Banks of Ethiopia. The study has applied stochastic frontier approach. The Water input was so well thought-out in this study. The study result reveals that the estimated coefficients for the water inputs are positive across all industrial firms, but its significant level differ with different industrial groups. For example in industries such as food and beverages, tanning & leather industries, paper & printings, and rubber & plastics industries; the estimated coefficient for the water input is positive and significant at 1 percent. Whereas in industries; like chemicals and furniture's; the coefficients for the water input is positive and significant at 5 percent. The study result reveals variations in efficiency exist among firms within the industrial group, indicating that there is room for improving efficiency levels if firms use the water input in a more efficient manner.

The study result reveals, the aggregate mean technical efficiency of operational industrial investment firms financed by the DBE was 43.8 percent during the study period. This implies that firms are operating below their optimum capabilities. In particular, the non-negligible variations in efficiency exist among firms within the industrial group, indicating that there is room for improving efficiency levels if firms use the water resources in a more efficient manner. Efficiency estimates vary considerably among firms in any given industry, with some firms achieving very low efficiency and others achieving high levels of efficiency.

The relevance of Water use efficient technologies to firms improves the performance. Technology based water resources management is important in order to preserve the resources from upset; ensure sustainable use the water resources and increase productivity of industrial firms.. The study finding provides evidence that use of water efficient technology in combination with other variables reinforce each others have effects on technical efficiency. The study findings therefore suggest that in the context of industrial investment firms, efficiency gains are realized from combining factors of water efficient technology use with internal and external other factors. Significant shortages in working capital prevent some firms from operating at full capacity, which in turn would lead to efficiency variations across firms. Some manufacturing firms are forced to operate in an inefficient way, thereby magnifying efficiency variations.

The effect of firm size and age on technical efficiency is one of the widely-studied areas in the literature. Similarly, in this study the direction of their effect markedly differs from industry to industry. The coefficients of size and age are positive in some industries and negative in other industries. This implies that policies that seek to address inefficiency problems in the sector should be industry specific. For instance, in industries where the coefficient for size is negative, the policy should be geared towards promoting small firms, while for positive coefficients, the reverse is true. Similarly, in industries where age is negatively correlated with efficiency, government policy should focus on encouraging young entrepreneurs in creating business.

It is argued that private ownership of enterprises enhances their efficiency for the reason that privatization changes the incentive structure of the enterprises. Private firms motivate their workers by providing reward associated with higher level of performance. Similarly, this study reveals solely owned proprietorship firms are more efficient than privately owned limited companies to positively affect technical efficiency.

5.2. Recommendations

The findings of this study primarily support for decision by firm owners, funding institutions and the policy makers. The efficiency variation of firms was been explained by firms' use of water input and water efficient technologies. The study result reveals that the estimated coefficient for the water input is positive across all industrial firms. Hence, national and regional policies that promote water efficient technology use are likely to enhance efficient utilization of the water resources; ensure sustainable use of the water resources and increase productivity of industrial firms. Indeed, it is the characteristics of both manufacturing and agro processing sub sectors within the industry sector. Thus, to enhance their efficiency performance, firms need to adjust to the use of water efficient technologies. In addition, the role of the government in providing finance, advisory support regarding training, market information, and technology choice is also recommended.

The results also indicate that firm technical efficiency level decreases with increasing size, suggesting that small firms are more efficient than larger firms in terms of employment. Hence, national and regional policies that focus on encouraging small and young firms will play an important role in creating job opportunities and addressing problems associated with income distribution. The government should also provide incentives to the small and medium enterprises willing to invest in the industry.

The raw materials for the agro-processing industry comes from the agricultural sector, this implies that technical efficiency improvement of the agro-processing industry can help to leverage the success of the agricultural sector. This study therefore, recommends that the government strengthens the agricultural sector; hence it has great contribution for industrialization strategy that the country adopted.

