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ENTREPRENEURIAL BUSINESS OPPORTUNITY IN CLOSED LOOP SUPPLY CHAIN: EXTRACTING OIL FROM WASTE TIRES

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ABSTRACT

The purpose and scope of the study is to introduce the untapped entrepreneurial business opportunity in closed loop supply chain by recovering fuel oil, steel and carbon char-pellet from used tires. The study is based on data gathered from primary and secondary sources and relevant assumptions. In the study, it is found that about 6,000 tons of used tires per year are available in and around Addis Ababa for the project. Demand for these products is huge and increasing. An enterprise plant with capacity of 3,600 tons per year is selected, which enables production of about 8,500 barrels of fuel oil, 9,000 quintals of char pellet and 432 tons of steel. Birr 12.6 million is the estimated total cost of the entrepreneurial project. The financial analysis shows that the entrepreneurial project is feasible with positive NPV and IRR of 43%. The project is primarily sensitive to fuel oil sales price and also to scrap tire acquisition cost. The project ceases to be feasible if char pellet and steel do not have market *which is in conformity with findings in the literature. This reverse logistics entrepreneurial project also possesses wide range of socio-economic and environmental benefits.*

Key Words: Entrepreneurship, Business Opportunity, Closed Loop Supply Chain, Reverse Logistics, Scrap Tyre Pyrolysis.

1. Introduction

In Ethiopia, small scale entrepreneurship (SSE) is considered to be an instrument of change and vehicle leading to the growth for development. Glebova et al. (2013, 2015), Panasyuk et al. (2013), examined practical and theoretical work had shown positive relationship between small enterprises' impact on socioeconomic development. Small and medium entrepreneurship development is the key to the strategic development of the territory (Audretsch 2003). Several studies examined the positive link between resolution of global problems and entrepreneurship (Schumpeter 1934 & 1942; Drucker 1985; and Matos and Hall 2007). Sheperd and Patzel (2011) suggested that entrepreneurship can help protect ecosystem, quality of environment, minimization of deforestation, protection of ecosystem, improvement of agricultural practices as well as freshwater supply. Hall et.al, (2010) and Wheeler et.al. (2005) pointed out that entrepreneurship could solve numerous social and environmental problems. Achieving economic resurgence through small scale entrepreneurship is the most recommended solution for fast developing countries like Ethiopia (Hegde Sreepada, 2015).

In the light of an evident worsening of poverty, economic inequality, and environmental degradation among others, discussions on sustainability have become common among developmental concerns for government, civic society and business since the 1980s. New form of economic growth that is solid, but socially and environmentally sustainable has been sought (Brundtland 1987). Sustainable Development Goals (SDGs) that won the endorsement of 189 countries to be executed during the period, 2015-2030 revolve around the three pillars of sustainability, i.e., economy, society, and environment (Abtew, 2017). The Growth and Transformation Plan II, which Ethiopia adopted has integrated SDGs.

The same sector can play a major role of sniff and grab opportunities to make profitable entrepreneurial business and at the same time ameliorate industrial footprints on the environment through closed loop supply chain. In cognizance of industrial environmental impacts and accelerated depletion of environmental resources, companies have become keen to do more in their sustainability activities. One efficient way to elevate sustainability is the consideration of corporate social responsibility (CSR) by designing a closed loop supply chain (CLSC) (Pedram et al, 2017, p1). In addition, given the environmental awareness, innovation, automotive consumer market competition, and the solid economic growth of nations including over 5 percent economic growth (www.worldtirereport.com, 2013) in Africa[1], the economic value of the reverse logistics can be attractive such that focusing only on the car forward logistics may be unjustified for car logistics industry (Mao &Jin, 2014). Through reverse logistics entrepreneurs can create value from returns by collecting and recovering end-of-life items (Guide Jr. and Wassenhove 2002) such as used tires and concurrently benefit the community and the earth (Krikke et al. 2003).

