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SECTOR SPECIFIC GUIDELINES FOR MAINSTREAMING CLIMATE CHANGE IN THE MANUFACTURING INDUSTRY SECTOR IN RWANDA

FINAL REPORT

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ACRONYMS AND ABBREVIATIONS

AR4	Fourth Assessment Report of Intergovernmental Panel on Climate Change
AR5	Fifth Assessment Report of Intergovernmental Panel on Climate Change
BDF	Business Development Fund
CHP	Combined Heat and Power
CIMERWA	Cimenterie du Rwanda
DRI	Direct Reduced Iron
EAC	East African Community
EAF	Electric Arc Furnace
EDPRS	Economic Development and Poverty Reduction Strategy
EMS	Energy Management Systems
REG Ltd	Rwanda Energy Group Limited
EWA	Early Warning Assessment
FONERWA	Fond National pour l'Environnement au Rwanda
GDP	Gross Domestic Product
GHG	Green Houses Gases
GI	Green Industry
GMP	Good Manufacturing Practice
GoR	Government of Rwanda
FAO	Food and Agriculture Organization
IDEC	Industrial Development and Export Council
IPCC	Intergovernmental Panel on Climate Change
ISO	International Organization for Standardization
MINICOM	Ministry of Trade and Industry
MINAGRI	Ministry of Agriculture and Animal Resources

MSDS	Materials Safety Data Sheets
MMD	Multi Model Dataset
NAPA	National Adaptation Action Plan
NIRDA	National Industrial Research and Development Agency
SMEs	Small and Medium Enterprises
PCBs	Polychlorinated Biphenyls
PSF	Private Sector Federation
RBA	Rwanda Broadcasting Agency
RBS	Rwanda Bureau of Standards
RDB	Rwanda Development Board
RECP	Resource Efficiency and Cleaner Production
REMA	Rwanda Environment Management Authority
RRECPC	Rwanda Resource Efficiency and Cleaner Production Center
RURA	Rwanda Utilities Regulatory Authority
SOP	Standard Operating Procedure
TPA	Tons Per Annum
UNEP	United Nations Environmental Program
UNFCCC	United Nations Framework Convention on Climate Change
UNIDO	United Nations Industrial Development Organization
UTEXRWA	Usine de Textile du Rwanda
USAID	United States Agency for International Development
VAT	Value Added Tax
WMO	World Meteorological Organization

EXECUTIVE SUMMARY

The conceptual basis of developing sector specific guidelines for mainstreaming climate change adaptation and mitigation in Rwandan manufacturing industry builds on the earlier initiatives for environmental mainstreaming in different sectors. Rwanda, like many other countries in sub-Saharan Africa is at the cross-roads of transiting from poor to middle income countries and this entails challenges of globalization, in particular competitiveness and climate change.

As such, the Rwanda Environment sub-sector strategic plan (2010-2015) in its second objective, clearly states the need "*to ensure that Rwanda is protected from the effects of climate change by putting in place appropriate mechanisms for mitigation and adaption through mobilization and collaboration with stakeholders*"; and manufacturing sector is one of the key contributors to climate change issues globally.

By vision 2020, the government of Rwanda is committed to promote the industrial growth in such way that after 2010, the industry sector will be able to contribute up to 26% of the GDP and these calls for addressing sustainability by balancing development with environmental protection. The social and economic dimensions are as important as the environmental dimension in sustainable development and also the process of doing this is as important as the results.

Analysis of manufacturing sector shows that food processing industries are predominant with more than 65% of all registered industries, mainly due to skills, labors, technological and capital investment which are reasonably lower in regard to other sub-sectors.
Regarding mapping and location of manufacturing industries, Kigali City Council has the highest proportion mainly due to high development of basic infrastructure in the city compared to other provinces mainly due to market proximity and availability of skilled labor.

Challenges encountered include; inadequate capital, water scarcity and electricity shortage, appropriate technology, limited market demand, shortage in supply of raw materials, lack of basic infrastructure, high taxes, standards requirements, and shortage of qualified labor, among others
Government efforts in addressing the identified challenges are significant and recognizable: for example, development of special economic zones, provincial industrial parks programs, establishment of funds such as Business Development Funds (BDF) and FONERWA, establishment of organs such as NIRDA and RRECPC, reinforcement of TVET at national level are some of initiative to address the above mentioned challenges.

In regard to policy, regulatory and institutional framework, Rwanda has also undertaken a lot of measures to ensure that there is an adequate framework for climate change mitigation and

adaptation starting from Vision 2020, medium term Economic Development and Poverty reduction Strategy EDPRS 2, Industrial Policy and Master Plan, among others. However, the current institutional framework still has gaps which will need to be rectified.

Impacts of climate change to the manufacturing industries include poor supply of raw materials, high costs of energy, flooding and its impacts, land use conflicts, loss of comparative advantage, need for diversification, and disturbance of operational procurement processes among others; while the impacts of industries to climate change include Green House Gases (GHGs) emissions and overuse of natural resources by industries.

Risks related to climate change for the manufacturing industries include limited access to water, financial risks and low profit margins while related opportunities include financial incentives as well as climate change insurance opportunities.

These guidelines and tools to mainstream adaptation and mitigation of climate change in the manufacturing industry have been developed, specifying in general what has to be done, when and where and what has to be addressed. These are general guideline for all manufacturing industries and sector specific guidelines for tea, dairy, cement, cosmetics, plastics, tannery, textile and steel industries. The tools contained in this report highlight parameters to be considered such raw materials to be used, water, energy and chemicals which are cross cutting in the manufacturing industry.

Strategic actions for sustainable manufacturing industry development in relation to climate change mitigations and adaptations include technology innovations, capacity building, standardization, cooperation between all stakeholders, communication and knowledge management, financing and monitoring & evaluation framework.

A green industry concept was developed at the end and constitutes an integral part of this document showing clearly its relevance in terms of economic benefits, job creation and poverty alleviation, approach and methodology to be followed, actions to be taken in order to achieve it and its implementation structure. For this, a Green Industry secretariat hosted by the Rwanda Resource Efficient and Cleaner Production Center (RRECPC) was proposed which has to work closely with all identified stakeholders with the aim of ultimately achieving a green economy.

DEFINITIONS OF KEY TERMINOLOGIES

Climate

Climate in a narrow sense is usually defined as the average weather, or more rigorously, as the statistical description in terms of the mean and variability of relevant quantities over a period of time ranging from months to thousands or millions of years. The classical period for averaging these variables is 30 years, as defined by the World Meteorological Organization. The relevant quantities are most often surface variables such as temperature, precipitation and wind. Climate in a wider sense is the state, including a statistical description, of the climate system (IPPC 2014)

Climate change

Climate change refers to a change in the state of the climate that can be identified (e.g., by using statistical tests) by changes in the mean and/or the variability of its properties and that persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forcings such as modulations of the solar cycles, volcanic eruptions and persistent anthropogenic changes in the composition of the atmosphere or in land use. Note that the Framework Convention on Climate Change (UNFCCC), in its Article 1, defines climate change as: 'a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods'. The UNFCCC thus makes a distinction between climate change attributable to human activities altering the atmospheric composition and climate variability attributable to natural causes (IPPC 2014).

Impacts of Climate change

Impacts generally refer to effects on lives, livelihoods, health, ecosystems, economies, societies, cultures, services and infrastructure due to the interaction of climate changes or hazardous climate events occurring within a specific time period and the vulnerability of an exposed society or system. Impacts are also referred to as consequences and outcomes. The impacts of climate change on geophysical systems, including floods, droughts and sea level rise, are a subset of impacts called physical impacts (IPPC 2014).

Climate system

The climate system is the highly complex system consisting of five major components: the atmosphere, the hydrosphere, the cryosphere, the lithosphere and the biosphere and the interactions between them. The climate system evolves in time under the influence of its own internal dynamics and because of external forcings such as volcanic eruptions, solar variations and anthropogenic forcings such as the changing composition of the atmosphere and land-use change. The climate system is the highly complex system consisting of five major components: the atmosphere, the hydrosphere, the cryosphere, the lithosphere and the biosphere and the interactions between them. The climate system evolves in time under the influence of its own internal dynamics and because of external forcings such as volcanic eruptions, solar variations and anthropogenic forcings such as the changing composition of the atmosphere and land-use change (IPPC 2014).

Climate variability

Climate variability refers to variations in the mean state and other statistics (such as standard deviations, the occurrence of extremes, etc.) of the climate on all temporal and spatial scales beyond that of individual weather events. Variability may be due to natural internal processes within the climate system (internal variability), or to variations in natural or anthropogenic external forcing (external variability) (IPPC, 2014).

Adaptation

The process of adjustment to actual or expected climate and its effects. In human systems, adaptation seeks to moderate or avoid harm or exploit beneficial opportunities. In some natural systems, human intervention may facilitate adjustment to expected climate and its effects (IPPC 2014).

Mitigation (of climate change)

A human intervention to reduce the sources or enhance the sinks of greenhouse gases (GHGs). The 5th Assessment Report [of the IPCC] also assesses human interventions to reduce the sources of other substances which may contribute directly or indirectly to limiting climate change, including, for example, the reduction of particulate matter emissions that can directly alter the radiation balance (e.g., black carbon) or measures that control emissions of carbon monoxide, nitrogen oxides, Volatile Organic Compounds and other pollutants that can alter the concentration of tropospheric ozone which has an indirect effect on the climate (IPPC 2014).

Resilience

The capacity of social, economic and environmental systems to cope with a hazardous event or trend or disturbance, responding or reorganizing in ways that maintain their essential function, identity and structure, while also maintaining the capacity for adaptation, learning and transformation (IPPC 2014).

Vulnerability

The propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements including sensitivity or susceptibility to harm and lack of capacity to cope and adapt (IPPC 2014).

Good Manufacturing Practice (GMP)

Good manufacturing practices (GMP) is a part of quality assurance which ensures that products are consistently produced and controlled to the quality standards appropriate to their intended use and as required by the marketing authorization (Vikash K. Chaudhari et al., 2015)

Standard Operating Procedure (SOP)

A Standard Operating Procedure (SOP) is a set of written instructions that document a routine or repetitive activity followed by an organization. The development and use of SOPs are an integral part of a successful quality system as it provides individuals with the information to perform a job properly, and facilitates consistency in the quality and integrity of a product or end-result (EPA, 2007).

CHAPTER 1: INTRODUCTION

1.1 BACKGROUND

In the recent years, climate change has become a social, economical, environmental and political challenge facing humankind both at local, regional and global level. The Fifth Assessment report (AR5) of the Intergovernmental Panel on Climate Change (IPCC) revealed that Climate change is a long-term challenge, but one that requires urgent action given the pace and the scale by which greenhouse gases are accumulating in the atmosphere and the risks of a more than 2 degree Celsius temperature rise. Today we need to focus on the fundamentals and on the actions otherwise the risks we run will get higher with every year (IPCC 2013).

Globally, manufacturing industries are responsible for some 35 percent of electricity use, 20 percent of CO_2 emissions, and a quarter of primary resource extraction. Manufacturing has a major impact on the environment and must be factored into the climate change discussions. At the same time, the sector's economic importance cannot be ignored: including extraction, construction and manufacturing which currently accounts for 23 percent of worldwide employment. Changing the way industries make things will go a long way towards mitigating manufacturing's negative environmental impacts. In some cases, simply re-designing a product can improve not only the product's life span, but also lead to a more efficient use of resources, easier recycling, and less pollution during the manufacturing process and life of the product. Modern innovations like recycling heat waste and closed-cycle manufacturing can save both resources and money. Remanufacturing and reconditioning, both labor-intensive activities, can create jobs and require relatively little capital investment[1].

In the Vision 2020, the government of Rwanda recognizes the importance of increasing investments in the industrial sector as one of the requirements towards a middle income economy. Since greenhouse gases are emitted from a variety of industrial processes, including gases that do not occur naturally such as chlorofluorocarbons (CFCs), necessary measure should be taken in order to mitigate climate change and, also reduce industries vulnerability to its negative effects (GoR *2013*).

The Government of Rwanda (GoR) has undertaken a number of measures to address climate change, beginning with ratification of the United Nations Framework Convention on Climate Change (UNFCCC) in 1992, developing a National Adaptation Action Plan (NAPA) in 2006 and a National strategy for climate change and low carbon development in 2011 among others.

The Rwanda Cleaner Production Centre was established to promote an integrated strategy applied to the whole of the production cycle to improve environmental performance of industrial firms in Rwanda. The Centre promotes more efficient use of raw materials, energy and water and aims to ensure a life cycle production approach ensuring environmental sustainability.

[1] (*http://www.unep.org/climatechange/mitigation/Manufacturing/tabid/104340/Default.aspx*)

All these efforts and initiatives need to be supported with guidelines which will help decision makers, regulators, and business community attain a sustainable industrial development that has less impacts to climate and vice versa.

1.2 WHY MAINSTREAM CLIMATE CHANGE INTO MANUFACTURING INDUSTRIAL PROCESSES?

Rwanda is heavily reliant on its traditional export sectors of tea and coffee, as well as the more recent growth industry of minerals. Together these consistently constitute around 90 per cent of exports. These sectors face volatile international prices – particularly coffee and minerals exports – and can therefore lead to sharp variations in the export receipts of the country, leading to an unstable balance of payments position. However, there is much room for expansion in existing exports industries, particularly to higher value added activities.

The importance of the manufacturing sector for the future of Rwanda requires a sustainable development strategy. GHGs measured in 2005 indicated that industrial processes contribute up to 151Gg of CO_2 emissions[2] (REMA, 2010) which undoubtedly did increase despite the government efforts to reduce emissions.

At sector level, mainstreaming of climate change responses includes implementation of the Government policies and programmes on climate change, identify capacity needs for addressing climate change issues at factory and sector level. There is a need to break the link between growth and increasing emissions at the expense of sustainability, by developing and innovating technological improvements for the benefit of the environment.

These guidelines will therefore give an overview of the manufacturing industrial sector in Rwanda, analysis of the current institutional and regulatory framework, the current situation relating to adaptation and mitigation of climate change, show opportunities, strengths, challenges and risks in relation to industrial development and climate change then propose strategic actions needed to attain sustainable industrial development.

1.3 SCOPE AND OBJECTIVES

The scope of this work was to do a situational analysis of the manufacturing industry sector and develop guidelines to mainstream climate change into the Rwandan manufacturing industry sector.

The specific objectives of the work are to:

[2] Assessment of operational framework related to climate change in Rwanda, Mutabazi report, 2010.

- Provide a situational analysis of the existing manufacturing industries indicating their GHG emissions and quantities, their solid and liquid waste quantities and its management, use of their resources, their main general challenges and current interventions in the sector.
- Indicate the policy, regulation and institutional framework of the manufacturing industry.
- Identify the impacts of climate change to the manufacturing industries and vice versa as well as risks, opportunities and vulnerability relating to climate change.
- Provide guidelines and tools for climate change mitigation and adaptation mainstreaming in manufacturing industry and
- Develop green industry concept.

1.4 METHODOLOGY AND APPROACH

The following methodology and approach was applied for the development of these guidelines:

1.4.1 REVIEWS OF EXISTING DOCUMENTATION

Reviewing of existing documentation was the initial step for this assignment. This was done with in collaboration with different stakeholders.

1.4.2 FIELD VISITS AND STAKEHOLDER CONSULTATIONS

Twenty five small, medium and large enterprises (selected based on their size, type of industries, GHG emissions) were visited to inspect the current situation (See Annex 4: list of visited industries). These visits provided a broader picture of particular sectors, and meeting with key operators helped to understand their challenges, risks and opportunities associated.

Workshops and meetings were organized whereby the main stakeholders involved in the manufacturing industry and climate change programs were consulted (See Annex 2).

CHAPTER 2: SITUATIONAL ANALYSIS OF MANUFACTURING INDUSTRY IN RWANDA

Generally the industry sector in Rwanda is mainly comprised of manufacturing, mining and quarrying and construction sector. This sector is young (opened in1964) and contributes to GDP for about 14%.

Construction is the largest industrial sub-sector, with 8 per cent of total GDP or 52 per cent of industrial output in 2009, up from 41 per cent in 2002. Manufacturing makes up 43 per cent of industrial output and just 6 per cent of GDP, predominantly in food processing and beverages and tobacco. Other sub-sectors of manufacturing are negligible in total GDP (Industrial Policy, 2011).