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APPENDICES

Appendix 1

1. The Water consumption Level and Flow types by industrial groups

Industry Group	Descriptive Statistics	None - production water in m3	Production water in m3	Total water consumption in m3	Consumed Embeded Water in m3	Discharged Water	Discharged Renewable Water in m3	Discharged None Renewable Water in m3	Consumed Lost water in m3	Total cost incured	(CEW + DRW)	Percentage (%)	(CLW + DNRW)	Percentage(%)
FOOD AND BEVERAGES	Minimum	251.20	1,256.00	1,507.20	145.20	351.68	105.50	246.18	19.88	223.00	267.17	18%	25.09	2%
	Maximum	171,264.20	856,321.00	1,027,585.20	736,436.06	239,769.88	71,930.96	167,838.92	71,356.25	48,697.00	808,367.02	98%	105,777.67	82%
	Sum	458,863.00	2,294,315.00	2,753,178.00	1,633,403.30	641,858.53	192,557.56	449,300.97	31,827.05	200,802.00	**1,825,960.86**	**79.59%**	**481,128.02**	**20.97%**
	Mean	12,075.34	60,376.71	72,452.05	42,984.30	16,891.01	5,067.30	11,823.71	837.55	5,284.26	48,051.60	80%	12,661.26	21%
	Median	2,877.60	14,388.00	17,265.60	9,944.55	3,990.84	1,197.25	2,793.59	732.71	1,768.00	11,141.80	77%	3,526.29	25%
	St.Dev	29,749.55	148,747.75	178,497.30	122,977.10	41,653.48	12,496.04	29,157.43	23,725.45	-	135,473.14	91%	52,882.89	36%
	Observation	38	38	38	38	38	38	38	38	-	-		-	
TEXTILES	Minimum	253.80	1,269.00	1,522.80	190.35	406.08	81.22	324.86	296.40	423.00	271.57	16%	997.43	29%
	Maximum	28,713.60	143,568.00	172,281.60	28,319.85	45,941.76	9,188.35	36,753.41	76,091.04	47,856.00	31,108.27	74%	112,844.45	84%
	Sum	116,659.20	583,296.00	699,955.20	196,126.35	182,303.88	36,460.78	145,843.10	208,437.77	194,432.00	232,587.13	40%	354,280.87	61%
	Mean	4,666.37	23,331.84	27,998.21	7,845.05	7,292.16	1,458.43	5,833.72	8,337.51	7,777.28	9,303.49	40%	14,171.23	61%
	Median	2,713.80	13,569.00	16,282.80	4,030.20	4,342.08	868.42	3,473.66	2,493.12	4,523.00	4,898.62	36%	5,966.78	44%
	St.Dev	5,975.25	29,876.26	35,851.51	9,299.37	9,552.60	1,910.52	7,642.08	15,196.11	9,958.75	11,209.89	38%	22,838.19	76%
	Observation	28	28	28	28	28	28	28	28	-	-		-	
WEARING APPAREL	Minimum	221.40	1,107.00	1,328.40	177.12	321.03	32.10	288.93	265.50	159.00	209.22	12%	644.33	32%
	Maximum	8,715.60	43,578.00	52,293.60	26,146.80	12,637.62	1,263.76	11,373.86	19,676.04	14,526.00	**27,410.56**	68%	**30,840.05**	88%
	Sum	77,698.80	388,494.00	466,192.80	159,398.94	112,663.26	11,266.33	101,396.93	116,431.80	88,251.00	**170,665.27**	44%	**217,828.73**	56%
	Mean	4,316.60	21,583.00	25,899.60	8,855.50	6,259.07	625.91	5,633.16	6,468.43	4,902.83	9,481.40	44%	12,101.60	56%
	Median	3,609.90	18,049.50	21,659.40	5,108.79	5,234.36	523.44	4,710.92	7,706.36	1,450.00	5,632.23	31%	12,417.27	69%
	St.Dev	3,809.98	19,049.92	22,859.90	8,872.46	5,524.48	552.45	4,972.03	4,652.98	5,786.06	9,424.91	49%	9,625.01	51%
	Observation	13	13	13	13	13	13	13	13	-	-		-	
TANNING ,LEATHER & FOOTWEAR	Minimum	154.80	774.00	928.80	131.85	255.42	38.31	153.25	38.70	258.00	193.11	9%	191.95	25%
	Maximum	39,539.40	197,697.00	237,236.40	39,539.40	65,240.01	26,096.00	55,454.01	92,917.59	173,718.00	65,635.40	75%	148,371.60	91%