From the perspective of environmental sustainability, the waste tire disposal has become a major concern globally for environment and this can be a major attributer to the increase in automobile usage as well as population especially in areas of large population. (Cheung et al., 2011; Gao N. et al., 2009; Leung DYC., 1998; Mazloom G. et al., 2009; Senneca et al., 1999). The problems caused by the waste tires is mainly because of non-biodegradability of tires which can last for several decades if no proper handling were carried out. The unattended waste tires can cause harm to the public health and the environment, while reverse supply chain through recycling will minimize the consumption of non-renewable raw materials and extend the durability of landfills probably with financial sustainability (Souza 2013).

A number of studies related to tire pyrolysis have been reported in the literature for its conversion into valuable compounds. Developed countries have been paying great attention to the effective utilization of discarded tires to achieve the goals of protecting environment, recycling resources and preserving energy. For many reasons, recycling of waste rubber has received much attention in recent years all over the world, due to the present rate of economic growth in utilization of the fossil energy fuels like, crude oil, natural gas or coal without saving for the future.

Despite the fact that recycling of materials has a history - tracing the times of Plato (BC400) and gathering scrap bronze and metals in Europe in pre-industrial times, the quest thunder for raw materials in the nineteenth and twentieth century's with industrial advancement created less expensive option of reusing scrap material as opposed to mining them out. Until the

[1]Ethiopia economy expected to overtake Kenya for example growing at about 10.8% per annum (Juma, 2016); http://www.theeastafrican.co.ke/business/Ethiopia-to-overtake-Kenya-as-Eastern-Africa-top-economy/2560-3408092-nhqc8nz/index.html

eighteenth century, Europeans used rubber for producing elastic bands and pencil erasers. Joseph Priestley, an author of the cutting edge investigation of chemistry, named the substance "rubber" for its utilization as an eraser (Oven, 2004).

Various studies have been carried out to explore the pyrolysis of waste tires in both laboratory and industrial scales. Williams et al., pyrolysed waste tires in a nitrogen atmosphere utilizing a fixed-bed batch reactor at a temperature extending from 300^0C to 720^oC. This sort of reactor was likewise utilized by Berrueco et al., Cunliffe and Williams and others. Rodriguez et al., Murena et al. and also, Laresgoti et al. for pyrolysing waste tires autoclaves. Kaminsky and Mennerich pyrolysed waste tires in a fluidized bed reactor at a temperature extending from 500^0C to 700^0C. Roy et al. utilized the thermal decomposition of waste tires vacuum pyrolysis. Additionally plasma technology was utilized by Tang and Huang for pyrolysing waste tires. Regardless of the way that pyrolysis is viewed as a noteworthy contrasting option to misuse the helpful chemicals and assets from waste tire, the procedure is still not in high use and this is, to a great extent, because of the high measure of energy required for the procedure. Different endeavors have been made by the specialists to make tire pyrolysis an economically practical process (Cheung et al., 2011; Ferrero et al., 1989, Mazloom. et al., 2009, Senneca et al., 1999).

As indicated by a report in 2010 by ETRMA (European Tire and Rubber Manufacturing Association), a positive pattern is found in the management of ELT (End of Life Tires). The tire recycling rate came to very nearly 96 percent and demonstrates a positive pattern in recycling tires in EU. This accomplishment, likewise, advances Europe as the standout amongst the most progressive districts on the planet in the recycling and recovery of tires. Consumption of fossil fuel assets and stringent natural laws have constrained analysts to create techniques to reasonably oversee assets. Focus has been steadily moving towards energy recovery from waste materials, which can take care of both the issues. One of the significant wastes in the automobile sector is automobile tires. These adversely affect the earth in the event that they are not disposed off appropriately. Promote, tires are a wellspring of high review energy consequently it's uncalled for transfer implies wastage of energy. A few techniques have been produced to concentrate energy from waste tires.

The average vehicle tire lasts for about 50,000 km before it is likely to require replacement (Rice, 2002). Then the tire has to be replaced and disposed off, making used tires and rubber materials one of the very common solid wastes. Globally, 1.0 – 1.5 billion waste tires are regenerated annually (Ware et al, 2013; Makitan, 2010). In addition to the annual continuous flow of waste tires, billions of tires are already stocked in piles.

When tires are disposed off, they would lose only a small percentage of their original features, indicating that used tires are essentially the same in physical and chemical properties to that of new tires. Hence, scrap tires present both environmental challenges and resource opportunities.