In regard to greenhouses gases, Rwanda has contributed to the emission of 530.88 Gg[3] of carbon dioxide (CO_2); 71.31 Gg of methane (CH_4); 10 Gg of nitrous oxide (N_2O); 14 Gg of sulfur oxides (NO_x); 2,327 Gg of carbon monoxide (CO); 42 Gg of Non methane Volatile Organic Compounds (NMVOC) and 18 Gg of sulfur oxides (SO_x) in 2005 which was taken as the base year (REMA, 2010).

Industrial processes alone contributed 29% or 151Gg of carbon dioxide (CO_2) and are expected to be even higher looking at the expected industrial development (*Rwanda Second National Communication to the UNFCCC, 2012*). According to the EDPRS 2, the industrial and services sectors in general are set to become the main thrust for the economic growth and poverty reduction which implies that in future, there is likely to be a significant increment in emissions attributed to the industry sector; if no appropriate measures are taken to mitigate emissions.

2.1 CLASSIFICATION AND TYPES OF MANUFACTURING INDUSTRIES

The International Standard Industrial Classifications (ISIC) provides a set of activity categories that can be utilized for the collection and reporting of statistics according to such activities. Based on ISIC categories, the Rwandan manufacturing industry can be categorized into 12 main subsectors:

- Food products manufacturing
- Beverages manufacturing
- Tobacco products manufacturing
- Textile manufacturing
- Leather and leather products manufacturing
- Wood and wood products manufacturing

[3] 1Gg = 1000 tons

- Furniture manufacturing
- Paper and paper products manufacturing
- Chemicals and chemical products manufacturing
- Pharmaceuticals, medicinal chemical and botanical products manufacturing,
- Rubber and plastics products manufacturing,
- None metallic minerals manufacturing.

The chart below show the current registered proportion of each subsector:

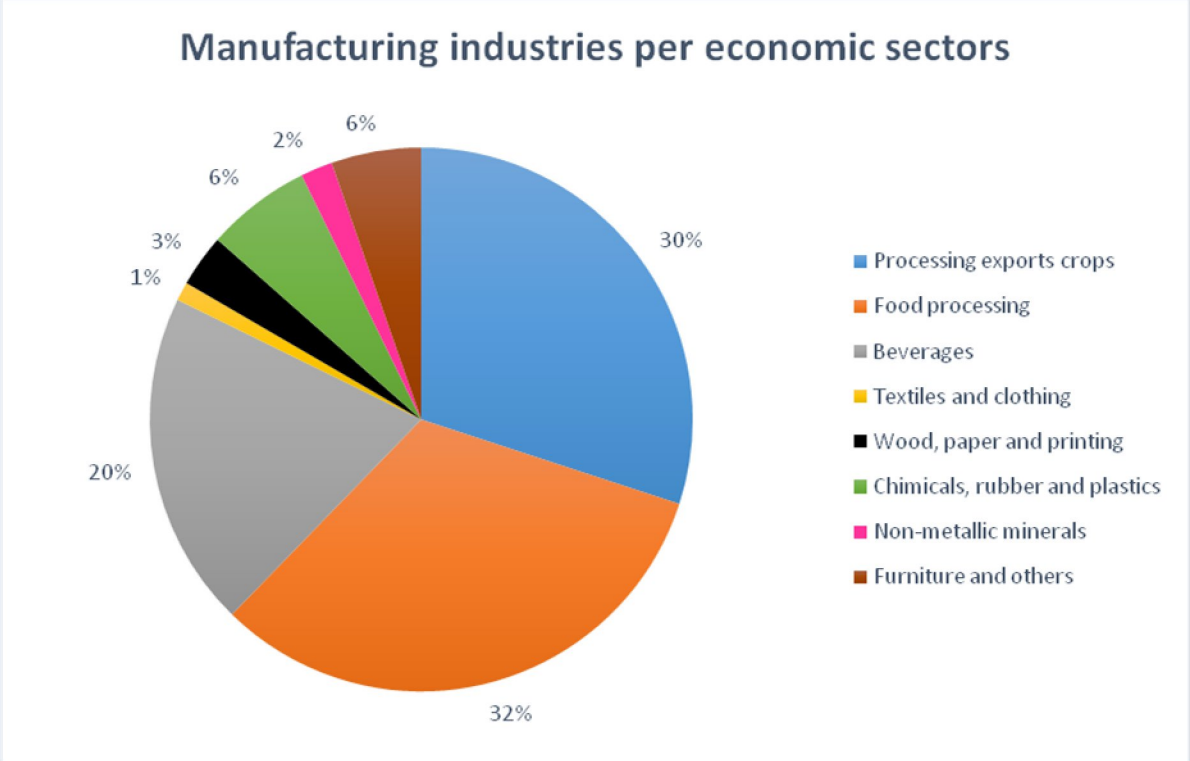

Figure 1: Manufacturing industries in Rwanda Disaggregated by Type (MINICOM, 2014[4])

It was revealed that the food processing sector counts more industries (32%) followed by the sector of processing export crops (30%), largely dominated by coffee washing stations. The narrowest sector is textiles and clothing counting 1% of the total manufacturing companies only.

The food processing industry is mainly dominated by maize processing factories totaling 47% of that category. The remaining figure is spread over amongst rice processing, cassava processing plants, honey, bread and confectionary and milk and diary. Very few industries produce sugar, mixed flours, wheat flours, processed fruits, etc.

[4](MINICOM, 2014: Comprehensive Assessment of the Manufacturing Industrial Capacity Utilization in Rwanda)

2.1.1 FOOD, BEVERAGES AND PROCESSING EXPORT CROPS MANUFACTURING INDUSTRIES

Food processing, beverage and processing export subsectors clearly dominates all others with more than 82% of all regitered manufacturing industries. This is mainly because most of the industries in agro/food processing are mainly in micro, small and medium categories. The skills, technological and capital investments are also reasonably lower as in regard to other sub-sectors. Small entreprises are dominated by banana wine processing, maize millers and coffee washing stations.

2.1.1.1 TEA MANUFACTURING INDUSTRIES

Tea is an important crop for Rwanda, grown in high altitude parts of the country. Rwanda counts 15 tea factories with more in the western province due to its high altitude which is favorable for tea plantations.

The total production of tea in Rwanda has been estimated from 60 tons of black tea in 1958, to 1,900 tons in 1990, to 14,500 tons in 2000, to 17,800 tons in 2001 and 24,700 tons in 2011.Over 90% of the production is exported, but represents only a small share of the total volume traded in the international market, which is about 1.4 million tons.[5]

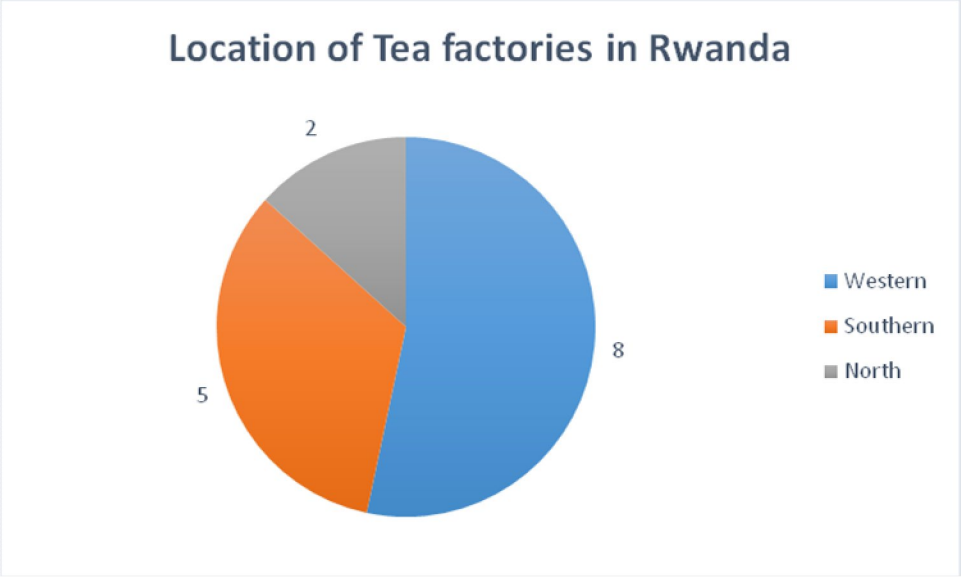

Figure 2: Location of tea factories in Rwanda

[5] http://www.ifad.org/english/operations/pf/rwa/i596rw/web/teac1D_intro1.htm

All tea factories in Rwanda are located in only three provinces. The majority of tea factories are located in the Western Province.

Generally, tea processing is the method in which the leaves from the tea plant (*Camellia sinensis*) are transformed into the dried leaves for brewing tea. The drying process involves heating wich requires a lot of energy most of which, in the context of Rwanda, comes from fuel wood leading to increased CO2 emissions. The CO_2 emitted from industrial tea processing is estimated to 1.8 kg per kg of made tea.[6] In 2012 the total tea production for the Rwandan industries amounted to 22,620 tons (MINICOM, 2013).
(MINICOM, 2013: Production, Export Made Tea and Tea Expansion 2012-2013)

Tea Manufactuiring Case study

Started in 1969, Kitabi Tea Factory has the capacity of producing 2,400 tons of black tea per year with a projected production of 4,800 tons of black tea in 2019. In order to ensure sustainable energy sources, the Factory dedicated 45% of its land to eucalyptus plantations that are available for exploitation. In addition to this, Kitabi has also benefited from RECPC's inititative to resource efficient and cleaner production training and application of best practices such as:

- Installation shed for scraps in the factory. Scraps are reused for scaffolds making for general repairs and maintenance;
- Lagging fully done in all steam lines;
- Installation of boiler economizer to recover lost heat from chimney;
- Improvement of the lighting system with each machine being provided with its own lighting or reducing the height of lamps;
- Factory wide water saving program to reduce wastage; and
- Awareness creation on power saving techniques and the partial covering of the firewood shed requiring an initial investment of 9,020 USD, saving up to 28,657 USD in less than 6 months.

These achievements provide a baseline for these guidelines which indicate that sectors like tea are already putting in place measures to mitigate the impacts of climate change.

2.1.1.2 DAIRY INDUSTRY

The largest contributor to greenhouse gas emissions from milk production is methane emissions resulting from feed metabolism by cows and recruitment heifers (40-45%). The next largest is feed production, which is estimated to represent 35-40% of total emissions and which is dealt with in a separate report. The remaining emissions come from manure, with methane production from slurry being the most important contributor, and direct energy consumption in milk

[6] http://www.psgtech.edu/research/Newsletter/SMI-Newsletter_Issue%2018.pdf

production (Ulf *et al*.2009)[7]. Emissions from milk productions originate from boilers which heat water in several milk production processes such as pasteurization and cleaning of instruments used.

Milk and meat production from the dairy herd (comprising of milking cows, replacement calves and surplus calves and culled animals) plus the processing of dairy products, production of packaging and transport activities are thus estimated to contribute 4.0 percent to total GHG anthropogenic emissions, estimated at 49 gigatons. Milk production, processing and transport alone are estimated to contribute 2.7 percent [±26 percent] to total anthropogenic GHG emissions (FAO 2010)[8].

Rwanda currently produces approximately 445,000,000 liters/year of milk with an estimated farm value of RWF 70 trillion (US$115.3 million). The cattle inventory is 1.33 million and 28 percent are improved dairy cows producing 82 percent of the milk production. The national herd is expected to expand to 1.67 million cattle in 2017 and 1.92 million in 2020. Milk production in 2017 could be an estimated 650,000,000 l/yr. and in 2020, the surplus would increase to 200 million liters. The dairy subsector contributes 15 percent to agricultural gross domestic product (AGDP) and 6 percent to GDP.

The country count now ten big dairies which are operational and at least 61 milk collection centers which are not all operational. Reasons being higher fixed cost structure with small utilization rates due to alternative milk distribution sector which takes up to 75% of all milk marketed.

Inyange Industries case study

Started in 1997, Inyange Industries is the biggest milk processing industry in Rwanda. At the opening, Inyange business consisted of processing and selling pasteurized milk and yogurt. In 2001, the plant introduced mineral water processing and packaging and now has added fruit drinks and nectars: apple, mango, orange, pineapple and passion fruit.[9] The dairy has a capacity of producing 100,000 liters of milk per day but, currently, exploits only 40% of its capacity. Although its installed capacity is far from the local demand, it gives Inyange the opportunity to expand its market to the neighboring countries taking advantage of Rwanda being part of the EAC and its customs union.[10]

[7] *Ulf Sonesson, Christel Cederberg and Maria Berglund 2009: Greenhouse Gas Emissions in Milk Production*

[8] *FAO, 2010: Greenhouse Gas Emissions from the Dairy Sector - A Life Cycle Assessment*

[9] http://inyangeindustries.com/products.php

[10] http://www.rwandaeye.com/featured/538/rwanda-inyange-industries-rwandas-leading-milk-plant/

2.1.2 CEMENT INDUSTRY

Cement subsector is another sector that requires adoption of climate change mitigation and adaptation measures because producing a ton of cement requires 4.7 million BTU of energy generally, equivalent to about 400 pounds of coal, and generates nearly a ton of CO_2.[11] There are three cement companies in Rwanda; those are CIMERWA (Bugarama, Western Province), Kigali Cement Company (Kigali) and Great Lake Company (Musanze, Northern Province). These factories are not yet able to meet the current cement demand which is about 350,000 tons per annum (TPA); CIMERWA current capacity being 100,000 TPA whereas Kigali Cement Company and Great Lake Company produce 5,500 TPA (Factory data). Consequently, the growing construction sector relies on cement importations from neighboring countries, especially from Uganda.

Table 1: Cement factories in Rwanda and their production capacity (as at end 2013)

Name of the factory	**Installed capacity (MT/year)**	**Capacity utilization (%)**
CIMERWA	100,000	85
Great Lakes Cement	70,000	15
Kigali Cement	30,000	66

(Source: MINICOM, 2014: Domestic Market Recapturing Strategy)

CIMERWA case study

CIMERWA is the only integrated cement plant in the country while others are only grading plants. CIMERWA started its activities in 1984 with a capacity of 50,000 TPA and increased its production to 100,000 TPA in 2001. The factory is currently being expanded to a capacity of 600,000 TPA. The factory is changing its technology from wet process to dry process technology. The wet process technology requires a lot of energy in the boilers for heating and produce high dust emissions to the environment. With the dry process technology, the factory becomes more efficient through reduced heating energy demand and reduced dust emissions. The new plant is estimated to have maximum dust emissions of 50mg/Nm^3[12]which in compliance the minimum global requirements for stack emissions in cement plants.

[11] http://blogs.ei.columbia.edu/2012/05/09/emissions-from-the-cement-industry/

[12] Milligrammes per Normal Cubic Meters

2.1.3 STEEL INDUSTRY

Regardless which process/technology used for steel processing on average, 1.8 tons of CO_2 are emitted for every ton of steel produced. According to the International Energy Agency, in 2010 the iron and steel industry accounted for approximately 6.7% of total world CO2 emissions. [13]

The booming of the construction sector means also increase of demand of construction materials, steel products inclusive. Steel products represent 4 of the 11 largest buildingmaterial imports into Rwanda (TradeMap data, 2011) and represent 74 million USD/year in imports, surpassing cement, Rwanda's biggest imported material, at 50 million USD/year (RDB, 2012).The table below shows the NISR data on domestic production of metal 2009-2013, in tons:

Table 2: Domestic production of metal 2009-2013 in tons

2009	2010	2011	2012	2013
13,447	12,937	14,386	15,564	30,062

(Source: MINICOM, 2014: Domestic Market Recapturing Strategy)

Steelrwa Industries case study

Started in 2011, SteelRwa one of the biggest steel manufacturing in Rwanda. SteelRwa produces up to 18 tons of steel (bars and hollow sections and profiles) per month. The raw materials consist of commercial scrubs which are heated at a very high temperature (1,800-3,000^{o}C) to melt down the scrubs in the process of steel production. The used scrubs come from Rwanda but also from neighboring countries as Burundi and RDC. With the current urban housing growth in Kigali, projections show that 13,000 tons of steel bars and 1.7 million m^2 of roofing sheets will be needed in 2022, implying increased emissions.