	Sum	103,938.64	519,693.19	623,631.83	121,451.82	171,498.75	47,518.69	123,980.06	226,742.62	13,362.92	**168,970.51**	**32.51%**	**350,722.69**	**67.49%**
	Mean	7,995.28	39,976.40	47,971.68	9,342.45	13,192.21	3,655.28	9,536.93	17,441.74	4,758.00	12,997.73	33%	26,978.67	67%
	Median	2,915.40	14,577.00	17,492.40	2,186.55	4,810.41	733.79	3,436.92	2,740.61	22,693.75	2,920.34	20%	6,177.53	42%
	St.Dev	14,103.90	70,519.52	84,623.42	14,221.51	23,271.44	7,226.82	17,216.89	33,729.39	49,572.53	21,448.34	30%	50,946.28	72%
	Observation	12	12	12	12	12	12	12	12	12	-	0%	-	0%
WOOD WORKS & WOOD PRODUCTS	Minimum	848.40	4,242.00	5,090.40	775.80	1,824.06	912.03	912.03	188.16	156.00	1,760.43	32%	1,199.52	26%
	Maximum	21,924.60	109,623.00	131,547.60	54,811.50	47,137.89	23,568.95	23,568.95	44,945.43	36,541.00	78,380.45	75%	68,514.38	69%
	Sum	107,458.65	537,293.25	644,751.90	205,315.53	231,036.10	115,518.05	115,518.05	100,941.62	107,934.00	**320,833.58**	**59.71%**	**216,459.67**	**40.29%**
	Mean	8,266.05	41,330.25	49,596.30	15,793.50	17,772.01	8,886.00	8,886.00	7,764.74	8,302.62	24,679.51	60%	16,650.74	40%
	Median	3,385.20	16,926.00	20,311.20	5,924.10	7,278.18	3,639.09	3,639.09	3,723.72	4,253.00	9,563.19	57%	7,362.81	44%
	St.Dev	8,362.53	41,812.63	50,175.15	18,004.60	17,979.43	8,989.71	8,989.71	11,881.14	11,071.70	26,994.32	65%	20,870.86	50%
	Observation	13	13	13	13	13	13	13	13	-	-	0%	-	0%
PAPER & PRINTINGS	Minimum	921.60	4,608.00	5,529.60	2,352.00	1,751.04	175.10	1,575.94	92.16	158.00	2,530.75	29%	1,668.10	36%
	Maximum	64,760.40	323,802.00	388,562.40	178,091.10	123,044.76	12,304.48	110,740.28	30,636.00	1,523,546.00	190,395.58	64%	133,406.42	71%
	Sum	163,166.74	815,833.69	979,000.43	418,880.74	310,016.80	31,001.68	279,015.12	86,936.14	4,443,174.00	**449,882.43**	**55.14%**	**365,951.27**	**44.86%**
	Mean	13,597.23	67,986.14	81,583.37	34,906.73	25,834.73	2,583.47	23,251.26	7,244.68	370,264.50	37,490.20	55%	30,495.94	45%
	Median	5,812.29	29,061.47	34,873.77	12,526.08	11,043.36	1,104.34	9,939.02	2,130.02	25,868.50	13,630.42	47%	12,069.04	42%
	St.Dev	21,106.67	105,533.37	126,640.05	56,706.93	40,102.68	4,010.27	36,092.41	10,112.00	579,938.96	60,717.20	58%	46,204.41	44%
	Observation	6	6	6	6	6	6	6	6	-	-	-	-	-
CHEMEICALS	Minimum	921.60	4,608.00	5,529.60	2,822.40	599.04	59.90	539.14	(548,476.56)	1,523.00	2,930.59	27%	861.70	9%
	Maximum	2,665,904.40	13,329,522.00	15,995,426.40	8,530,894.08	3,065,790.06	306,579.01	2,759,211.05	1,732,837.86	1,475,623.00	2,930.59	27%	861.70	9%
	Sum	5,370,370.17	26,851,850.87	32,222,221.05	16,068,197.51	6,175,464.90	617,546.49	5,557,918.41	4,608,188.47	4,443,174.00	8,837,473.09	91%	4,492,048.91	73%
	Mean	537,037.02	2,685,185.09	3,222,222.10	1,606,819.75	617,546.49	61,754.65	555,791.84	460,818.85	170,633.50	**16,685,744.00**	**62.14%**	**10,166,106.88**	**37.86%**
	Median	234,079.35	1,170,396.75	1,404,476.10	471,138.86	269,191.25	26,919.13	242,272.13	286,484.28	8,145.00	1,668,574.40	62%	1,016,610.69	38%
	St.Dev	820,328.26	4,101,641.32	4,921,969.59	2,736,452.35	943,410.98	94,341.10	849,069.88	724,131.19	460,539.66	498,057.99	43%	528,756.41	45%
	Observation	6	6	6	6	6	6	6	6	-	2,830,793.45	69%	1,573,201.07	38%