The environmental challenges come from the property of the tires themselves. Tires are designed to be abrasive, load carrying and indestructible made to high quality standards. These distinctive properties that ensure safe travel and long service life make scrap tires disposal a difficult task. Rubber, the major component of the tire, is a non-biodegradable material which can last for many years. In addition to being unpleasant, tire piles are also breeding grounds for mosquitoes and rats, and they are susceptible to fire hazards that might transfer to property and forest. Moreover, uncontrolled open-air burning of tires releases potentially hazardous chemicals that affect the ground, surface of water and the air (Secretariat of the Basel Convention, 2002).

Applications of used tires as a resource include direct use, furniture and shoes (in poor communities), asphalt admixture, reclaimed rubber, tire derived fuel (for industrial heating, steam and power generation), and pyrolysis (i.e., recovery of oil, carbon black, gases and steel). Other disposal options such as land filling and stockpiling are also practiced[2].

Research and development on scrap tire pyrolysis technology has been going on in the USA, Japan and Europe for so long. Recently, other countries, mainly China and India are also producing used tire pyrolysis plant equipment for affordable price. As a result, pyrolysis is emerging as a more efficient way to utilize scrap tire resources compared to the other applications. The literature and suppliers of equipment report yields of fuel oil: 40-45 percent, carbon char: 30-35 percent, steel: 10-15 percent and gases: 10-12 percent of the weight of waste tires pyrolysed (Fels and Pegg, 2009; Bhatt and Patel, 2012).

However, scrap tire pyrolysis has not been the leading technology option for the use of scrap tires in the past because of problems related to the products (specifically the carbon char) marketability, quality and prices and used tire acquisition costs (Dodds et.al, 1983 and Klein et.al, 2004). As a result, many projects in various parts of the world have failed. The project viability also varies from country to country.

In Ethiopia, waste tires either as a resource opportunity or as an environmental problem are not studied well. Some of the current applications of scrap tires include: making of rubber-based items, construction applications (e.g., retaining walls), burning as fuel, burning for the

[2] Land filling is banned in the European Union and many other countries.

steel, cutting for the nylon cord, and other uses. Still, a considerable amount of used tires are piled up in the shops of tire repairers and traders, compounds of organizations and individuals.

It is observed that the current practices of utilizing used tires in Ethiopia do not result in higher value-added products and some of them are not environment-friendly. The current applications do not take full advantage of the potential value-added recovery for energy and materials from scrap tires. Introduction of new tire recycling technologies into the environmentally safe countries are needed[3].

Hence, it is intended in this paper to discuss the feasibility of establishing a scrap tire pyrolysis enterprise plant that creates demand for waste tires, adds value and develops markets for the products. An overview of the project idea is shown in Figure 1 below.

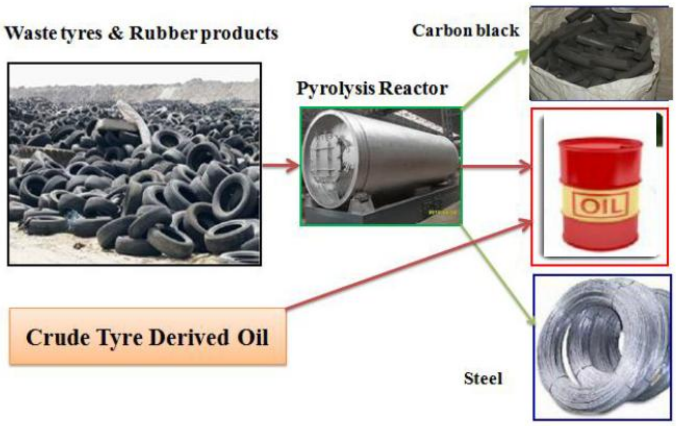

Figure 1: The project idea of converting waste tires into useful products

1.1 Statement of the Problem

1.1.1 Used Tyres Utilization in Ethiopia

In Ethiopia, the demand for new tyres is met through import and local production. Moreover, there are tyres coming with imported vehicles. Due to low quality of imported tyres, bad road conditions, inadequacy of tyre life lengthening practices such as retreading, and other factors, waste generations are relatively higher for the existing number of vehicles.