The adoption of an emission control system by SteelRwa has enabled the factory to become more efficient as observed from a recent environment audit that shows that it is releasing less than 150 ppm which is compliance with steel manufacturing industry best practice.

2.1.4 TEXTILE INDUSTRY

The textile industry is one of the biggest GHG emitters on Earth, owing to its huge size and scope. Many processes and products that go into the making of fibers, textiles and apparel products consume significant quantities of fossil fuel. Apparel and textiles account for approximately 10 percent of the total carbon impact. The estimated consumption for an annual

[13] http://www.worldsteel.org/publications/position-papers/Steel-s-contribution-to-a-low-carbon-future.html

global production of 60 billion kilograms of fabrics boggles the mind: 1 trillion kilowatt hours of electricity and up to 9 trillion liters of water. [14]

The Rwandan textile manufacturing industry is particularly small with only one major manufacturer, UTEXRWA and small cooperatives which produce handmade clothes. Currently, almost all fabrics are imported – cotton from EAC member Countries and artificial fabrics, primarily polyester, from South Africa, Taiwan, Korea and Indonesia. The local textile articles demand is higher than national production, thus the Country imports almost all textiles products.

In the past Rwanda has tried to reduce this competitive disadvantage by producing cotton domestically, but the soil and climate are not appropriate for the production of competing quality cotton. However, neighboring countries like Burundi could be good suppliers of quality cotton to Rwandan textiles manufacturers.[15]

There are also a National Sericulture Centre with four Provincial Sericulture Centres (PSC) and 40 pilot sericulture cooperatives distributed countrywide. Both the centres and cooperatives receive logistical and technical support for sericulture operations. The decision to produce silk come after several trials of producing cotton domestically, but the soil and climate are not appropriate for the production of competing quality cotton.

UTEXRWA Industries case study

UTEXRWA is a composite textile mill consisting of spinning, weaving and other section of cotton and synthetic fibers. It started in 1984, and has been the first textile manufacturing company in Rwanda. It produces about 12,000 meters/year, and has a turnover of USD $ 2-3M.

The plant is working at 40% capacity due to slow market, cheaper Chinese products and second hand clothes. In addition, the country is also producing knitted clothes by artisans' cooperatives and their products include: knitted clothes, hand knitted hood, hand woven cardigan, tailored clothes, kids clothes and shoes, hand bags and accessories made from cloth, batik fabric, decorated fabric, screen printed fabrics etc., but the production from the sector is still very small compared to the existing demand.

UTEXRWA has improved its emissions release to the environment as it has now emissions control system to its boiler (the only emission point in the process), and its wastewater treatment plant is functional, reducing up 70% of organic loads.

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[14] http://www.textileworld.com/Issues/2010/July-August/Dyeing_Printing_and_Finishing/Climate_Change-Carbon_Mitigation_And_Textiles

[15] http://www.rdb.rw/fileadmin/user_upload/Documents/Manufacturing/Textiles__profile.pdf

2.1.5 COSMETIC INDUSTRY

The Rwandan cosmetic industry is not well developed: the country has only twelve manufacturing industries ranging from production of cosmetics products, essential oil, soap and detergents; the remaining being retailers of imported cosmetics products.

Apart from essential oil manufacturing that requires raw materials from agriculture such as geranium plants; other cosmetics products are manufactured through a process of mixing pre-processed oil and chemicals in order to produce the final products.

Case study 1: Ikirezi Natural Products

For essential oil, heat production is necessary to extract oil from plants; in most cases wood and diesel are used as fuel in boilers and this generate CO_2 emissions. On the other hand, the Ikirezi Natural Product, a factory located in Kirehe District produce essential oil through steam distillation and extraction of geranium. The factory uses a combination of diesel and wood for heating purposes. Ikirezi has an industry standard smoke control system that limits/reduces the amount of CO_2 released to the environment. Ikirezi currently produce 250 to 400 tons of geraniums per year with projections of producing 1,000 tons of geraniums in 2020. The production of one ton of geranium requires one stele of wood and approximately 100 liters of diesel. Although the factory has a smoke control system, the Factory is not really measuring the amount of CO2 released to the environment.

Case study 2: Sulfo Rwanda Industries

Started in 1964, Sulfo Rwanda Industry is the biggest cosmetic manufacturing industry in Rwanda with many brands of cosmetics, and detergents as well as mineral water. The factory has more than 700 employees and produces up to 100 tons of cosmetics per year all brands combined. Sulfo products are also being sold in Eastern African region. In the Factory's cosmetics unit the machines are in a good condition, and the process is relatively clean with no emissions to the environment. However, the cleaning process of machineries uses heat from diesel burning. The boiler has a smoke control system which filtrate emissions before they are released to the environment. Sulfo is committed to Total Quality Management with production units fully equipped with state of art plant and machinery. Additionally, Sulfo has a separate Research and Development wing that ensures products quality and innovations.

In regard to their soap factory, Sulfo applies best practices learned from the RECP training and changed some of the equipments: the old blow molding machines and injection molding machines were replaced by new energy saving ones, normal taps were replaced by push type taps. Sulfo adopted the use of harvested rain water for car washing, garden/toilets, and

installation of water meters in each and every consumption points, monitoring and making water balance calculation.

The investment made (costing around 85,000 USD) resulted in annual savings of about 32,000 USD but, more importantly, enabled Sulfo to retain up to 110.32 tons of CO_2 emissions.

2.1.6 PLASTIC INDUSTRY

The Rwandan plastic industry is less developed compared to other manufacturing industries and up to thirteen registered plastics industries were counted. They produce a various items ranging from water tanks, plastics chairs, plastics crates, plastics PVC pipes, plastics buckets and basins, plastics jerrycans, plastics kitchen products, plastics shoes and plastic bottles for cosmetics.The table below shows NISR data on domestic production of plastic products 2009-2013, in tons:

Table 3: Domestic production of plastic products in tons

2009	2010	2011	2012	2013
1,267	1,362	1,112	1,031	1,217

(Source: MINICOM, 2014: Domestic Market Recapturing Strategy)

Ameki Color case study

Ameki Color started in 1982 with workshop furniture manufacturing both wood and metallic. Currently, Ameki also produces paints, water tanks and paint plastic containers. Water tanks from Ameki are manufactured from polyester materials, while paint plastic containers are manufactured from plastics materials. The factory has a capacity to produce up to 1,000 tanks per year and 150 containers per day. Currently, Ameki doesn't measure its CO_2 emissions however its factory equipments are in good condition.

Generally, plastic manufacturing industries are classified among the biggest polluters from their emissions and their impacts to environment. CO_2 emissions from plastics have been estimated to 1.9kg of CO_2 per Kg of plastics manufactured (Brandt, Pilzet *et al.*2010).

(*Harald Pilz, Bernd Brandt, Roland Fehringer 2010: the impact of plastics on life cycle energy consumption and greenhouse gas emissions in Europe*).

2.2. MANUFACTURING INDUSTRIES MAPPING

It is important to understand the different aspects that determine the performance of the industrial sector. Based on the list of industries obtained from MINICOM, most of manufacturing industries are concentrated in the City of Kigali which account 28% of all registered industries: due to being the capital city, high development of basic infrastructure in the city compared to

other provinces, market proximity and availability of skilled labors are factors that determine the location of industries in the City of Kigali.

According to the Rwandan industrial master plan, infrastructure is the foremost constraint consistently cited by Rwandan firms as an impediment to their growth. Energy costs are higher than in many other countries, while power outages cause many firms to rely on expensive electricity from their own generators.

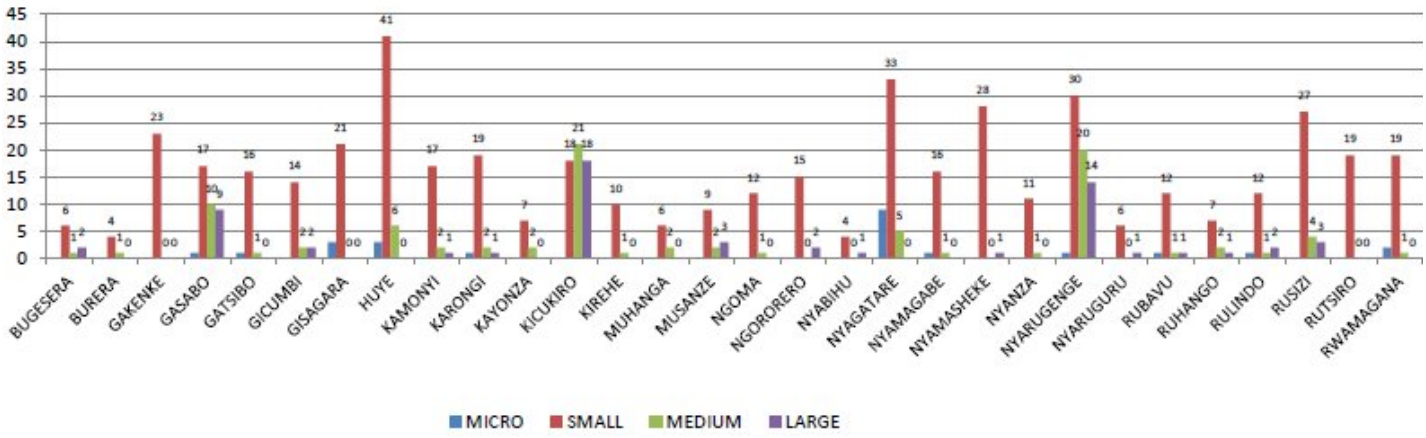


Figure3: Distribution of manufacturing industries per District (MINICOM, 2014[16])

As it was observed earlier, the districts composing the city of Kigali accommodate many industries. Huye district presents the highest number of small industries, followed by the district of Nyagatare, Nyarugenge and Rusizi. As opposed to the other two urban districts, Nyarugenge also accommodate a sizeable number of small industries as it is historically a core business center of the country. However, there are some districts such as Burera, Nyabihu, Nyaruguru, Kayonza, and Ruhango which are least industrialized (MINICOM, 2014).

Furthermore, Rwanda is reliant on petroleum imports, a product that is likely to see increasingly volatile price fluctuations in the medium to long-term. In transport, national roads are consistently being upgraded, but district roads still suffer, while maintenance is underprovided leading to significant inefficiencies. Despite abundant natural water sources, the provision of water supply to consumers and businesses is often unreliable and many water resources are contaminated by pollutants. Given that the City of Kigali has a small surface area with a high water table, then it is vulnerable to pollutants from these industries as well as air emissions.

The industries for processing export crops are mostly found in the Western and Northern Provinces due to the local area's climate which is favorable to such crops (tea and coffee

[16](MINICOM 2014: Comprehensive Assessment of The Manufacturing Industrial Capacity Utilization in Rwanda)

plantations need average temperature inferior to 15^{o}C). But in general food processing dominates in each province as earlier indicated.

2.3 ANALYSIS OF THE MANUFACTURING INDUSTRIES

2.3.1 GENERAL CHALLENGES

An analysis of challenges in the Rwandan manufacturing sector gives the following results[17]:

- Lack of enough capital/ working capital dues to limited access to financing: This may hinder industry growth and in some cases industries find it difficult, especially where the industries lack sufficient collaterals, to access loans, or in situations where business plans are poorly designed. In relation to mainstreaming climate change, the lack of capital may negatively affect the adoption of sustainable production methods that would make factories vulnerable to climate change risks;
- Lack of enough electricity and power cuts: this may lead to extra investment in generators or seasonally running out of production. Inconsistent power supply constitutes a serious challenge, especially to start-ups that have to bear high expenses and makes it difficult to break even or incur losses. Consequently, the higher costs of energy makes Rwandan factories uncompetitive;
- Inadequate technology. The technologies used in some industries are outdated which leads to high resource wastage and high production costs. For instance, the dust emissions from the local cement factories. Some industries find it difficult to upgrade their technology either because they require costly investments or, due to lack of awareness on the benefits of investing in cleaner production technologies;
- Insufficient demand/limited market: market is still small to justify big investments; Industries may fail to grow in the market either because of poor feasibility studies especially in regards to market surveys or just because their products have lost comparative advantage and can no longer compete in the market. Opportunities of regional integration and product diversification are some of the measures that the Government of Rwanda is promoting in the industrial masterplan after realizing the need to limit dependence on climate sensitive sectors of production;
- Shortage of raw materials: raw materials are mainly imported and at high prices which is also affecting the local industries. Most Rwandan Industries rely on foreign imported raw materials and in some cases international market forces may push-up prices of these imported raw materials and thus impact on the production costs of the local industries and their long term profitability;

[17]Comprehensive assessment manufacturing industrial capacity utilization report, MINICOM,2014

- Poor road infrastructure: which is affecting distribution and cost becomes also high. Poor infrastructure and location of some industries limits market accessibility and may cause high cost of transportation and market distribution.
- Water supply issue: Water shortages are also affecting the sector, especially food processing industries. Water is a critical input in most production processes and lack of adequate water supply chain seriously affects both quality and quantities of production in industries.
- Standards requirements: where standards are not met industries are obliged to upgrade or close. For instance, many local small scale industries dealing in beer brewing and agro-processing are routinely subjected to rigorous inspections by the Rwanda Standards Board (RSB).
- Shortage of qualified/skilled labor. The gaps in local skills are a big a handicap to the national industrial development. Foreign-hired personnel are very costly for the local Industries and have big impact on both sustainability and cost of production.

2.3.2 CURRENT INTERVENTIONS

Several interventions are being done in the country to facilitate and rather overcome the above challenges. The Government of Rwanda and specifically MINICOM as the line ministry in charge of industrial development have been endeavoring to address the challenges encountered.

The National Industrial Policy and its master plan were developed to guide industrial development of the country. Their implementations started with initiatives such as the development of the Special Economic Zones (SEZ) in Kigali, as one of the strategies to address issues of basic infrastructure needs, Provincial Industrial Parks (PIP) program for rural industrialization is underway with studies all over the country. The creation and promotion of viable and dynamic small and medium enterprises (SMEs) through Business Development Funds (BDF) is showing success and finally, market access for sustainable Business development through adhesion to communities such as EAC is also a recognizable initiative to industrial promotion.

Among the governmental flagship initiatives include the Environment and Climate Change Fund (FONERWA), the public institution established by law Nº16/2012 of 22/05/2012, which is a cross-sectoral financing mechanism, intended to support environment and climate change initiatives that further Rwanda's objectives for green and resilient growth.

On electricity and water supply, REG and RDB are facilitating investors in the energy sector with the aim of increasing power generation: by 2017 the country should have at least 70% power access; and several initiatives in water supply are undergoing such as Mutobo among

other. As for the newly launched Nyabarongo Hydropower Station, the 28 MW station is now functional.

In regard to specialized technologies, the government has now established the Industrial Research and Development Agency (NIRDA) with the mandate to carryout research on appropriate technologies for value addition to local raw materials. The agency will establish a strong foundation for agro-processing and facilitate rapid technology transfer from other countries.

Most importantly, Rwanda Resource Efficient and Cleaner Production Center (RRECPC) is a UNIDO – MINICOM program hosted by PSF which promotes the use of resources efficiently and promotion of cleaner production practices in all industrial sectors. Currently the center has trained more than 500 people and 100 industries.

Most Rwandan manufacturing industries depend on the agricultural sector for inputs and the sector benefits from initiatives such as irrigation programs at national level to overcome the burden of relying only on rainfall. Rice and maize intensifications programs among others are intended to ensure that agro processing raw materials are available.

Infrastructure development is also being addressed where several roads are being developed either by the Government of Rwanda and other programs like Rwanda Rural feeder Road Program being initiated by USAID with the aim to enhance market access, reduce transport costs for farm inputs and products, and increase the country's competitiveness in the regional trade of staple crops.

The Rwanda Environment Management Authority (REMA) has the mandate to raise awareness on climate change and facilitate mitigation and adaptation knowledge transfer and has championed a number of climate change initiatives in the country.

On taxes issues, theefforts to provide incentives for specific investments and harmonization with EAC is ongoing.

Lastly but not least, shortages of qualified labor is an important issues which is being addressed gradually. Besides the traditional educational system, which is intended to produce qualified labor, the government has also initiated TVET programs which aim at training in specific needs in a relatively short period of time.

2.3.3. POLICY, LEGAL AND INSTITUTIONAL FRAMEWORK

This section discusses how the existing national policies, laws, regulations and institutional framework support the mainstreaming of climate change.