RUBBER& PLASTICS	Minimum	91.38	456.90	548.28	68.54	105.09	10.51	94.58	283.28	1,523.00		79.04	**17%**	377.86	83%
	Maximum	568.02	2,840.10	3,408.12	426.02	653.22	65.32	587.90	1,760.86	9,467.00		491.34	**17%**	2,348.76	83%
	Sum	846.48	4,232.40	5,078.88	634.86	973.45	97.35	876.11	2,624.09	14,108.00		732.21	**17%**	3,500.19	83%
	Mean	211.62	1,058.10	1,269.72	158.72	243.36	24.34	219.03	656.02	3,527.00		**183.05**	**17.30%**	**875.05**	**82.70%**
	Median	93.54	467.70	561.24	70.16	107.57	10.76	96.81	289.97	1,559.00		80.91	17%	386.79	83%
	St.Dev	237.61	1,188.03	1,425.64	178.20	273.25	27.32	245.92	736.58	3,960.10		205.53	**17%**	982.50	83%
	Observation	2	2	2	2	2	2	2	2	-					
NON-METALS	Minimum	921.60	4,608.00	5,529.60	691.20	1,059.84	105.98	953.86	2,856.96	1,536.00		797.18	**17%**	3,810.82	83%
	Maximum	2,665,904.40	13,329,522.00	15,995,426.40	1,999,428.30	3,065,790.06	306,579.01	2,759,211.05	8,264,303.64	15,346.00		2,306,007.31	**17%**	11,023,514.69	83%
	Sum	2,675,981.40	13,379,907.00	16,055,888.40	2,006,986.05	3,077,378.61	307,737.86	2,769,640.75	8,295,542.34	20,238.00		2,314,723.91	**17%**	11,065,183.09	83%
	Mean	668,995.35	3,344,976.75	4,013,972.10	501,746.51	769,344.65	76,934.47	692,410.19	2,073,885.59	5,059.50		**578,680.98**	**17.30%**	**2,766,295.77**	**82.70%**
	Median	4,577.70	22,888.50	27,466.20	3,433.28	5,264.36	526.44	4,737.92	14,190.87	1,678.00		3,959.71	**17%**	18,928.79	83%
	St.Dev	1,331,273.82	6,656,369.08	7,987,642.90	998,455.36	1,530,964.89	153,096.49	1,377,868.40	4,126,948.83	6,858.97		1,151,551.85	**17%**	5,504,817.23	83%
	Observation	18	18	18	18	18	18	18	18	-		-		-	
FABRICATED METALS	Minimum	85.38	426.90	512.28	42.69	145.15	21.77	123.37	239.06	1,423.00		64.46	**15%**	362.44	85%
	Maximum	9,140.76	45,703.80	54,844.56	4,570.38	15,539.29	2,330.89	13,208.40	25,594.13	152,346.00		6,901.27	**15%**	38,802.53	85%
	Sum	11,167.50	55,837.50	67,005.00	5,583.75	18,984.75	2,847.71	16,137.04	31,269.00	46,531.25		8,431.46	**15%**	47,406.04	85%
	Mean	2,791.88	13,959.38	16,751.25	1,395.94	4,746.19	711.93	4,034.26	7,817.25	16,178.00		**2,107.87**	**15.10%**	**11,851.51**	**84.90%**
	Median	970.68	4,853.40	5,824.08	485.34	1,650.16	247.52	1,402.63	2,717.90	70,953.91		732.86	**15%**	4,120.54	85%
	St.Dev	4,257.23	21,286.17	25,543.41	2,128.62	7,237.30	1,085.59	6,151.70	11,920.26	70,953.91		3,214.21	**15%**	18,071.96	85%
	Observation	7	7	7	7	7	7	7	7	-		-		-	
FURNITURE	Minimum	919.20	4,596.00	5,515.20	1,194.96	367.68	44.12	323.56	3,033.36	1,423.00		1,239.08	27%	3,356.92	73%
	Maximum	8,464.80	42,324.00	50,788.80	11,004.24	3,385.92	406.31	2,979.61	27,933.84	4,256.00		11,410.55	27%	30,913.45	73%
	Sum	10,335.60	51,678.00	62,013.60	13,436.28	4,134.24	496.11	3,638.13	34,107.48	7,202.00		13,932.39	27%	37,745.61	73%
	Mean	3,445.20	17,226.00	20,671.20	4,478.76	1,378.08	165.37	1,212.71	11,369.16	2,400.67		**4,644.13**	**26.96%**	**12,581.87**	**73.04%**
	Median	951.60	4,758.00	5,709.60	1,237.08	380.64	45.68	334.96	3,140.28	1,523.00		1,282.76	27%	3,475.24	73%
	St.Dev	4,347.13	21,735.66	26,082.79	5,651.27	1,738.85	208.66	1,530.19	14,345.53	1,607.54		5,859.93	27%	15,875.72	73%
	Observation	10	10	10	10	10	10	10	10	10					