[3]For example, a master's thesis has been done on the use of scrap tires as a partial replacement for coarse aggregates in concrete at Addis Ababa Institute of Technology, AAU.

The situation of waste tyres either as a resource opportunity or as an environmental problem is not studied well in Ethiopia[4]. There is no specific law or regulation regarding end-of-life tyre management either[5]. Some of the current destinations of scrap tyres include: Making of rubber-based goods, civil engineering applications (retaining walls, etc.), burning as a fuel, burning for the steel and cutting for the nylon thread, and other uses. However, a large amount of used tyres are piled up in the shops of tyre repairers and traders, compounds of organizations and individuals, and so on.

It is easily observed that the current practices of utilizing used tyres in Ethiopia are not effective, do not result in higher value-added products, and are not environment-friendly. The current practices do not take full advantage of the potential economic recovery for energy and other products. Environmentally safe and feasible new tyre recycling technologies are needed.

Hence, given the raw material availability, feasibility of the technology and inherent demand for fuel oil, carbon char materials and steel in Ethiopia, pyrolysis technology offers the opportunity to solve sustainably the end-of-life tyre problems and to recover added-value products. But the challenges attributed to tyre pyrolysis such as scrap tyre costs, product marketability, product quality and price issues are not explored yet, and deserve studying in respect of the local conditions in Ethiopia.

1.1.2 Research Questions

From the preceding discussions, one can postulate that pyrolysis technology will reduce environmental problem due to waste tyres and produce value-added products that create wealth and support economic development. Moreover, the general literature as well as many equipment suppliers in Europe, China, India and other countries claim the commercial viability of producing oil, carbon black and steel from waste tyres.

Hence, the study questions are:

- Will production of oil, carbon char and steel from used tyres be feasible in the current circumstances in Ethiopia?
- What waste tyre collection and product marketing approaches need to be optimized in order to make it more feasible?

[4] *Abrham Kebede Seyfu has worked on his MSc thesis in Civil Engineering at AAU entitled "The Use of Recycled Rubber Tires as a Partial Replacement for Coarse Aggregates in Concrete Construction" in 2010.*

[5] *The Environmental Protection Authority is drafting a law on used tyres to comply with the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal to which Ethiopia is a signatory.*

- What incentives and/or kinds of support can be expected to achieve a sustainable and financially-viable business operation?

These and other related questions will eventually be answered by a systematic study following relevant methodology and format similar to that of a pre-feasibility study.

1.2 Objective of the Study

1.2.1 General Objective

The goal of the research project is to study the business viability of establishing a new plant based on pyrolysis technology that creates demand for waste tyres, adds value and builds sustainable markets for the products in the country.

1.2.2 Specific Objectives

The specific objectives of the study are the following:

i. To determine the quantity of waste tyres generated and available as raw material
ii. To assess the marketability/competitiveness of the proposed products
iii. To select appropriate technology and its sources
iv. To determine the necessary organizational set up, type of machinery and equipment and human resource requirements
v. To conduct financial analyses and evaluation by determining all investment and factor costs.

1. Methodology

The purpose of the study is to show the entrepreneurial business opportunity what reverse logistics can offer by providing preliminary information on used tire pyrolysis project. Thus, the study is conducted on the basis of information and data available in published form. Some primary data are also obtained from market assessment and trusted informants. Experiences and data from other studies are also taken in cases where there are no other sources of information. In general, data on quantities and costs related to investment, production operations and marketing aspects of the project are collected.

Data and information were collected from companies and individuals through relevant communication means.

- 13 companies were visited in-person;
- Web sites and/or databases of 9 companies were accessed;
- 5 suppliers were contacted through email;
- 15 individuals were contacted.

For the analysis, descriptive statistical techniques are used to present data. Arithmetic trend analysis is used to project growth. Static (payback period and rate of return) and dynamic (internal rate of return and net present value) methods of investment profitability analyses are used to assess project feasibility. Cash flow analysis has been performed to determine project liquidity. Key financial and efficiency ratios are calculated to enable comparison with other projects of other investors. Uncertainty analysis is done to identify variables that make the project most sensitive to changes. Assessment on national socio-economic implications (such as national value added) of the project is done. Microsoft Excel program is used for the analysis.