2.3.4. POLICIES, STRATEGIES AND PLANS

Rwanda being a fast growing country needs its industrial sector to grow in order to achieve short and long term goals. For that several policies, strategies and plans were developed to support the industrial growth. However, to achieve a sustainable industrial development, it requires integrating climate change concerns into the industrial policies, strategies and plans. The table … below shows the analysis of the existing policies, strategies and plans for manufacturing industry sector with regard to the mainstreaming climate change:

Table 4: Review of policies, strategies and plans for manufacturing industries.

Policy, Strategies and Programmes	**Opportunities for mainstreaming climate change**	**Limitations**
Vision 2020 • Promotion of agro-based manufacturing • Industrial growth from 20% to 26% Private sector led economy • Protection of environment and sustainable natural resource management	• This can be a basis for promoting climate compatible agro-based industries in particular and other industries in general • The emphasis of a private sector led economy can be an opportunity for climate financing/investment	• The vision 2020 does not show the consideration of climate change in industrial growth • The focus on natural resources and environment is the implementation of land and water management techniques which are directly linked to improved land productivity, while with industries the focus should be on energy efficiency and related indicators including reduced GHG emissions and other pollutants

EDPRS 2 (2013 – 2018)		
• Pursue green Economy by promoting green urbanization and innovation in industrial and private sectors under	• The proposed Environment and Climate change innovation center should be able to support industries in adaptation and mitigation as its scope will include the following; o support to research and development through links to industry and academia in Rwanda and internationally; o promoting technology transfer in priority sectors through business advice and training; o linking innovation with finance through identifying international funding sources, supporting proposal development and providing seed funding (FONERWA will play an instrumental role in this	• While it is proposed that environment and climate change should be handled as a cross cutting issues with emphasis on o mainstreaming environmental sustainability into productive and social sectors; o reducing vulnerability to climate change and o preventing and controlling pollution; The Key sectors expected to deliver on these include agriculture, energy, environment and natural resources, infrastructure, health, private sector and financial sector. The manufacturing industry is not mentioned. There is no mention of a national database that can capture indicators of climate change adaptation and mitigation that would then feed into climate finance; this is key issue for industries and also strengthens the EDPRS 2 monitoring framework in form of costs saved.

	area); o Providing analyses and information on market and sector trends. This will build on and link to existing institutions – specifically the National Industrial Research and Development Centre, the Cleaner Production Centre, and the Centre of Excellence	
The National Environment Policy • The policy provides a framework for the reconciliation of the three pillars of sustainable development, namely environment, social and economic issues. • The policy provides for the creation of industrial zones separate from residential areas to avoid negative impacts on human health • Relocation of industries located in valleys or marshes	• Within the policy it is proposed that particular attention should be paid to the integration of the environmental dimension in all educational, sensitization and development policies and programmes and at all levels of decision making. • The application of laws and regulations, the adoption and dissemination of environment friendly technologies will constitute a high	• One key aspect for facilitating adaptation and mitigation is dissemination of information on best practices to the masses, the responsibility of this activity lies with RBA which has limitations. In order to assess the effectiveness of adaption and mitigation options, there is need for research, to date, there is no national programme engaged in research on aspects of the environment.

	priority for the central and local authorities. • In relation to industries the policy embraces the agro industry; textiles; wood; chemical industries; construction industries; mining; metallurgical industries; engineering; printing and paper industries. It further notes that with concern that most of these industries are located in the City of Kigali and are classified as the "most dangerous, insalubrious and inconvenient institutions" due to their negative effects on human health and environment. The establishment of industrial parks adds value to addressing this concern.	
National Industrial Policy (2011) The policy was developed with the aims of structural transformation, with industry accounting for 20% of GDP by 2020; the national investment rate reaching 30 per cent of GDP; and non-farm employment reaching 1.4 million. Specific objectives being: • Increase domestic production for local	• Provision of guidance on industrial relocation, resource efficiency & cleaner production and effluent treatment	No emphasis laid in climate change adaptation and mitigation yet these industries are the most vulnerable to climate change related risk.

consumption • Improve Rwanda's export competitiveness • Create an enabling environment for Rwanda's industrialization • Ensure the environmental sustainability of industry through treatment at source and industrial location.		
Green Growth and Climate Resilience: National Strategy for Climate Change and Low Carbon Development (2011) Scale-up resource efficiency to reduce energy and water demand, thus reducing emissions and promotion resilience; • Employ efficient and zero waste technologies , practices and design in special Economic Zones and provincial industrial parks; • Establish Climate Innovation Centre to support investment in industries production green technologies and those adopting green technology; and • Build carbon trading capacity within the private sector to harness innovative funding	• Establishment of green industries and greening of existing industries	• This strategy did not recommend the measures to strengthen capacity for establishing GHG accounting, reporting and auditing at industrial level

opportunities provided by CDM and voluntary carbon markets		
National Energy Policy 2015 • The policy vision is to ensure that all residents and industries can access energy products and services that are sufficient, reliable, affordable and sustainable: o ensuring the availability of reliable and affordable energy supplies for all Rwandans; o Ensuring the sustainability of energy exploration, extraction,supply and consumption so as to prevent damage to the environment and habits; o Promote safe, efficient, and competitive production ,procurement, transportation and distribution of energy o o encouraging the rational and efficient use of energy; o Establishing environmentally	• Clean energy production and use for/by industries; • Energy efficient technologies and options will be enhanced	

sound and sustainable systems of energy production, procurement, transportation, distribution and end-use.		
Small and Medium Enterprises (SMEs) Development Policy (2010) • The policy aims to address macro-level structural challenges which have characterized government interventions thus far while also taking into account the development goals of the Rwandan government, specifically to increase value-added processing, to reduce the trade deficit and rise out of poverty and address challenges articulated by SMEs on the ground.	• Through promotion of innovation and technological capacity, SMEs can be supported to assess their resource use and hence increase their productivity especially through the 12 centres of excellence	No emphasis laid in climate change adaptation and mitigation yet these industries are the most vulnerable to climate change related risk

2.3.5. LAWS AND REGULATIONS

The legal framework provides benchmarks against which compliance to set resource utilization standards are assessed. The review of laws and regulations focuses on opportunities that will support the compliance of manufacturing industries to set standards.

Table 5: Review of Laws and Regulations related to manufacturing industry

Laws and Regulations	**Opportunities for mainstreaming climate change and mitigation in the manufacturing sector**
Constitution of the Republic of Rwanda • Citizens are entitled to a healthy and satisfying environment. • To protect, safeguard and promote the environment. • To determine the modalities for protecting, safeguarding and promoting the environment. • To provide for land use planning in an environmentally sensitive manner.	• Mainstreaming of climate change adaptation and mitigation measures promotes the voluntary reduction in emissions and GHGs that would be in line with the requirements in the Constitution of Republic of Rwanda
The Organic Law No. 04/2005 of April 08, 2005 determining the modalities of protection, conservation and promotion of environment in Rwanda • **Article 67:** Every project shall be subjected to environmental impact assessment, before obtaining authorisation for its implementation. This applies to programmes and policies that may affect the environment. • **Article 72:** The National Fund for Environment may grant support to public services, associations and individuals in case they invest or put in place	• Manufacturing industries can within their environment and social impact statements include information on energy demand as a baseline and use such data to monitor performance, this would also inform climate change risk assessment at factory level thus informing decision making • The law also gives provisions for incentives for those companies that control emissions and pollution through adoption of clean technologies; manufacturing industries can benefit from such climate finance • More awareness is needed regarding these incentives

campaigns or carry out activities intended to fight against causes of pollution or support existing installations so as to match with the environmental quality standards, in accordance with instructions of competent authorities. **Article 73:** Industries that import equipment which assist in eliminating or reduce gases like carbondioxide and chlorofluorocarbons which intoxicate the atmosphere and those which manufacture equipment that reduce the pollution of the environment, are subject to reduction of customs duty on the equipment and for a period to be determined depending on the needs, and it shall be governed by the law concerning taxes and revenues.	
Ministerial order N° 005/2008 of 15/08/2008 Establishing modalities of inspecting companies or activities that pollute the environment In addition to searching and inspecting premises of suspected polluters, the order provides for: • **Article 6: Routine Inspection procedure:** During routine inspection there needs to be a standard checklist of what needs to be verified and it should be signed by both the competent officer and the	• Manufacturing industries though mainstreaming climate change and mitigation measures are able to respond more positively to inspections because they would already have a system of corrective action embedded within their management systems.

owner of the company or activity after the inspection. After the inspection, a report shall be sent to the owner of the company or the activity indicating the details and evidence of the activities or products that are harmful to the environment and the effects of that pollution • **Article 7: Alternative measures:** After the inspection, the owner of the company or the person responsible for the activity who has accepted the report made by the competent officers shall indicate alternative means that he / she will be using in order to protect the environment	

2.3.6. INSTITUTIONAL FRAMEWORK

The institutions involved in activities related to manufacturing industry are highlighted below:

Table 6: Review of the current institutional framework for manufacturing industries

Institution	Role/responsibilities	Opportunity for mainstreaming climate change
MINICOM	• Policy formulation and development of strategies and laws related to promotion and operation of the industries; • Coordination of programme and project implementation and monitoring;	• Through its mandate the ministry can mainstream climate change adaptation and mitigation into policies, strategies and plans; • Through technical support to the industries and creation of industrial parks there is an opportunity to adopt

		cleaner technologies while sharing associated costs
REMA	The authority in charge of environmental protection and pollution control. Relevant to this subject matter is the Climate change and International Obligations directorate which is proposed to address the issues of climate change and coordination of the implementation of regional and international agreements. As specific role to the manufacturing industries, REMA develops guidelines for EIA and EA as well as guidelines for mainstreaming climate change into the industries	Through its mandate REMA can facilitate the development and implementation of green technologies in manufacturing industries
Rwanda Standards Board	Is mandated to provide standards based solutions for Consumer Protection and Trade promotion for socio-economic growth in a safe and stable environment. With regard to the manufacturing industries, RSB develops standards, conduct audits and issues certifications (product and system certifications) .	In relation to climate change mainstreaming the organisation, there is opportunity to promote the carbon management within industries by providing international standards for GHG emission accounting , reporting and management such as ISO standards and GHG Protocol
Private Sector Federation (PSF) •	The Private Sector Federation - Rwanda (PSF) is a professional organization,	• Within this framework, manufacturing industries can benefit from information

	dedicated to promote and represent the interests of the Rwandan business community. The objectives of PSF include the following: • To represent the interests of the private sector • Dialogue with Government on matters related to the improvement of business through the economic partnership forum • Business promotion and development. • Promote Entrepreneurship and Business Growth • Build Private Sector Capacity • Effective private sector advocacy • Support active involvement in Regional and International Trade	dissemination, and capacity building programmes on international best practices on climate change. • Opportunity for setting up a working group aimed at mainstreaming climate change issues in the PSF strategic plan.
Rwanda Cleaner Production Center (RCPC)	The mandate of Rwanda Cleaner Production Center is to promote resource efficient and cleaner production practices for production efficiency, environmental performance and sustainable development of Rwandan enterprises	• Greening and creation of green industries • Mainstreaming of climate change concepts in Industries • Demonstration of best available practices for environment protection .
NIRDA	The mandates of NIRDA include : • To carry out industrial and technology	• Carryout research on green technologies to be implemented by manufacturing industries to adapt and

	development research through the establishment of technology incubation centres and pilot plants and rural industrialization • To build the capacity of small and medium enterprises by providing prototype development, reverse engineering, manufacturing facilities and business incubation • To establish and develop industrial research and development partnership with international, regional and national institutions, whether private and public	mitigate climate change • Facilitate in the mainstreaming of Climate change adaptation and mitigation
MININFRA	Setting energy supply and infrastructure policies and strategies which includes those one related to the manufacturing	Increase renewable energy sources for industries and provision of plan for industrial location which are climate resilience
MINIRENA	Ensures the protection and conservation of the environment and optimal and rational utilization of natural resources for sustainable national development	Promotion of green industries that utilize the natural resources efficiently and reduce emissions
MINAGRI	Creating enabling environment for productive investment and development of entrepreneurship and employment in agro-industry	Efficient use of resources in agro-processing industries and promotion of reuse and recycling of agro-wastes into organic fertilizers
RHA	• Development of the master plans for	• Climate resilient location

	industrial parks; • Supervision of construction and quality control of building materials; • Development of building codes	• Provision of green building codes
FONERWA	• Contribute to sustainable wealth creation and poverty reduction in Rwanda, through sustainable management of natural resources , climate resilient and green economy growth	Financing the green technology projects developed by manufacturing industry
RDB	• Promote investments in the manufacturing sector through investment opportunities profiling and outreach activities to potential investors; • Provide technical assistance to manufacturing industries for competitiveness and growth	Promotion of green investments
International Development partners including UNIDO and UNEP	• Provide technical and financial support to the ministries, agencies involved in the industry sector	Support to manufacturing industry through Rwanda Resource Efficient Cleaner Production Centre

2.3.7. CLIMATE CHANGE ISSUES AND CHALLENGES IN THE MANIFACTURING INDUSTRIES IN RWANDA

The impacts of climate change on several sectors in Rwanda have been well documented Extreme weather already negatively impacts the economy and climate change could result in annual economic costs of just under 1% GDP by 2013 (GoR, 2009).

- **Impact on availability of raw materials**: Rwanda is currently highly vulnerable to climate change as it is strongly reliant on rain-fed agriculture both for rural livelihoods and exports of tea and coffee (GoR2011). Additionally it has experienced a temperature increase of 1.4°C since 1970, higher than the global average, and can expect an increase in temperature of up to 2.5°C by the 2050s from 1970. A significant decrease in agricultural productivity caused by changing climatic conditions is leading to poor performance of crops. Crop failures affect the availability and price of raw materials which leads to increased costs of production. Impacts on the food industry depend mainly on changes in the availability and price of agricultural products. Temperature rise may increase the spread of vector-borne diseases, air-borne and water-borne diseases. This affects the livestock sub sector, increased animal health problems lead to low productivity and hence the price of milk as a raw material.
- **High cost of energy**: Rwanda depends on hydropower for half of its electricity generation, a driver of economic growth. Decreased water levels and sedimentation of hydropower systems means that they do not produce power to their optimal production potential. Constant power shortages due to low production make manufacturing systems inefficient and thus increase the cost of production. In some cases for example cement production and where old technology is used, constant shortage lead to increased dust emissions which become a nuisance to environment.
- **Flooding and impact on fixed assets and increased expenditure**: Rainfall is highly variable in Rwanda but average annual rainfall may increase by up to 20% by the 2050s from 1970. Projections for East Africa over Rwanda and Burundi show an increasing trend in rainfall intensity for both rainy seasons which is likely to continue to cause floods and storms which can result in landslides, crop losses, health risks and damage to infrastructure. In the recent years the floods had an impact on loss of assets, degradation of building fabric, interruptions in supply chains and alterations in the manufacturing cycle. Consequently this leads to additional costs (capital expenditure and operational expenditure) especially as a result of flooding.

2.3.7.1. PONTENTIAL IMPACTS AND RESPONSES OF MANUFACTURING INDUSTRIES TOWARDS CLIMATE CHANGE

2.3.7.2. POTENTIAL IMPACTS OF INDUSTRIES ON CLIMATE CHANGE

Rwanda has one of the lowest emissions per capita in the world, estimated at 0.65 tons CO_2/ person (including land use change), compared to a global average of 4.63 tons CO_2/person. But recent economic growth has led to doubling of GHG emissions from 2003 to 2006 and this trend is set to continue. Currently, the main industrial processes emission sources in Rwanda are releases from processes that chemically or physically transform materials (for example, the manufacture of cement is a process that releases a significant amount of GHGs). Different GHGs—including CO_2, CH_4, N_2O, hydro fluorocarbons and per fluorocarbons—can be produced during these processes. The table below gives the values of GHG emissions calculated from some case studies of manufacturing industries:

Table 7: GHG emissions from industries

Industry	**GHG emission (tonCO_2) in 2013**
Inyange Industries Ltd	5665.55
Mata Tea Company	8627.7
SOPYRWA	853.9
CIMERWA	70,000

Emission calculated for the tea and coffee industries show an increase in trends of GHG emissions for business as usual scenario. The following figures illustrated the trends in emissions from 2008 to 2030.