2. Technical Efficiency Distribution by industrial groups for relevant variables

Group	Food and beverages	Textile	Wearing apparel	Tanning, leather & footwear	Wood products	Paper & printing	Chemicals	Rubber & plastics	Non-metals	Fabricated metals	Furniture
Employees group											
10 to 19	0.738	0.872	0.857	0.834	0.882	0.705	0.764	0.824	0.814	0.683	0.826
20 to 49	0.748	0.879	0.852	0.811	0.873	0.687	0.715	0.81	0.808	0.669	0.814
50 to 99	0.746	0.877	0.853	0.835	0.888	0.706	0.768	0.816	0.826	0.695	0.804
100 +	0.775	0.885	0.846	0.835	0.882	0.728	0.733	0.814	0.811	0.703	0.82
Age group											
Age ≤ 5	0.77	0.889	0.835	0.823	0.886	0.687	0.737	0.795	0.809	0.679	0.826
5< Age≤10	0.736	0.882	0.861	0.813	0.883	0.715	0.733	0.833	0.812	0.695	0.813
10<Age≤20	0.727	0.887	0.85	0.828	0.882	0.655	0.727	0.823	0.816	0.673	0.819
Managerial Experience											
Age ≤ 5	0.341	0.452	0.541	0.441	0.341	0.461	0.591	0.341	0.461	0.541	0.641
5< Age≤10	0.691	0.802	0.891	0.791	0.691	0.811	0.941	0.691	0.811	0.891	0.776
10<Age≤20	0.711	0.822	0.911	0.811	0.711	0.831	0.961	0.711	0.831	0.911	0.796
Water Efficient Technology use											
High-technology industry	0.830	0.780	0.730	0.680	0.630	0.640	0.650	0.660	0.670	0.680	0.690
Medium-technology industry	0.560	0.550	0.500	0.450	0.400	0.410	0.420	0.430	0.440	0.450	0.460
Ownership Structure											
Sole proprietors	0.885	0.835	0.785	0.735	0.745	0.755	0.765	0.775	0.785	0.795	0.515
Pvt.Ltd.comp	0.440	0.430	0.380	0.330	0.280	0.290	0.300	0.310	0.320	0.330	0.340

Appendix 3

3. Water efficient technologies recommended for Industrial Firms

Water efficient technologies recommended for Industrial Firms	**Descriptions of the technology (appropriateness, effectiveness and efficiency)**
	1. Efficiency- Technical solutions
Metering:	The use of meters is the first step to reducing water use on site. Sub-meters can record water use indifferent parts of the sites, and can be connected to data loggers to match production and cleaning shifts to water use. Metering is especially useful to determine baseline data, and to ensure that there are no leaks on site during down time such as site closure. Meters promote water efficient appliances.
Water Pinch	Water Pinch is a systematic technique for analyzing water networks and reducing water costs for processes. It uses advanced algorithms to identify and optimize the best water re-use, regeneration, and effluent treatment opportunities. It has also helped to reduce losses of both feedstock and valuable products in effluent streams. This technique can help reduce charges on water volume and should be used in conjunction with online analyzers and dosing equipment (below) in reducing effluent loads as well biological oxygen demand as charges are also based on pollution load.

CIP optimization systems	This systems offer a highly efficient way of cleaning large vessels or tanks that require regular cleaning. CIP systems incorporate spray balls/nozzles/rotating heads and generally use high-pressure cleaning. As there is no human contact, stronger detergents ensure more efficient cleaning and water use is optimized. If fitted with partial solvent recirculation, these systems can increase washing efficiency by 90%.
Mechanical seal water management	A mechanical seal is a device which helps join systems or mechanisms together by preventing leakage (eg in a plumbing system), containing pressure, or excluding contamination. A mechanical seal can be used around pumps and other rotating equipment and promotes savings from effective control of flush and quench water (waters used to wash out batch systems for example). Mechanical seals use 12 liters of water per minute on average but this can be cut by 75%.
2. Re use and Recycling	
Water harvesting	Water harvesting is the collection of water that would otherwise have gone down the drainage system, into the ground or been lost to the atmosphere through evaporation. Installing rainwater harvesting equipment in a factory can provide rainwater for use as non-drinking water applications such as toilet flushing and washing machines, process or cooling water, or cleaning water.