2. Findings and Discussions

2.1. The Market

Tire pyrolysis products can have various applications. The uses proposed in this study and potential customers are listed in Table1 below:

Table 1: Applications of pyrolysis products

Products	Applications	Potential Customers
Tire pyrolysis-oil	Substitute to heavy fuel oil	Firms burning heavy fuel oil
Carbon char pellet	Substitute to coal, coke and firewood as source of heat	Organizations burning solid fuels (coal & commercial biomass fuels)
Steel wire	Recycled as scrap steel	The metal industry
Gases	Fuel (source of heat)	Internally used by the pyrolysis plant

From the data collected, the current annual national consumption of fuel oil (about 168,577 tons), coal (about 282,614 tons), biomass fuel (about 1.7 million tons) and scrap steel (more than a million tons) is found to be big and increasing. Thus, the envisaged products can serve as alternatives to currently used inputs and will have adequate demand.

The market analysis shows that a low cost strategy can be achieved and maintained. Selling prices (before tax) at the gate of the plant in Addis Ababa are proposed as follows: Tire pyrolysis oil: 10.55 Birr/liter, carbon black pellet: 2.50 Birr/kg, and scrap steel: 10.00 Birr/kg which are below the imported or local prices.

2.2. Availability and Collection of Waste Tires

2.2.1. Scrap Tire Availability

The annual scrap tire generation in the country is estimated from data of imported and locally produced tires, and imported vehicles. Hence, the quantity of used tires generated currently is about 40,000 tons. To determine the amount of scrap tires that can be available for pyrolysis project, the following assumptions are considered:

i. About 55-60% of the total tires in the country are bias (nylon/rayon cord reinforced) tires[6]. These types of tires are not considered for pyrolysis in this study. So, steel reinforced radial waste tires available for pyrolysis are estimated to be about 45% of the total quantity.

ii. About 75-80% of the registered vehicles in Ethiopia are found in Addis Ababa[7] (Plate AA, 56% and ET, 15%) and Oromia (OR, 9%) (Demiss, 2012). Hence, 75% the total radial tires are considered for pyrolysis.

iii. Collection of scrap tires is not so easy. At the beginning, the collection rate will be low and expected to be about 45%[8]. This rate will progressively be increased up to 80% after the collection system is implemented well and awareness campaign has had its full effect.

Hence, the amount of projected scrap tire generation available for pyrolysis project comes to about 6,000 tons per year from 2018, and is likely to increase progressively.

2.2.2. Collection Cost

In order to calculate the cost, it is assumed that scrap tires will be delivered to the project by independent suppliers, i.e., by the informal sector. In order to motivate the informal sector to collect and deliver scrap tires, a price needs to be paid, which is competitive compared to the revenues from open burning of tires and selling the steel.

An average cost of 8 Birr per kg of steel from scrap tires is considered to be paid to the primary collectors or owners, and for middle men, 4 Birr per kg of steel is considered towards cost of collection of tires from waste pickers or owners and cost of transportation to collection points, summing up to 12 Birr per kg of scrap steel. This gives an average cost of 2.44 Birr/kg of tire. The cost is higher than the current market price for radial scrap tires. In practice, cost reductions might be possible if individuals or companies from the tire and transportation sector deliver their scrap tires directly to the project at lesser cost.

The cost of transportation of waste tires is high. This is due to the bulkiness of tires, and hence, full loads of scrap tires can’t achieve the maximum weight allowed in any truck load. This means additional trips are required, and therefore increasing the transportation cost. A

[6] It is not possible to identify from Ethiopian Revenue and Customs Authority database, the radial and bias tire types. These estimates are based on the discussion with importers and engineers who have worked in Horizon-Addis Tire S.C.

[7] Hence, the project location is preliminarily assumed to be in Addis Ababa or its surroundings.

[8] From local experience in PET recycling (33%) and also referring estimation in a similar study in Kenya, 60% and Malaysia, 55%.

ton of tire is estimated to cost Birr 400 for transportation within Addis Ababa ascertained from experience in similar operations. Adding the transport cost and outsourced weighbridge fee gives Birr 2.85 per kg of tire, as initial cost of scrap tire at the gate of the plant.