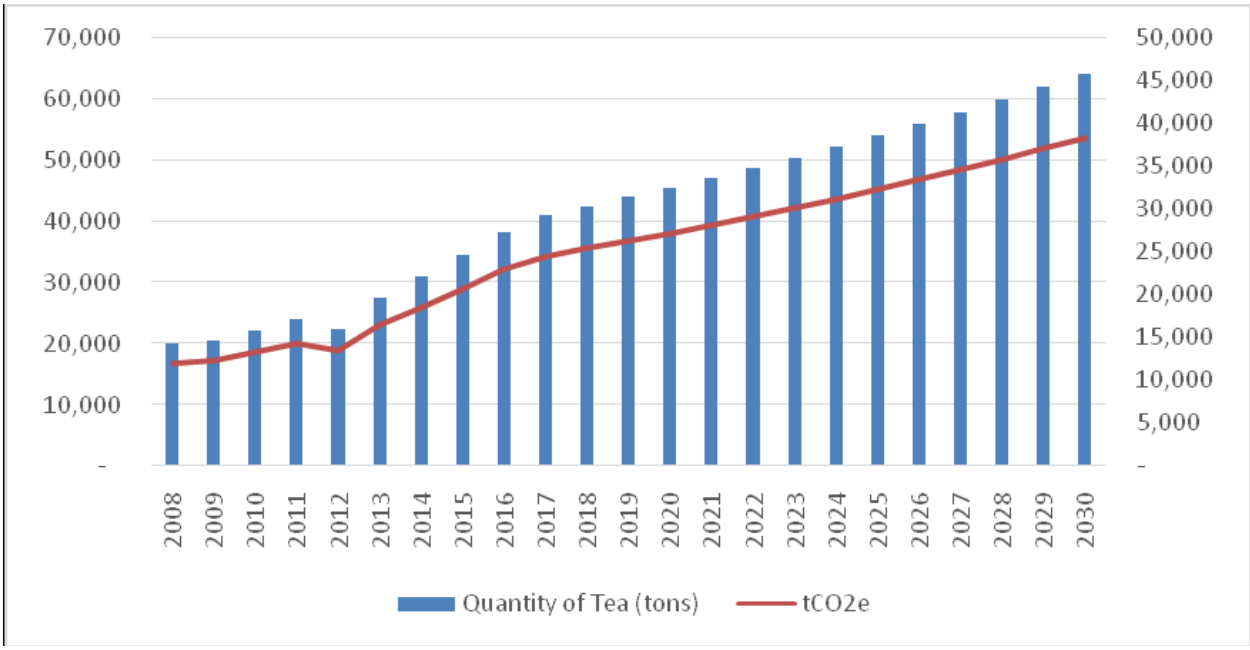


Figure 4: *Baseline emissions (line chart) and annual tea production (Source: REMA 2015)*

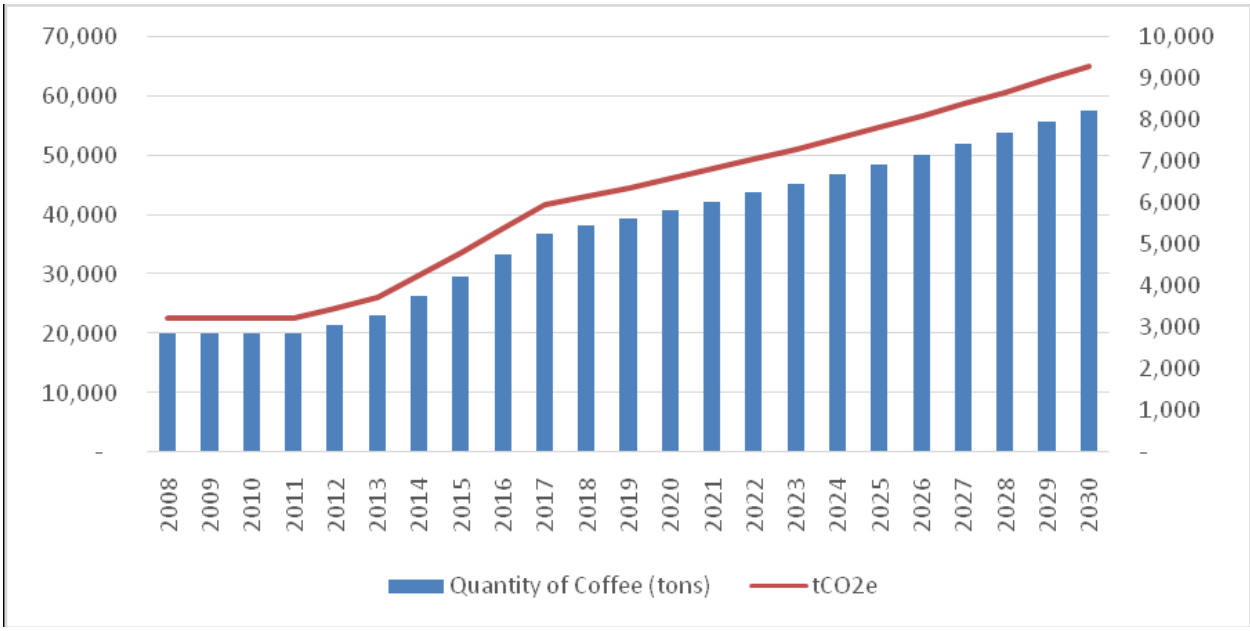


Figure 5: Baseline emissions *(line chart) and annual* coffee production (*(Source: REMA 2015)*

INDUSTRIAL RESPONSES TO CLIMATE CHANGE EFFECTS

A number of adaptation and mitigation measures have been adopted by some industries in Rwanda; the following sections highlight the different mitigation and adaptation responses to climate change.

Table 8: Mitigation and adaptation responses

Responses/strategies	**Types of responses**	**Benefits**	**Case studies**
Lagging fully done in all steam lines	Mitigation	• Energy efficiency • Reduced GHG emissions gas emissions due to reduced demand for fuel wood	Kitabi and Mata Tea Companies
Installation of boiler economizer to recover lost heat from chimney	Mitigation	• Energy efficiency • Reduced GHG emissions gas emissions due to reduced demand for fuel wood	Kitabi and Mata Tea Companies
Awareness raising on power saving techniques and Construction of firewood shades	Mitigation and Adaptation	• Energy saving • Reduced GHG emissions gas emissions due to reduced demand for fuel wood • Deforestation reduced	Kitabi and Mata Tea Companies
Construction of wastewater treatment plant and installation of dry cleaning	Adaptation	• Water pollution reduced • Less demand for water	Mata Tea Company

Protection of Akavuguto river sides	Adaptation	• Reduced vulnerability to potential flooding • Increase in water quality • Soil erosion reduced	Mata Tea Company

Improving existing poor storage and handling practices in the Factory, Proper sorting and Recycling	Mitigation	• Improved solid waste management • Emission reduced	UTEXRWA
Enhanced steam pipe insulation, Fixing Leakages, servicing the motors, carrying out the preventive maintenance and efficient use of lights through better natural utilization	Mitigation	• Reduced air emissions • Reduced greenhouse gas emissions	UTEXRWA
Replacement of the fuel use in the boiler by reusing solid waste.	Mitigation	• Reduction in energy consumption • Reduced waste disposal costs • Reduced emissions	UTEXRWA
Replacing existing blow molding machines to new energy saving blow molding machines	Mitigation	• Emissions reduced • Reduction in energy consumption	SULFO
Rainwater harvesting.	Adaptation	Water saving	SULFO, SORWATHE
Changing the profile of the mould with less spruce & less weight runner	Adaptation	Reduced solid waste production	SULFO

2.3.7.2. CAPACITY AND TECHNOLOGY NEEDS ASSESSMENT

A number of industries in Rwanda have already started to mainstream climate change mitigation and adaptation technologies in their business plans. However, challenges on capacity and technology are still observed in many industries. The table below shows general gaps/ challenges and needs for the manufacturing industry in Rwanda.

Table 9: Climate Change Mainstreaming capacity and technological gaps and needs

Identified gaps Challenges	**Needs**
Capacity	
• Limited knowledge on climate change impacts, risks and strategies for , manufacturing industries • Inadequate planning and coordination skills at firm level to mainstream climate change issues into their plans and strategies • Lack of technical capacity at firm level to adopt low carbon technologies • Limited capacity to tap into climate finance • Low skills to manipulate tools and software used to track changes in management process and risks related to climate change	• Institutional strengthening for climate change adaptation and mitigation measures • Technical assistance to industries to implement best practices for climate change mitigation and adaptation • Skills development for Technical staff within industries to handle climate change issues • Sensitization and knowledge transfer in areas of climate finance and incentives for industries
Technology	

• Use of old technologies with high consumption of resources and high waste generation. • Limited research and innovation for green technologies at industrial level. • Low rate of adoption of green technologies	• Technical assistance to the industries • Institutional strengthening to support the climate change initiatives including linking research and industry • Knowledge sharing systems • Research development • Organize show casing fora/expo for new technologies • Incentives in form taxes and other benefits

CHAPTER 3. GUIDELINES AND TOOLS FOR MAINSTREAMING CLIMATE CHANGE MITIGATION AND ADAPTATION IN MANUFACTURING INDUSTRY

This Chapter introduces guidelines and tools to mainstream climate change adaptation and mitigation in manufacturing industry. After linking climate change and industry sector in the above chapter, it is crucial to clearly indicate what each category of manufacturing industry should do in order to reduce emissions as well as to reduce vulnerability to climate change impacts. Therefore, the ultimate goal of those guidelines is to adopt measures to make manufacturing industry resilient to climate change shocks relating from extraction - through production - to consumption and waste,

3.2. GUIDELINES TO MAINSTREAM CLIMATE CHANGE IN THE MANUFACTURING INDUSTRY

In the life cycle assessment of a manufacturing industry, each step offers an entry point for mainstreaming of climate change mitigation and adaptation measures. Those measures will enable industries to reduce their emissions and vulnerability to climate change risks. The figure below portrays steps of a life cycle assessment of a manufacturing industry.

General life-cycle chain from extraction - through production - to consumption and waste.

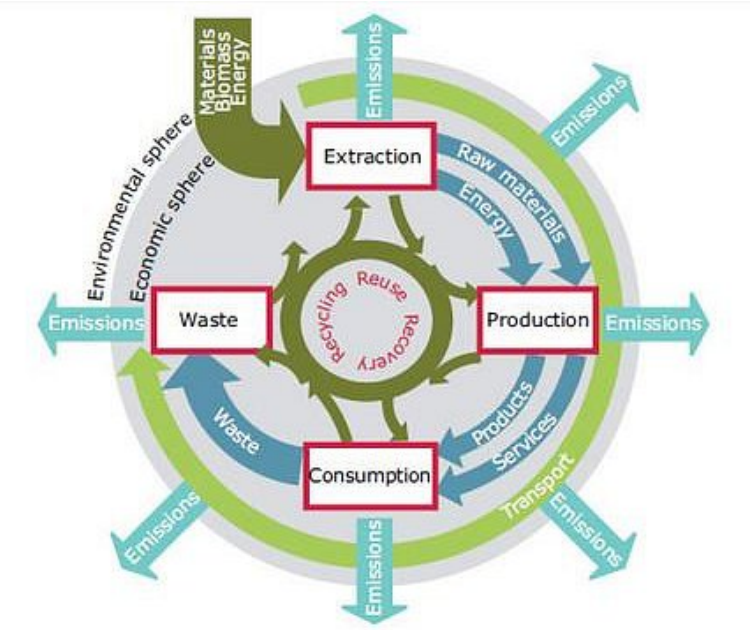


Figure 6: Life cycle assessment of manufacturing industry

Source: http://vi.sualize.us/view/eco_oficina/36c1e40bfc65e6972412e7863f9464e1/

- In addition to the figure above, the table below summarizes the key entry points for mainstreaming climate change mitigation and adaptation in the manufacturing industry.

Table 10: Entry points for Mainstreaming Climate Change Adaptation and Mitigation Measures in manufacturing industry

Production Component/Steps	**Entry points for mainstreaming Climate Change Mitigation and Adaptation Measures**
Raw Materials Input	• Energy efficiency measures • alternative raw materials and source, input and equal or effectively higher output, • Waste minimization • Emission minimization, • Quality of labor/workforce. • Efficient transport • Extraction/harvesting technics
Production	• Raw material to product output efficiency, • Process system technology and design for efficiency, • water, energy resource needs, • Training and quality of labor/workforce**,** waste and emissions**.** • Waste minimization • Emission minimization • Product-raw material and previous resource efficiency, • Knowhow and skills of the workforce, • Conditions imposed by the authorities, waste and emission.
Packaging	• Nature of Packaging and its source • waste component, disposal littering and decomposing type, • The energy and water resource demand of manufacturing or acquiring the packing. • Respecting regulations and standards in acquiring packaging alternatives.
Distribution & consumption	• The distance and mode of transport/traffic, • Greenhouse Gases Emissions from transport, • The customer climate change knowledge responsibility and reasonableness, • Knowhow and skills of the workforce • Waste minimization

	• Emission minimization
Waste	• Type of waste for example liquid waste, solid waste, Smell, • Pollution prevention (air pollution and others) • Waste reduction, Waste avoidance, Waste separation for reuse, recycling, • Exhaust air, Disposal, location and transport, conditions imposed by authorities

3.1.1. CEMENT SUBSECTOR

The main raw materials used in the cement manufacturing process are limestone, sand, shale, clay, and iron ore. The main material limestone is usually mined on site while the other minor materials may be mined either on site or in nearby quarries. For both wet and dry processes, the basic chemical reactions are; evaporating all moisture, calcimine the limestone to produce free calcium oxide, and reacting the calcium oxide with the minor materials (sand, shale, clay, and iron). This results in a final black, nodular product known as "clinker" which has the desired hydraulic properties.

In the wet process, the slurry is fed to a rotary kiln, for clinker making process. In the dry process, kiln feed is fed to a pre-heater tower, from where Material from the pre-heater tower is discharged to a rotary kiln which can have the same diameter as a wet process kiln but the length is much shorter. The pre-heater tower and rotary kiln are made of steel and lined with special refractory materials to protect it from the high process temperatures. Regardless of the process, the rotary kiln is heated with an intense flame, produced by burning coal, coke, oil, peat, gas or waste fuels. Pre-heater towers can be equipped with firing as well. In Rwanda we are using peat

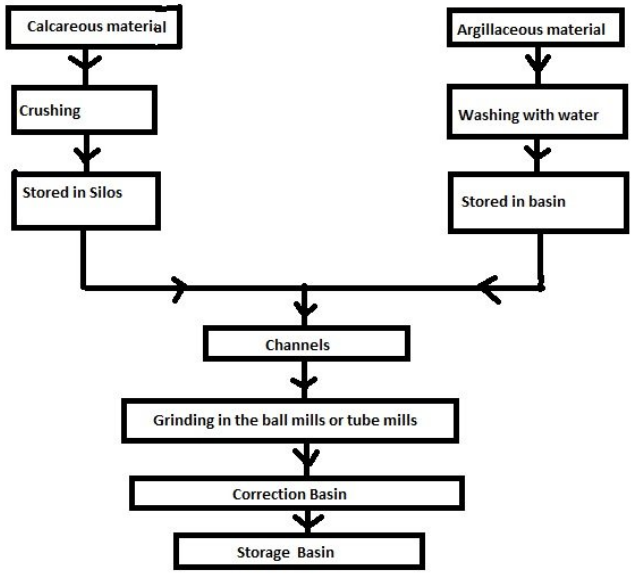


Figure 7: Typical dry process for cement manufacturing

The kiln discharges the red-hot clinker under the intense flame into a clinker cooler. The clinker cooler recovers heat from the clinker and returns the heat to the pyro processing system thus reducing fuel consumption and improving energy efficiency. Clinker leaving the clinker cooler is at a temperature conducive to being handled on standard conveying equipment. The black, nodular clinker is stored on site in silos or clinker domes until needed for cement production. Clinker, gypsum, and other process additions are ground together in ball mills to form the final cement products. Fineness of the final products, amount of gypsum added, and the amount of process additions added are all varied to develop a desired performance in each of the final cement products. Each cement product is stored in an individual bulk silo until needed by the customer and can then be distributed either by truck or which means that are powered by diesel fuel.