Countercurrent rinsing	This is a well-established technique in industries, but much less applied on food manufacturing plants. Rinse water can often be more effectively used by moving a product through a series of tanks or stages. Instead of each of these stages being supplied with fresh ‘make-up’ water, counter current rinsing can be employed, so long as hygiene standards are ensured. In counter-current rinsing, the product is rinsed first in grey water and then in progressively cleaner water. At the same time, the rinse water moves progressively from the last rinse (clean water) towards the first rinse (grey water).Typical savings in water use are between 40 and 50%.
Membrane separation	A membrane is a thin physical barrier through which materials can either pass or be rejected and retained. The structure and character of the membrane determine the nature of the separation. Membranes have many uses in the food and drinking industry: apart from recovering water, they can be used to concentrate or purify product and recover raw materials and product from waste streams. Membrane filtration systems are characterized into four main categories according to the pore sizes of the membranes.
3. Effluent Reduction and Treatment	
Pigging	It is a technique used for removing blockages in water pipes and sewers and cleaning pipes in the chemicals industry and is ideal as the pipe does not need to be opened. It is often used in connection with clean-in-place (CIP) systems. The technique uses a solid object, such as a rubber or plastic plug or lump of ice, or it can use pressurized air to force out any remaining product from the pipe from the last process batch and thus clean it ahead of the next batch. By using this technique large quantities of water can be saved when cleaning transfer pipes between batch productions. Product efficiencies are also important and can be made by capturing the final amounts of the process batch, which can be incorporated into the final product.

Slurry dewatering/drying	This is a broad technique commonly used for reducing the volumes of water held by slurries and sludge's from various industries. Technologies include centrifuging, belt presses and high temperature driers to drive off excess water. The resulting solid is often described as 'cake' with an appropriate percentage of dry solids, indicating the amount of water in the material. The main aim is reduce the weight and volume of slurry or sludge so that transport costs and volumes are lower.
Electro-coagulation:	Electro-coagulation is used to clean wastewater by using electricity to precipitate out dissolved material and suspended solids. After going through this process the resulting cleaner water can then be used in many applications, such as for on-site facilities and cleaning operations. By doing so costs for both clean water in and wastewater out are reduced due to lower volumes. Furthermore, the costs for electro-coagulation are lower in comparison to conventional chemical coagulation as there is not the operational need for chemical addition and subsequent smaller sludge volumes to dispose.
Online analyzers	Online analyzers can be used in wastewater treatment to ensure that the correct level for effluent load is attained in the process, often using Total Organic Carbon, TOC, as the key indicator. This is relevant for two reasons. It is important that wastewaters meet discharge consent values and thus do not incur punitive measures and so the manufacturer would use analyzers to ensure that effluent loads are not exceeding their consents. A manufacturer however also wants to be sure that their wastewater is not being unnecessarily overly-treated beyond what is required, under the terms of their discharge consents for example, and therefore wasting money through energy costs for example. Analyzers can also be used to measure the amounts of water being used and thus pinpoint where efficiencies in volume can be made. One key advantage is that online analyzers are instant rather than needing a sampling and testing regime which adds delays into the process.

Dosing equipment	Dosing equipment: By optimizing the dose of ingredients to the correct amount there is less wastage of raw materials and subsequently less washing needed (ie less water required).
Closed transfer equipment:	This is a technique whereby products are moved from one vessel to another without the need for direct contact. It therefore ensures minimization of spillages between batch processes prevents waste product from having to be washed out to sewer and reduces the chance for contamination.
UV/Ozone	UV/Ozone: Ozone gas and UV light are widely used in the treatment of water and wastewater to kill pathogens. They can also oxidize trace chemicals making them less harmful and easier to separate out. For wastewaters specifically this can be applied to reduce the effluent load and thus make the water more appropriate for re-use in other processes.
Sand Filters:	Sand Filters: Sand filters are a long-standing separation technology. Layers of fine and coarse sands and other materials are employed to filter wastewaters and physically remove suspended matter. Some dissolved material is also separated out through adsorption onto the surface of the filtration substance. The filter has to be backwashed periodically with clean water to ensure optimal performance, the resulting sludge then requiring further treatment or disposal.
Dissolved Air Flotation (DAF):	Dissolved Air Flotation (DAF): In combination with coagulation techniques, DAF can be used to separate out flocks and precipitates from the water by passing gas (usually air) upwards through the water. This pushes the suspended matter to the surface from where it can be scraped off for disposal.

Source: AEA Energy & Environment: with reference no. AEAT/ENV/R/2457 (ED05226), Final Report (Issue 1) on Resource use efficiency in food chains Priorities for water, energy and waste opportunities.