2.3. Description of the Plant

3.3.1 Plant Capacity and Production Program

Though scrap tire is available in and around Addis Ababa to the tune of 20 tons per day (i.e., 6,000 tons/year), a medium size plant with 12 tons per day capacity (i.e., 3,600 tons per year) is proposed, based on Chinese technology, facilitated by the technology absorption capacity, marketing and raw material collection experience, and investment cost. In addition, it is considered that new entrants might share the raw material, and hence, the current potentially available scrap tires will not be for this project only. It is planned that the plant works 24 hours/day, 6 days/week for 300 days/year in three shifts, where the residual days will be scheduled for maintenance stoppages and Sundays.

However, at the initial stage, the plant requires some years to penetrate into scrap tire collection system and products marketing and to develop skills in production. Therefore, production and sales target of 50% of the full capacity is assumed in the first year of operation, 75% in the second, and 100% in the third year of operation and beyond.

3.3.2 Process Description

A simplified process flow chart for the pyrolysis of waste tires is shown in Figure 2.

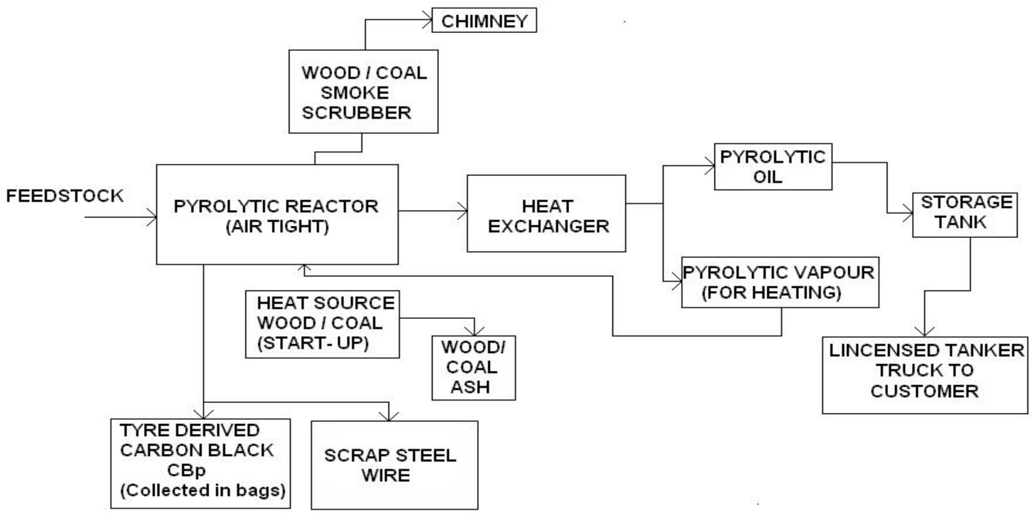

Figure 2: Tire Pyrolysis: Simplified Process Diagram

Scrap tires are delivered by trucks, weighed and stock piled. Then they are fed into the pyrolysis reactor. Initial heat is provided for the reactor by burning wood or coal under controlled conditions of temperature and pressure. The process will convert the tires into oil vapors and gases at operating temperatures of about 450-500^{0}C (CalRecovery, 1995). The vapors and gaseous products exiting the reactor are cooled, whereby the pyrolysis-oil (TPO) is condensed from the gases. Moreover, the gases are condensed and utilized to give energy for the pyrolysis reactions. At last, the oil is then pumped (transferred) to storage tanks.

The solid residue (char) that exits from the pyrolysis reactor contains carbon black, steel and other materials. The steel is separated and baled for delivery to recyclers. Two types of steel wires are obtained: thick wires found along the rim, and thin wires found elsewhere around the tire. The carbon char is then sent to the carbon char pellet unit. The following are the average values of yields assumed for this analysis: Oil: 42%, carbon char: 32%, steel wire: 12% and gas: 14%.

3.3.3 Location and Land Requirement

The ideal location for establishing the envisaged project, in view of the two major factors, i.e., the availability of the raw material and market for the products, is Addis Ababa, or Oromia towns around Addis Ababa. As transport of scrap tires is a significant cost to the plant, it is important that the plant be situated in a site that minimizes the overall distance from collection points/main sources of scrap tires.