Table 11: Key actions for mainstreaming Climate Change adaptation and mitigation in the cement manufacturing industry

No	Climate change issues	Impact (Direct/Indirect)	Adaptation Measures	Mitigation Measures
1	**Availability of raw materials**	Raw material not sufficient with a negative impact on productivity	• Improve technology for extraction and efficient use of raw material • 2.carry out a periodic resource	Raw material input practices form the starting point for carbon sequestration and forms the

			use efficiency assessment to determine the amounts of raw material	basis for overall GHG behavior of the cement manufacturing process.
2	**Air Pollution**	GHG and dust emission during extraction of raw material	Install GHG reading meters at every emitting stage of the cement manufacturing process.	Reduce GHGs and dust emissions through technology change
		Increase of dust may have a negative impact on human and animal health	• Encourage dry process for cement manufacturing • 2. Use of personal protective equipment in cement processing • 3. Relocation of households living near the cement manufacturing industry.	Tree plantation and rehabilitation of degraded land due to extraction of raw material
3	**Energy**	Disruption and high cost in energy supplies affect production	• Assess the general resource input that includes energy and water consumption • Energy saving • Environmental Management System (EMS), general plant personnel should know and discipline direct resource use such as water, peat, fuel wood, hydropower, and other forms of energy where utilized, to appreciate general	• Clean energy practices • Use of dry technology (dry)

			conservative utility of these resources.	
4	**Water**	Mismanagement of liquid and solid waste have a negative impact on the environment	• Hierarchical application of the practices of source reduction, reuse, recycling, recovery, treatment and responsible disposal. • Rainwater harvesting • Water treatment and reuse practices • Self-audit, regulatory compliance or where a climate change adaptation preference business or otherwise opportunity may arise.	
5	**Waste management**	Elimination of solid and liquid waste during manufacturing process	• Application of the practices of source reduction, reuse, recycling, recovery, treatment and responsible disposal. • Responsible waste management and disposal • Undertake periodic checks from raw material input to product output should to ensure that	Regular training and sensitization of personnel handling potentially carbon emitting processes and polluting substances at any point of the process and the appropriate emergency response procedures be put in place

			process material losses and resource wastages are eliminated.	
6	**Flooding and impact on fixed assets and increased expenditure**	Loss of assets, degradation of building fabric, interruptions in supply chains and alterations in the manufacturing cycle. Consequently this leads to additional costs (capital expenditure and operational expenditure)	Locate industry in proper industrial zone	
5	**Land use conflicts**	Extraction of raw material can be done where the crops can thrive well; this may significantly impact the land available for surrounding local community and may result in land use conflict.		Tree planting Rehabilitation of degraded land due to extraction of raw material
	Cumulative Aspects	Extreme weather events associated with climate change, such as flooding may damage transport infrastructure or slow delivery of inputs and supplies via road.	Infrastructure resilient to extreme weather.	

3.1.2. STEEL SUBSECTOR

There are two major processes for making steel, namely basic oxygen steelmaking which has liquid pig-iron from the blast furnace and scrap steel as the main feed materials, and electric arc furnace (EAF) steelmaking which uses scrap steel or direct reduced iron (DRI) as the main feed materials. Oxygen steelmaking is fuelled predominantly by the exothermic nature of the reactions inside the vessel where as in EAF steelmaking, electrical energy is used to melt the solid scrap and/or DRI materials.

In secondary metallurgy, alloying agents are added, dissolved gases in the steel are lowered, and inclusions are removed or altered chemically to ensure that high-quality steel is produced after casting. Some of the operations performed in ladles include de-oxidation (or "killing"), vacuum degassing, alloy addition, inclusion removal, inclusion chemistry modification, de-sulphurisation and homogenization. By-product gases from the steel making process can be used to generate electricity through the use of reciprocating gas engines.

The Hisarna steelmaking process is a process for primary steelmaking in which iron ore is processed almost directly into steel. The process is based around a new type of blast furnace called a Cyclone Converter Furnace, which makes it possible to skip the process of manufacturing pig iron pellets that is necessary for the basic oxygen steelmaking process. Without the necessity for this preparatory step the Hisarna process is more energy-efficient and has a lower carbon footprint than traditional steelmaking processes.

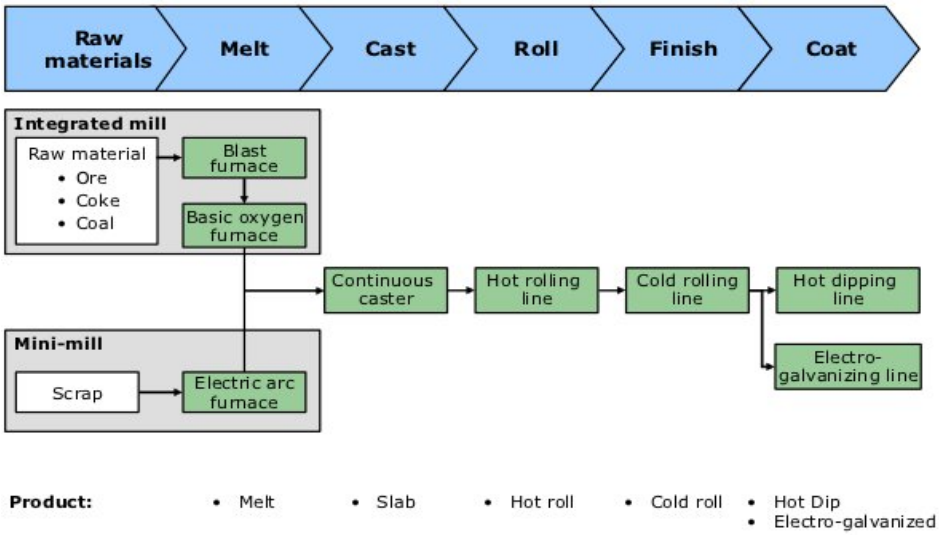


Figure 8: A typical steel process flow

Source: http://www.consultingcase101.com/riva-group-to-exit-hot-roll-commodity-steel-production/

The GHG emissions in steelmaking are generated at one of the following;

- process emissions, in which raw materials and combustion both may contribute to CO_2 emissions;
- emissions from combustion sources alone;
- And indirect emissions from consumption of electricity primarily in EAF and in finishing operations such as rolling mills at both Integrated and EAF plants. The primary combustion sources of GHGs include the following: Coke oven battery combustion stack; Blast furnace stove; Boiler; Process heater; Reheat furnace; Flame-suppression system; Annealing furnace; Flare; Ladle reheated; and other miscellaneous combustion sources.

Table 12: The following table describes key actions for mainstreaming Climate Change adaptation and mitigation in the steel manufacturing industry

No	Climate change issues	Impact (Direct/Indirect)	Adaptation Measures	Mitigation Measures
1	**Availability of raw materials**	Raw material not sufficient with a negative impact on productivity	• Application of the practices of source reduction, reuse, recycling, recovery, treatment and responsible disposal. • Carry out a periodic resource use efficiency assessment to determine the amounts of raw material	• Install GHG reading meters at every emitting stage of the steel manufacturing process. • Raw material input practices form the starting point for carbon sequestration and forms the basis for overall GHG behavior of the steel manufacturing process.

2	**Air Pollution**	GHG and dust emission during extraction of raw material		Reduce GHGs and dust emissions through technology change
		1.Increase of dust may have a negative impact on human and animal health	• Encourage the Hisarna process for Steel manufacturing • Use of personal protective equipment in steel processing • Relocation of households living near the steel manufacturing industry.	Tree plantation and rehabilitation of degraded land due to extraction of raw material
3	**Energy**	Disruption and high cost in energy supplies affect production	• Assess the general resource input that includes energy and water consumption • Energy saving	• clean energy practices
4	**Water**	Water not sufficient and with high cost	• Rainwater harvesting • Water treatment and reuse practices • Environmental Management System (EMS), general plant personnel should know and discipline direct resource use such as water, peat, fuel wood, hydropower, and other forms of energy where	

			utilized, to appreciate general conservative utility of these resources.	
5.	**Waste management**	1. Hierarchical application of the practices of source reduction, reuse, recycling, recovery, treatment and responsible disposal.	• Responsible waste management and disposal • Rehabilitation of degraded land due to extraction of raw material • Self-audit, regulatory compliance or where a climate change adaptation preference business or otherwise opportunity may arise. • Undertake periodic checks from raw material input to product output should to ensure that process material losses and resource wastages are eliminated.	• Regular training and sensitization of personnel handling potentially carbon emitting processes and polluting substances at any point of the process and the appropriate emergency response procedures be put in place
6	**Flooding and impact on fixed assets and increased expenditure**	• Loss of assets, degradation of building fabric, interruptions in supply	• Locate industry in proper industrial zone	

		chains and alterations in the manufacturing cycle. Consequently this leads to additional costs (capital expenditure and operational expenditure)		
7	**Cumulative Aspects**	Extreme weather events associated with climate change, such as flooding may damage transport infrastructure or slow delivery of inputs and supplies via road.	Infrastructure resilient to extreme weather.	Rehabilitation of degraded land due to extraction of raw material
		Extraction of raw material can be done where the crops can thrive well; this may significantly impact the land available for surrounding local community and may result in land use conflict.		

3.1.3. TEXTILE SUBSECTOR

Textile manufacturing is based on the conversion of three types of fiber into yarn, then fabric, then textiles. These are then fabricated into clothes or other artifacts. Cotton remains the most

important natural fiber, so is treated in depth. There are many variable processes available at the spinning and fabric-forming stages coupled with the complexities of the finishing and coloration processes to the production of a wide range of products. There remains a large industry that uses hand techniques to achieve the same results.

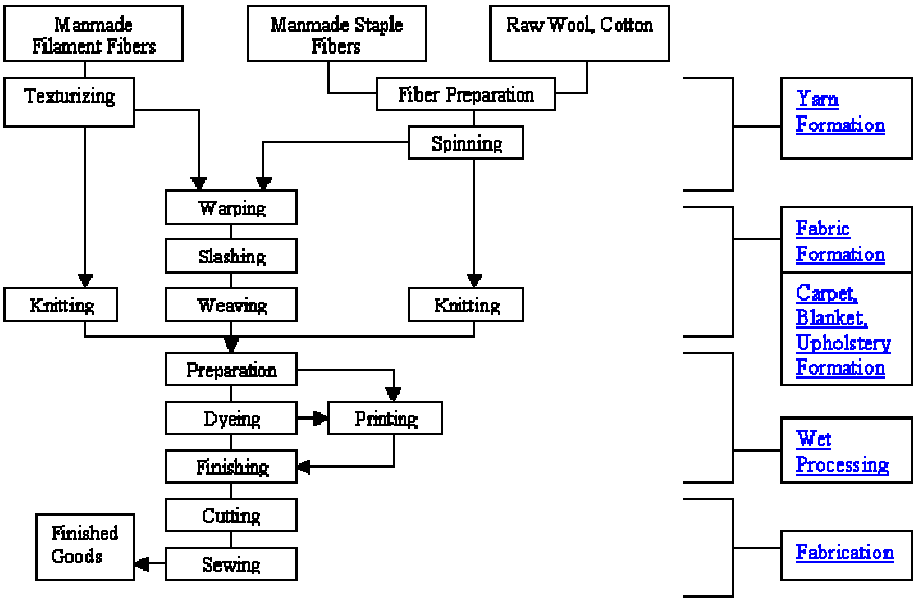


Figure 9: A typical textile flow chart

Source: http://apkfun.co/cotton-manufacturing-process-flow-chart.html

There are six stages of cotton textiles processing: thus cotton cultivating and harvesting, preparatory processes, spinning, weaving, finishing, and marketing. Cotton is grown in regions of long, hot dry summers with plenty of sunshine and low humidity. The cotton bolls are harvested the stripper harvesters and spindle pickers remove the entire boll from the plant.

In ginning the seed cotton goes into a cotton gin which separates seeds and removes the dirt, stems and leaves from the fiber. In a saw gin, circular saws grab the fiber and pull it through a grating that is too narrow for the seeds to pass. A roller gin is used with longer staple cotton. Here a leather roller captures the cotton. A knife blade, set close to the roller, detaches the seeds by drawing them through teeth in circular saws and revolving brushes which clean them away. The cotton seed is pressed into cooking oil. The husks and meal are processed into animal feed, and the stems into paper. The other processes that follow are blending, carding, combing, checking, gassing, weaving winding, warping or beaming, sizing, drawing in, looming, pining (processing the weft), knitting- fabric manufacture, finishing- processing of final textiles.

Not only cotton is used but also synthetic fabrics can also be used in textile industries.

Table 13: Key actions for mainstreaming Climate Change adaptation and mitigation in the textile manufacturing industry

No	Climate change issues	Impact (Direct/Indirect)	Adaptation Measures	Mitigation Measures
1	Availability of raw materials	The production of cotton made in Rwanda is not competing quality cotton. Most of raw material used in textile industry are imported from neighboring countries like Burundi	• Improve mode of raw material transport 2. Improve storage and handling practices in the Factory, Proper sorting and Recycling • Good field input practices • Producing cotton domestically, by providing cotton seeds adapted to the soil and climate of Rwanda. • 3. Produce synthetic fibers	Minimize the distance from raw material area (cotton fields) to industry
		Extreme weather events associated with climate change, may cotton plantation.	Use of seed resilient to extreme weather.	
2.	**Air Pollution**	GHG emission during many processes and products that go into the making of fibers, textiles and apparel products consume significant quantities of fossil fuel.	• Establish a control system for emissions from boiler (the only emission point in the process) • Reduce GHGs emissions through technology	

			change	
3.	**Energy**	Disruption and high cost in energy supplies affect production	Energy saving with replacement of mercury light 125 W with fluorescent light 36 W	• Clean energy practices • Reuse of solid waste in boiler
4	**Water**		• Rainwater harvesting • Water treatment and reuse practices	
5	**Waste management**	• Discharging waste water in the wetlands before treatment lead to environmental pollution • Excess use of pesticide in cotton plantation contribute to environmental pollution	• Use of ecologically friendly production methods, • by treatment/disposal of liquid waste (wastewater treatment plant) • Progressive substitution of inorganic fertilizers or inputs dependency with organic • Control the use of pesticide in cotton plantation • Undertake periodic checks from raw material input to product output should to ensure that process material losses and resource wastages are eliminated. • Responsible waste management and disposal	Enhanced steam pipe insulation,

		• Increase of pesticides, chemicals and dust in textile processing may have a negative impact on human	• Use of personal protective equipment in cement processing • Relocation of households living near the cement manufacturing industry.	
6	**Flooding and impact on fixed assets and increased expenditure**	Loss of assets, degradation of building fabric, interruptions in supply chains and alterations in the manufacturing cycle. Consequently this leads to additional costs (capital expenditure and operational expenditure)	Locate industry in proper industrial zone	
7	**Cumulative Aspects**		Self-audit, regulatory compliance or where a climate change adaptation preference business or otherwise opportunity may arise.	Regular training and sensitization of personnel handling potentially carbon emitting processes and polluting substances at any point of the process and the appropriate emergency response procedures be put in place
		Market competition due to Chinese product and second hand	Improve technology and diversification in order to be competitive on local	

		clothes	market	

3.1.4. TEA SUBSECTOR

For all tea industries it is necessary to carry out a periodic resource use efficiency assessment to determine the amounts of raw material and general resource input that includes energy and water consumption, the total output, the waste component and the waste management system options that should optimize the 3Rs and the risk of pollution associated with the industry.