4. Questionnaire Survey

SECTION 1:

A. General Background Information of the Key informants;

Please encircle as appropriate

1. Name of the respondent: ________________

2. Age of the respondent ______________ (Years)

3. Your Position in the company or firm organization.

1. Managerial level □ **2.**Marketing & Sales Expert □ **3.**Production expert □ **4.**Technical Staff □
5. Other, Specify ---------------------------------------

4. Gender: **1**. Female □ **2**. Male □

5. Highest educational level obtained:

1. Diploma / Level IV □ **2.** First Degree □ **3.** Masters and above □

6. Field of specialization: _____________________

7. How long have you been Working in the company? ____________ (Years)

1.2. General Back ground Information of your Firm

1. Name of your company/ firm __________________

2. Year establishment of your firm ___________________ (Year)

3. Age of your firm since its establishment ---------------------------- (Years)

4. The current total registered capital of your Firm______________ (Birr)

5. Location (Address) of your firm

Region/City____________ Sub-city/Zone: ___________

Town _______ Woreda ________ Kebele: _______

Tel. ______________________

Fax______________ P.O.Box___________

E-mail____________

a. Distance to infrastructures & Market outlet _____________ (Km)

b. Distance to infrastructures to input market _______________ (Km)

6. The Amount of loan approved to your firm by Development Bank of Ethiopia …………………(Birr)

7. Is working capital approved to your firm sufficient to run your project as smooth?

1. Yes □ **2**. No □

If no, Please write your comment, if any on the insufficiency of the working capital

____
____
____
____

8. The production capacity of your firm______________ (unit/annum), take the average; and also the actual produced amount for the last 12 months _____________ (unit/annum)

9.Ownership structure of your firm

1. Sole proprietorship

2. Private limited company

3. Share Company

4. Other, Specify _______________

10. How many years of experiences do your firm General Manager has? ______ (years)

11. Size of your firm;

1. If, total registered capital ;**(X< 500,000 Birr**): Micro and Small Enterprises (**MSEs**);

2. If, total registered capital); **(500,000** Birr <u><</u>**X<7.5 Million** Birr)**:** Small and Medium Enterprises (**SME) s**and;

3. If, total registered capital (X <u>**></u>7.5 million** Birr): **Large Scale firms**

<u>**NB.**</u> As per the new credit policy of the Bank; it doesn't support MSEs (Micro and Small Enterprises), and hence are not to be included, but if any; that are before the endorsement of the policy, answer the above question accordingly)

12. The Sub - Sector that your firm aligns within the industry sector:

1. Agro- processing □ **2.** Manufacturing □ **3.**Others, Specify_________

13. Please put ☑ mark in the box below that best describes your firm category from the followings.

>>**Hint**: A firm category will lie to one of the following listed below. Marking a firm in two or above category is not appropriate.

S.No	List of Firms	Put ☑ mark
1	Food & beverage	
2	Textile	
3	Wearing apparel	
4	Tanning, leather & footwear	
5	Wood	
6	Paper & printing	
7	Chemicals	
8	Rubber & Plastics	
9	Non-metals	
10	Fabricated Metals	
11	Furniture	
12	Others, Specify___________________	

>>**NB**: A firm category will lie to one of the following listed above. Marking a firm in two or above category is not appropriate.

Section.2

B. This section tries to assess the production status of a firm for the last 12 months. Please list the products or give them a code.

2.1. The kind of Output produced_________________, amount produced for the last 12 months ______________ kg, liter or other unit of measurement

Sr.No	Type of Product	Production amount in unit	Sold quantity in unit	Total Income from sale
1				
2				
3				
4				

2.2. This part is used to gather data on inputs that a firm used in the process of producing the target output. The major input costs or amount utilized for the last **12 months**

Sr.No	**Name of input**	**Amount for the last 12 months**	**Unit**	**Total Cost incurred (Birr)**
1	Labor (L)			
2	The value of fixed assets (K) in Birr			
3	Water consumption (W) in m^3			
4	Major raw material (M) Please list those raw materials a)________________ b)________________ c)________________ d)_______________			

Section 3

C. This section ought to assess the water consumption and the water use technologies that a firm currently using

3.1. Does your firm currently have using Water use technologies?

1. Yes ☐ 2. No ☐

If yes, please List out the water uses technologies that your firm has currently using;

List of Water use technology/equipment	Date of purchase	Age of the technology since started using	Cost incurred to purchase the Equipment	Current market value of the technology	Rental price of the technology
A.					
B.					
C.					
D.					