The land required for the project as per the communication with the equipment supplier is about 1,500-2,000m^2. Considering double capacity plant expansion, an area of 3,000 m^2 is proposed to be leased with 1,500 m^2 built-up area in the first phase.

3.4 ProfitabilityAnalysis

Birr 12.6 million is the estimated total cost of the project including fixed investment, preproduction expenses and net working capital. Considering the current practices, 70% of the total investment is supposed to be financed by long-term loans from commercial banks with 12.5% interest rate per annum, and the balance by equity. The total time for implementation of the project is estimated to take one year.

Though the final decision depends on the criteria to be established by the investor(s), the project is viable in all measures of profitability analysis as described below:

- The simple rate of return on total investment at full capacity operation is 52%.
- The payback period is 3.6 years including the construction period.
- The net present value for the project over the total investment, calculated at 12.5% discount rate, is positive (i.e., Birr 19,447,413).
- The internal rate of return for the project over the total investment is 43%, which has a 30% spread over the required discount rate.

- Annual cash surplus starts in the second year and continues to grow.

The result of sensitivity analysis shows that the envisaged project is primarily sensitive to oil sales price, and also to scrap tire acquisition cost at secondary level. The project ceases to be feasible if both carbon char pellet and steel wire do not have markets. This is in conformity with the findings in the literature.

3.5Environmental, Economic and Social Benefits

3.5.1 Environmental Impact

With correct design and operation, the plant is environment-friendly with little or no harm on the external environment. Technologies are available to control potential discharges to the environment. Waste water can be treated by the emulsifying unit included in the production equipment. Many of the emissions are negligible or below standards in actual operations (CalRecovery, 1995; Fels and Pegg, 2009).The excess gas is flared to non-polluting gas and water.

Moreover, the project greatly contributes to the environmental protection effort by cleaning waste tires, and reducing the health and fire hazards, avoiding release of chemicals that harm the environment by open burning.

3.5.2 Economic and Social Benefits

The proposed project has several advantages that support socio-economic objectives of the country. Some of the advantages are described below:

- **i. Net value added**. As net value added shows positivity (i.e., Birr 77,636,570), it is a good sign for proceeding further with the project. The project generates at years 3 and 6 social surpluses of Birr 8,707,183 and Birr 9,303,361 respectively over and above wages and, therefore, passes the absolute efficiency test.
- **ii. Employment effect**. The total, direct and indirect employment effect is 11, 4 and 35 jobs respectively per million Birr investment for the first phase of the project. Hence, the project creates total job opportunities for at least 178 citizens out of which 139 are unskilled and 39 are skilled.
- **iii. Distribution effect**. The distribution effect among social groups for the sixth year shows that wage earners, profit earners and the Government are expected to receive respectively 21%, 53% and 25% of the value added generated by the project. A portion of the value added (2%) is expected to remain in the project.
- **iv. Other benefits**. The project brings with it a lot of benefits such as import substitution, contribution to the transfer of technology and development of local skills and capabilities.

3. Conclusions and Recommendations

In this study, an attempt is made to show the sustainable entrepreneurial business opportunity from closed loop supply chain offers by creating value from returns of reverse logistics. To demonstrate this, a preliminary study on the feasibility of establishing a scrap tire pyrolysis plant enterprise has been carried out. Marketing, raw material and supplies, technological and engineering, organization and management aspects, and financial commitments and rewards of the project have been assessed.

The preliminary study showed that the entrepreneurial project is financially feasible, environmentally and socio-economically acceptable and, hence, it is worth further studying and implementing. For investors who are interested to engage in the project, conducting a detailed feasibility study based on specific technology of a selected supplier, specific site by getting the feedback of potential scrap tire suppliers and buyers of the products is recommended.

The following issues need further study and research in view of the local conditions.

- Experimental or laboratory study to ascertain yields and product composition.
- Study on techniques to upgrade product quality of tire oil and carbon char.
- Study on optimum operating conditions to maximize the yield of high value products and reduce operational costs.

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