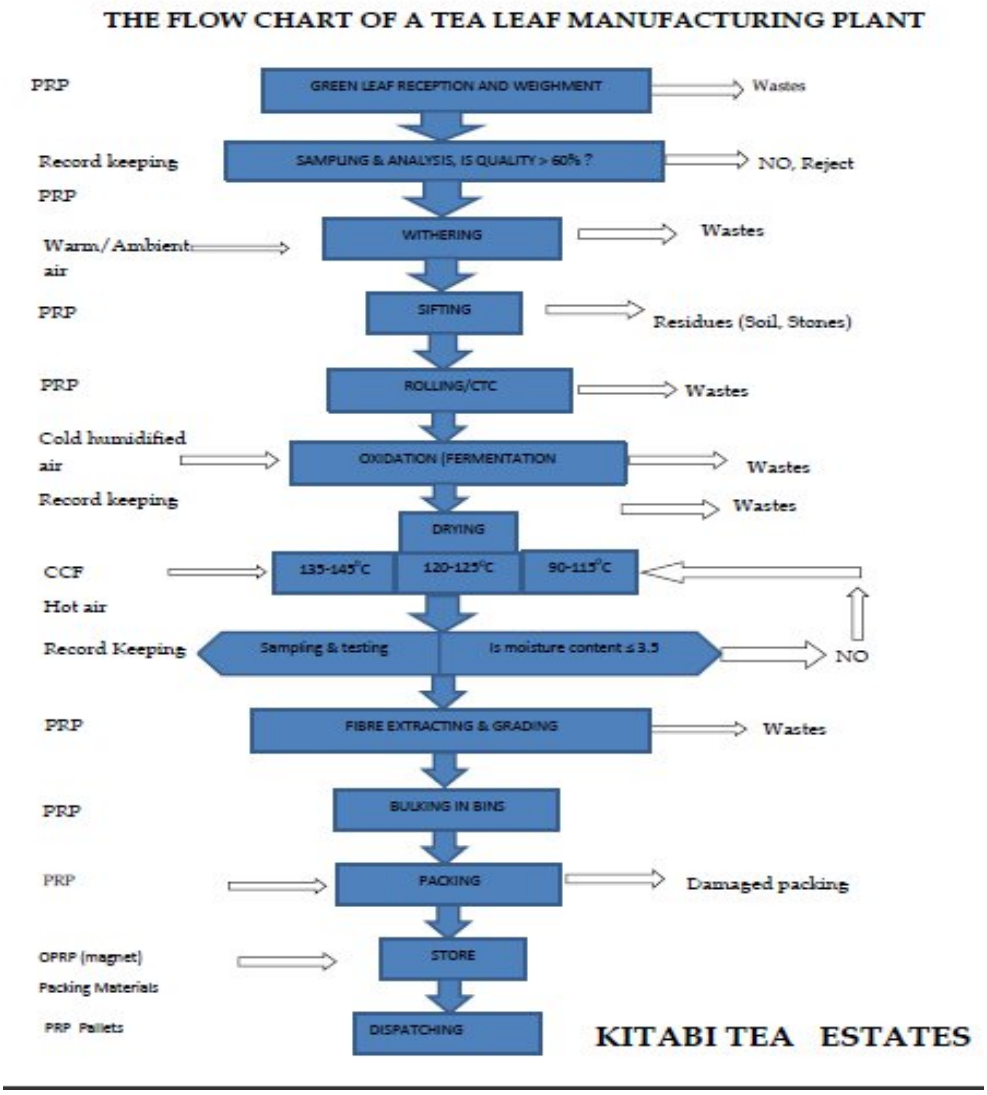


Figure 10: Typical tea flow process of Kitabi Tea factory

The tea processing flow is mainly for achieving quantifiable market interests of the producer and largely subject to controls example of moisture loss to required amounts to produce certain types of tea such as green tea, yellow tea, white tea, black tea and post-fermented teas etc. While there are an infinite number of variations that result in an infinite number of tea styles, the underlying processing methods are working on constant water resource in form of leaf moisture at harvesting and limited amounts for domestic use for cleaning and general domestic use, and the main variable resource in the process remaining the process energy needs.

Table 14: Key actions for mainstreaming Climate Change adaptation and mitigation in the tea manufacturing industry

No	**Climate change issues**	**Impact (Direct/Indirect)**	**Adaptation Measures**	**Mitigation Measures**
1	Availability of raw materials	Availability of raw material and distance may affect productivity	• Conduct an accurate inventory of raw material development and management practices recording the types of performance at a given interval, the inputs in form of fertilizers, labor, spraying or other methods for pesticide control where applicable • Improve the mode of raw material transport • carry out a periodic resource use efficiency assessment to determine the amounts of raw material	minimize the distance from raw material area (tea plantation) to industry
2.	Air Pollution	GHG emission	Raw material input	Reduce GHGs

		during transportation of raw material	practices form the starting point for carbon sequestration and forms the basis for overall GHG behavior of a given tea industry with pollution prevention	emissions through technology change
3	**Energy**	Disruption and high cost in energy supplies affect production	• Energy saving • Conduct periodic resource use efficiency assessment in order to determine the amounts of raw material and general resource input that includes energy and water consumption, the total output	• clean energy practices • Installation of boiler economizer to recover lost heat from chimney • Awareness raising on power saving techniques and partial covering of firewood
4	**Water**		• Continuous/periodic assessment/analysis of water from tea plantation • .Rainwater harvesting • Water treatment and reuse practices	
5	**Waste management**		Actual single tea plant practice by involving zeroing of a single or an identifiable group of tea plants in the field. Sample plants that represent the entire field are selected for close	

			observation at a given interval.	
		Increase in use of inorganic NPK may have a negative impact on human and animal health	• Use of personal protective equipment in tea harvesting • Making an accurate estimate of fertilizers to be used, • Progressive substitution of inorganic NPK dependency with organic compost forms	
6	**Flooding and impact on fixed assets and increased expenditure**	Loss of assets, degradation of building fabric, interruptions in supply chains and alterations in the manufacturing cycle. Consequently this leads to additional costs (capital expenditure and operational expenditure)		Tree plantation for/and protection of rivers through the tea plantations to reduce floods risks
7.	**Cumulative Aspects**	Unsustainable production methods read to environmental degradation, and increase cost of so cost of effluent treatment/disposal.	• Undertake periodic checks from raw material input to product output to ensure that process material losses and resource wastages are eliminated. • Responsible waste management and disposal	

			• Use of ecologically friendly production methods, so that they are more at a competitive price, by using safer dyes and chemicals and by reducing cost of effluent treatment/disposal	Use of new, less polluting technologies
		Tea plantation can be done where other crops can thrive well; this may significantly impact the land available for surrounding local community and may result in land use conflict.	Good soil practices by ensuring continued high productivity on less land/soil acreage, covering both the nursery and tea plant field	Rehabilitation of degraded land due to transportation of raw material
		Extreme weather events associated with climate change, such as flooding may damage transport infrastructure or slow delivery of inputs and supplies via road.	Infrastructure resilient to extreme weather.	

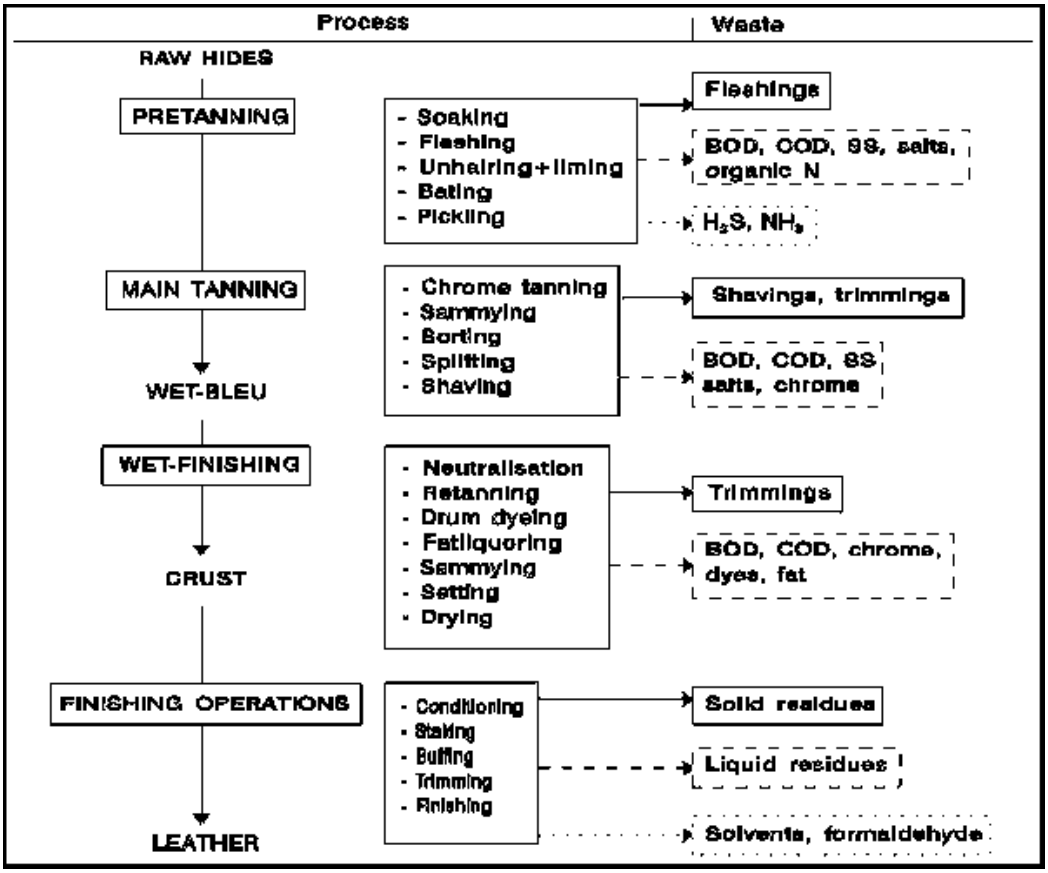
3.1.5. TANNING SUBSECTOR

Tanning is the process that converts the protein of the raw hide or skin into a stable material which will not putrefy and is suitable for a wide variety of end applications. A large number of different tanning methods and materials can be used the choice of which is ultimately dependent on the end application of the leather. The most commonly used tanning material is chromium,

which leaves the leather, once tanned, a pale blue colour (due to the chromium), this product is commonly called “wet blue”. The chemicals traditionally used for tanning have been derived from plants, whereas the most common process nowadays is a combination of chrome salts (chrome tanning) and readily usable vegetable extracts (vegetable tanning).

The process begins from the preparatory stages when the hide/skin is prepared for tanning. Here many of the unwanted raw skin components are removed. Many options for pretreatment of the skin exist. The stages may include; preservation where the hide/skin is treated with a method which renders it temporarily un putrescible, soaking where water for purposes of washing or rehydration is reintroduced, liming where unwanted proteins and "opening up" is achieved. Un-hairing where the majority of hair is removed, fleshing where subcutaneous material is removed, splitting where the hide/skin is cut into two or more horizontal layers, re-liming where the hide/skin is further treated to achieve more "opening up" or more protein removal, de-liming where liming and unhairing chemicals are removed from the pelt, bating where proteolytic proteins are introduced to the skin to remove further proteins and to assist with softening of the pelt, where degreasing - natural fats/oils are stripped or as much as is possible from the hide/skin where frizing - physical removal of the fat layer inside the skin where bleaching chemical modification of dark pigments to yield a lighter coloured pelt, pickling - lowering of the pH value to the acidic region. Must be done in the presence of salts. Pickling is normally done to help with the penetration of certain tanning agents, e.g., chromium (and other metals), aldehydic and some polymeric tanning agents and depickling pH is raised out of the acidic region to assist with penetration of certain tanning agents.

It has been noted that, the production processes have a heavy use of polluting chemicals in the tanning process, and cause air pollution due to the transformation process (hydrogen sulfide during dehairing and ammonia during deliming, solvent vapours). Pesticides are also often added for hide conservation during transport with solid wastes representing up to 70% of the wet weight of the original hides, the tanning process comes at a considerable strain on water treatment installations.



Source: http://www.fao.org/wairdocs/lead/x6114e/x6114e05.htm

Figure 11: a typical tanning process

Table 15: Key actions for mainstreaming Climate Change adaptation and mitigation in the tanning manufacturing industry

No	Climate change issues	Impact (Direct/Indirect)	Adaptation Measures	Mitigation Measures
1	**Availability of raw materials**	hide or skin as a raw material, for tanning are not sufficient	• Goods hides and skins as raw materials' collection practice and non-wasteful tanning processing and production system • Conduct an inventory to identify the sources of hides and skins as a raw material, and records the costs associated with obtaining them and delivery to the market which can help provide a baseline for identification of opportunities to improve practices.	
2	**Air Pollution**	GHG and dust emission during during the tanning process (Unhairing/liming, Deliming/Batin and finishing) as a result of gas-combustion		• Reduce GHGs and dust emissions through technology change • Good field input practices form the starting point for carbon

				sequestration will minimize on carbon emissions relating to for example the diesel trucks collecting the hides and skins, limit the number routes that have to used
3	**Energy**	Disruption and high cost in energy supplies affect production Power dominates consumption pattern in the main tanning process	• Assess the general resource input that includes energy and water consumption • Energy saving	Clean energy practices
4	**Water**	the quantity of water needed during the tanning process increases the bill	• Rainwater harvesting • Water treatment and reuse practices • A reduction of the total water use by re-use of produced wastewater and by the development of technologies that minimize the quantity of water needed during the tanning process	
5.	**Waste management**	• The discharge of solid waste and	• A reduction of the used chemicals such as lime, salt,	

		wastewater containing chromium/ commonly called "wet blue". (a highly toxic compound) is the main environmental problem. • Every tanning process step, with exception of the crust finishing operations, produces wastewater.	sulphide etc and a reduction of chromium • Elimination, change or reduction of operating practices which result in discharges to land, air or water se resources. • Self-audit, regulatory compliance or where a climate change adaptation preference business or otherwise opportunity may arise.	
6	**Flooding and impact on fixed assets and increased expenditure**	Loss of assets, degradation of building fabric, interruptions in supply chains and alterations in the manufacturing cycle. Consequently this leads to additional costs (capital expenditure and operational expenditure)	Locate industry in proper industrial zone	
7.	**Cumulative Aspects**		• Undertake periodic resource use efficiency assessment to determine the amounts of raw material and	Regular training and sensitization of personnel handling potentially carbon emitting processes and

			general resource input that includes energy and water consumption, chemicals consumption to the total output. • Responsible waste management and disposal	polluting substances at any point of the process and the appropriate emergency response procedures be put in place
		Chemical used in tanning process may have a negative impact on human and animal health	• Use of personal protective equipment in steel processing • Relocation of households living near the steel manufacturing industry.	
		Extreme weather events associated with climate change, such as flooding may damage transport infrastructure or slow delivery of inputs and supplies via road.	Infrastructure resilient to extreme weather.	

3.1.6. PLASTIC SUBSECTOR

A plastic material is any of a wide range of synthetic or semi-synthetic organic solids that are moldable. Plastics are typically organic polymers of high molecular mass, but they often contain other substances. They are usually synthetic, most commonly derived from petrochemicals, but many are partially natural. The production of plastics can be roughly divided into four categories:

a. Acquiring the raw material or monomer.
b. Synthesizing the basic polymer
c. Compounding the polymer into a material that can be used for fabrication,
d. Molding or shaping the plastic into its final form.