3.2. This part tries to gather data on the water consumption by your firm while producing the output. Water used as an ingredient to outputs or for other purpose. Therefore, please fill the following table as per depicted below that your factory water consumed in m^3 **for the last 12 months.**

FACTORY WATER USE BY YOUR FIRM						
Factory Water use in m^3 (System Water)		Production Water use (PDW) in m^3				Total Expense incurred on water consumption for the last 12 months
NPDW in m^3	PDW in m^3	CEW in m^3	CLW in m^3	DRW in m^3	DNRW in m^3	

Where;

NPDW= "Non-Production Water" (NPW), which is the water used by auxiliary activities that facilitate production within a factory.E.g. cleaning and sanitation

PDW => Production Water includes **CEW, CLW, DRW & DNRW.**

*__CEW__ =>Consumed Embedded Water that is embedded into the product as an ingredient.

*__CLW__=>Consumed Lost Water is defined as the water lost in the process through evaporation or spillage that cannot be recovered.

* __DRW__ =>Discharged Renewable Water is that fraction of discharged water which is of a quality allowing reuse either directly or after treatment.

*__DNRW__=>Discharged None Renewable Water is the proportion of discharged water that is unfit for reuse, because of higher levels of contamination, and is discharged as

NB. **I**f, **CEW** plus **DRW** are much, much greater than **CLW** plus **DNRW** or **IF, (CEW+DRW) >> (CLW+DNRW)**, then a firm is effective in water consumption/saves water. So, please valuate your firm in accordance**.**

3.3. In which type of water consumption does you currently using water use technology is more effective?

1. Saves the water unit consumed/output (technically efficient) □ **2**.Re-use and recycling □

3. Effluent reduction and treatment □ **4.** Other, Specify___________________

3.4. How do you evaluate the water use technology that your firm currently is using?

1. Efficient □ **2**.Moderate □ **3**. Inefficient □ **4.** Obsoleted (Old) □ **5.**Other, Specify_______________

3.5. Given below are list of water use technologies recommended for industrial investment firms. Thus, please identify as appropriate to your firm

Code	List of Water use technologies Recommended for Industrial Firms	Put (√) Where appropriate to your firm
	(A) Efficiency-Technical solutions	
1	Metering	
2	Water Pinch	
3	CIP (clean in place) optimization systems	
4	Mechanical seal water management	
	(B) Re-use and recycling – technical solutions	
5	Countercurrent rinsing	
6	Membrane separation	
7	Water harvesting	
	(C) Effluent reduction and treatment - technical solutions	
8	Pigging	
9	Slurry dewatering/drying	
10	Electro-coagulation	
11	Online analyzers	
12	UV/Ozone	
13	Dosing equipment	
14	Sand Filters	
15	Dissolved Air Flotation (DAF):	
16	Closed transfer equipment	

Source: AEA Energy & Environment: with reference no. AEAT/ENV/R/2457 (ED05226) Final Report (Issue 1) on Resource use efficiency in food chains Priorities for water, energy and waste opportunities.

3.6. For given below; Put (√) **Where appropriate to your firm**

	Water Technologies used by your Firm		
	(A)Efficiency-Technical solutions	(B) Re-use and recycling – technical solutions	(C) Effluent reduction and treatment - technical solutions
Put (√) Where appropriate to your firm			

SECTION 4

This section tries to gather data on a firm's contribution to the socio - economic merits and the environmental protection as well.

4.1. Has your firm created job opportunities as per the planned number, especially for youth?

1. Yes □ **2.** No □

If yes, please state the age of employees on average ____________ (Years)

4.2. Here is to fill the table regarding the actual total number of employees hired vs. the planned numbers to be hired for the firm

The total number of employees **Planned** to be hired by the firm		The **Actual** total number of employee that a firm hired		**Total Cost incurred in the last 12 months for salary payment**
Number of Temporal employees	Number of Permanent employees	Number of Temporal employees	Number of Permanent employees	

4.3**.** Does your firm met tax obligation for the last physical year (2010.Ec)

1. Yes □ **2**. No □ **3.** Has tax holiday privilege □

If yes, please state the amount ____________ (Birr)

4.4. Does your firm emit waste materials to the **environment?**

1. Yes □ 2. No □

If yes, please list the type of wastes and the quantity also;

Type of waste	Quantity/annum
A.________________	________________
B. ________________	________________
C. ________________	________________
D. ________________	________________

If no, please state the mechanism that you follow_________________________

4.5. Does your firm emit waste materials to the **water resources** confined to the project?

1. Yes □ 2. No □

If yes, please list the type of wastes and the quantity also;

A.________________	________________
B. ________________	________________
C. ________________	________________
D. ________________	________________

If no, please state the mechanism that you follow____________________