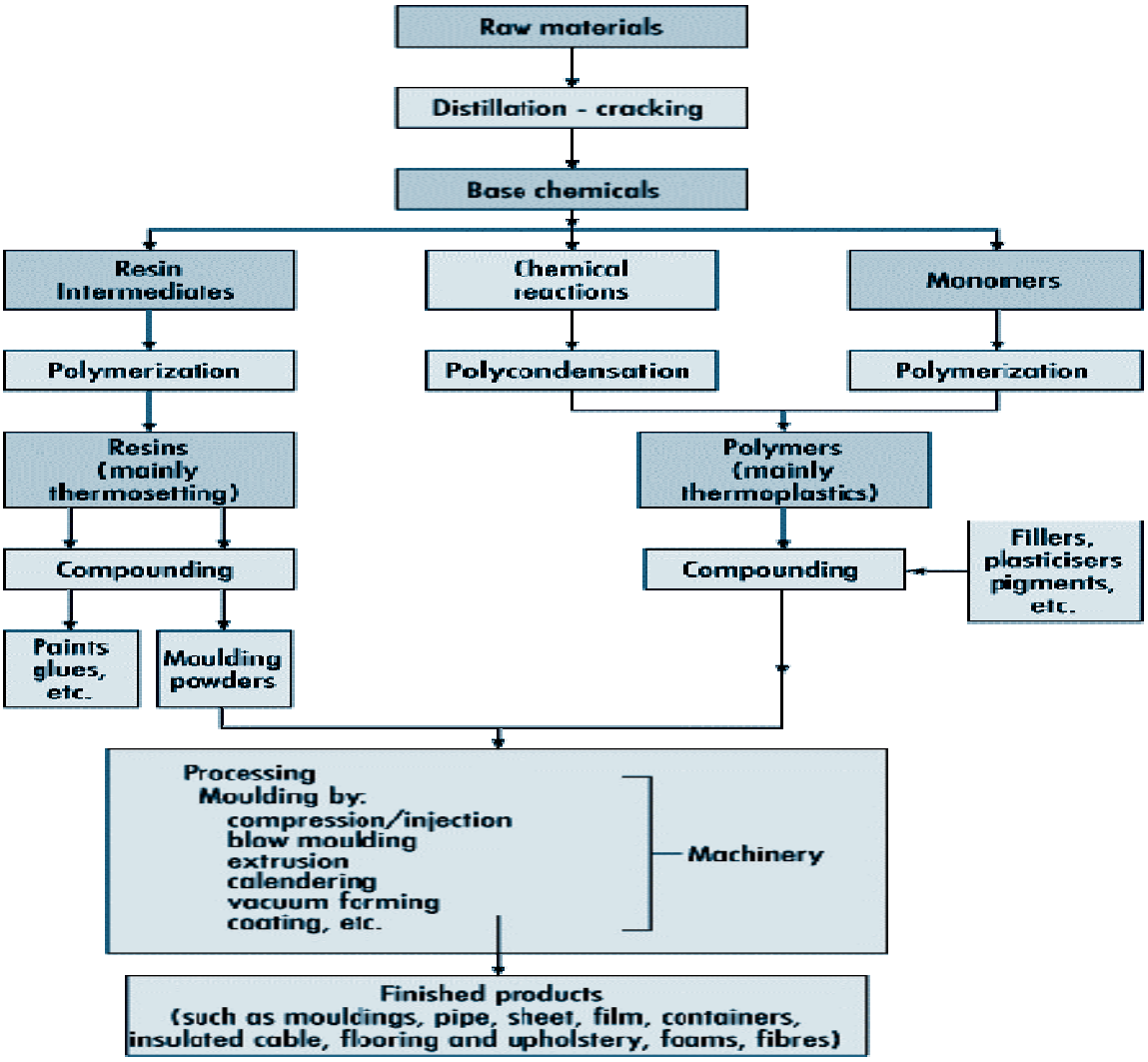


Figure 12: A typical Plastic flow chart

Climate change effect of plastics: A mixed effect of plastics on global warming is has been marked. Plastics are generally made from petroleum. If the plastic is incinerated, it increases carbon emissions, if it is placed in a landfill; it becomes a carbon sink, although biodegradable plastics have caused methane emissions. Due to the lightness of plastic versus glass or metal, plastic may reduce energy consumption. For example, packaging beverages in plastic rather than glass or metal is estimated to save 52% in transportation energy. [18]

The overall chain from points of the required raw materials to the manufacturing process on to the customer and mainly at disposal of plastics, for GHG emission in its entirety is fairly immense although measures its environmental friendliness have been improvised from time to time. Also in the process is a remarkable uptake of water and energy and process resources in varying amounts along the process. For the entire Plastic process chain, it is necessary to carry out a periodic resource use efficiency assessment to determine the amounts of raw material and general resource input that includes energy and water consumption, the total output, the waste component and the waste management system options that should optimize the 3Rs and the risk of pollution associated with the industry.

Table 16: Key actions for mainstreaming Climate Change adaptation and mitigation in the plastic manufacturing industry

N	Climate change issues	Impact (Direct/Indirect)	Adaptation Measures	Mitigation Measures
1	Availability of raw materials	1.GHG emission during transportation of raw material	1.Conduct an accurate inventory of raw material development and management practices recording the types of performance at a given interval, 2.Improve mode of raw material transport 3. Raw material input practices form the starting point for carbon sequestration and forms the basis for	1. Reduce GHGs emissions through technology change

[18] http://goeiirj.com/upload/Feb2014/3.pdf

			overall GHG behavior of the plastic manufacturing process. 4.carry out a periodic resource use efficiency assessment to determine the amounts of raw material	
2.	Air Pollution	1. CO_2 emission released during manufacturing and/or incineration of plastic may have a negative impact on human and animal health	1. Use of personal protective equipment in plastic manufacturing	Tree plantation around the industry to trap CO_2 emission
3	**Energy**	Disruption and high cost in energy supplies affect production	1.Energy saving 2. Conduct periodic resource use efficiency assessment in order to determine the amounts of raw material and general resource input that includes energy and water consumption, the total output,	1.clean energy practices
4	**Water**	Water is needed in recycling industries	1Rainwater harvesting 2.Water treatment and reuse practices	
5.	**Waste management**	Solid and liquid wastes are generated especially from recycling industries	1. Undertake periodic checks from raw material input to product output should to ensure that process material losses and resource wastages are eliminated. 2. Responsible waste management and disposal	
7	**Flooding and impact on**	1. Loss of assets, degradation of	1. Locate industry in proper industrial zone	Rehabilitation of degraded

	fixed assets and increased expenditure	building fabric, interruptions in supply chains and alterations in the manufacturing cycle. Consequently this leads to additional costs (capital expenditure and operational expenditure)		land due to floods

3.1.7. DAIRY SUBSECTOR

The milk processing for various products is mainly driven by market demand for the different products and while there are an infinite number of variations that result in an infinite number of dairy products, the underlying Industry methods are working on constant water resource up to at harvesting and large amounts during plant processing itself. The water during the flow process is used for cleaning and general domestic use, and the main variable resource in the process remaining is energy mainly in direct demand during processing.

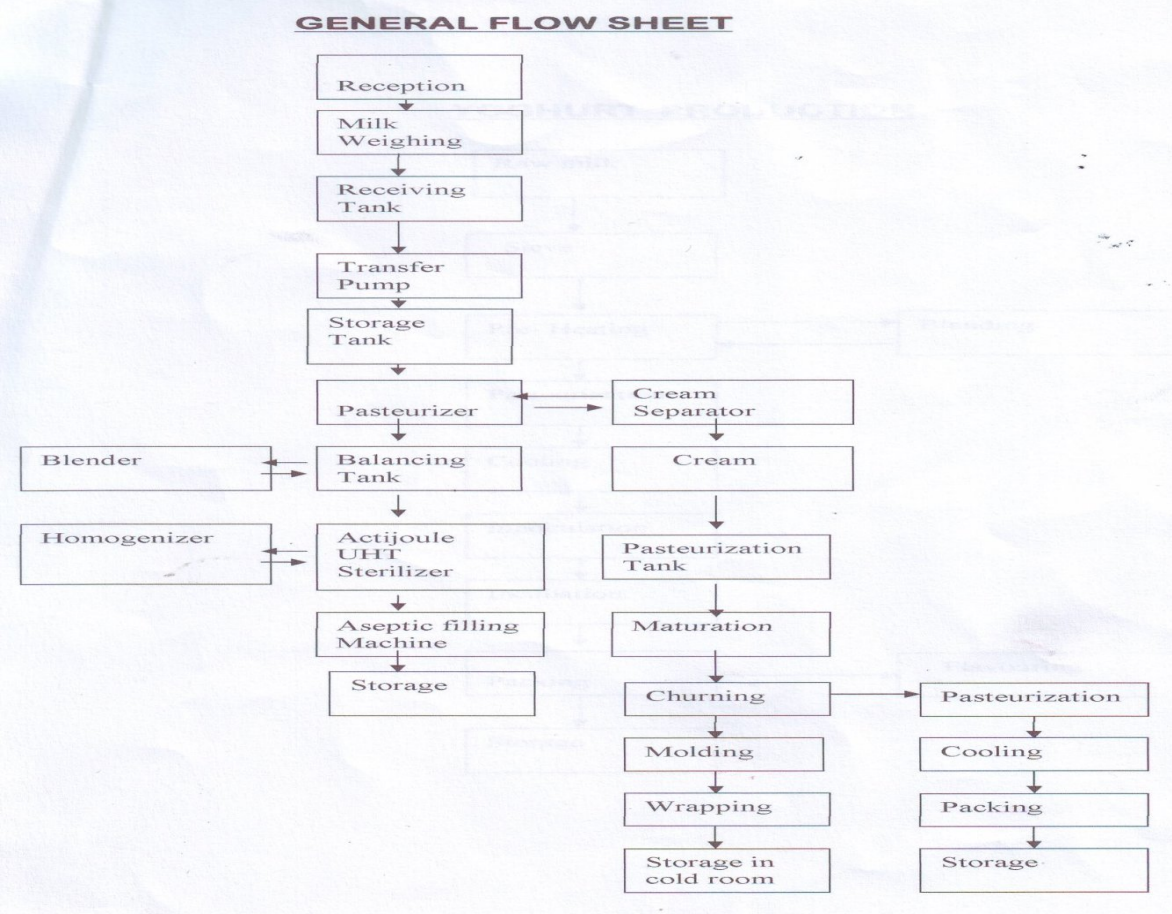


Figure 13: A typical Dairy flow

Table 17: Key actions for mainstreaming Climate Change adaptation and mitigation in milk processing industry

N	Climate change issues	Impact (Direct/Indirect)	Adaptation Measures	Mitigation Measures
1	Availability of raw materials	1.GHG emission during transportation of raw material	1. Periodic inventory and update of pasture land as a raw material for dairy production and the process running from growing of pasture, on to processing plant 2.Improve the mode of raw material transport 3. Raw material input practices form the starting point for carbon sequestration and forms the basis for overall GHG behavior of a given diary with pollution prevention	1. minimize the distance from raw material area (farms) to industry
	Air pollution Air pollution	1.GHGs emission during milk processing 2. Methane emitted from cows' digestions process, called enteric fermentation and their manure is the most critical potential impact of dairy production.		1. Reduce GHGs emissions through technology change 2. Progressive substitution of any inorganic inputs with organic compost forms to tremendously improve the GHG character of a given dairy process enterprise.
2	**Energy**	Disruption and high cost in energy supplies	1.Energy saving 2. Conduct periodic resource use efficiency	1.clean energy practices 2. Installation

		affect production	assessment 3. Use of ecologically friendly production methods	of boiler economizer to recover lost heat from chimney
3.	**Water**	Water pollution is another major concern, as manure and nutrients run into waterways	Water treatment and reuse practices 2.Rainwater harvesting 3.Water treatment and reuse practices	Use of new, less polluting technologies
4.	**Waste management**	1.Used chemicals for from animal medicine may negative impact if not managed well	1. Avoid leakage and spills by a proper and regular maintenance. 2. Responsible waste management and disposal 3.Use of personal protective equipment	
5.	**Cumulative Aspects**	The dairy industry is also responsible for land conversion, particularly in the tropics, to grow the feed required by dairy herds	1. Very low levels of inorganic or artificial farm inputs should be used to boost pasture production.	1. Good soil practices will have an effect on less GHG emission by ensuring continued high productivity on less land/soil acreage.
6.	**Flooding and impact on fixed assets and increased expenditure**	1. Loss of assets, degradation of building fabric, interruptions in supply chains and alterations in the manufacturing cycle. Consequently this leads to additional costs (capital expenditure and operational expenditure)	1. Locate industry in the planned industrial zone 2. Infrastructure resilient to extreme weather.	

3.1.8. COSMETIC SUBSECTOR

Consumers are increasingly demanding "greener" products. Today more than ever, buyers care not only about the ingredients inside their favourite products, but also about the impact manufacturing these products has on the environment.

In the production of cosmetics and personal care products, the highest standard of quality control must be followed to assure the manufacture of safe products of uniform quality. It is the job of the chemical engineer to design and oversee the manufacturing process.
Products can be either an oil-in-water or water-in-oil emulsion consisting of emollients and lubricants dispersed in an oil phase, and a water phase containing emulsifying and thickening agents, perfume, color and preservatives. Active ingredients are dispersed in either phase depending on the raw materials and the desired properties of the end product.

A typical manufacturing process would be as follows:

- Flake/powder ingredients, such as cetyl alcohol and stearic acid, sometimes dry blended in advance, are dispersed into the oil phase. Heating may be required to melt some of the ingredients.
- Active ingredients are dispersed in the appropriate phase.
- The water phase, containing emulsifiers and stabilizers such as Veegum® or Carbopol®*, is prepared separately.
- The two phases are then mixed to form an emulsion. This is aided by heating to between 110-185℉ (45-85℃) depending on the formulation and viscosity.
- Mixing is continued until the end product is homogeneous

Cosmetic Raw materials for cosmetics include Mineral oil and wax, Glycerin, perfume, mineral oil, colour and R.O water.

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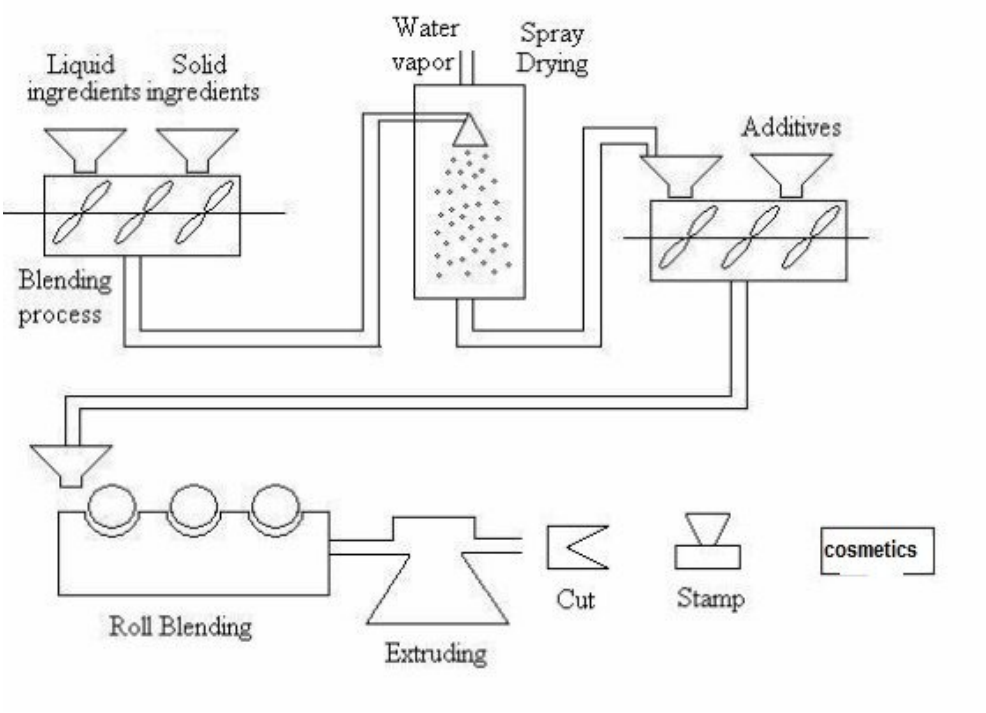

Figure 14: Atypical cosmetics flow chart

All of the steps in the process must be determined including temperature control, mixing speed, addition of ingredients, etc. These "process requirements" are essential to the quality of the finished product.

Table 18: Key actions for mainstreaming Climate Change adaptation and mitigation in cosmetic processing industry

No	Climate change issues	Impact (Direct/Indirect)	Adaptation Measures	Mitigation Measures
1	**Availability of raw materials**	Availability of land to plant trees for oil (palm, sun flowers)	1.Improve road network for easy access on raw materials 2. points, monitoring and making water balance calculation 3. Undertake periodic checks from raw material input	1. Reduce GHGs and dust emissions through transport 2.Planting more trees for oil and reducing erosion.
2	**Air pollution**	Emission cosmetic processing (blow molding machines)		1.Tree planting were applicable 2.Using green technology to reduce air pollution by minimizing or trapping emissions from the plant. (carbone capture, carbone filtration)
3	Energy	Disruption and high cost in energy supplies affect production	1.Assess the general resource input that includes energy and water consumption	1.using clean energy to avoid GHG emissions 2. Replacing existing blow molding machines to new energy saving blow molding machines

4	Water	Wastage of water during cosmetic process wich increace Water bill and sarcastic for other water users	1. Hierarchical application of the practices of waste reduction, reuse, recycling, recovery, treatment and responsible disposal. 2.Rainwater harvesting 3.Water treatment and reuse practices Usage of harvested rain water for car washing, garden/toilets 3. Installation of water meters in each and every consumption	
5	**Waste management**	1.Used chemicals can have a negative impact if not managed well	1. Avoid leakage and spills by a proper and regular maintenance.	
6	**Flooding and impact on fixed assets and increased expenditure**	1. Loss of assets, degradation of building fabric, interruptions in supply chains and alterations in the manufacturing cycle. Consequently this leads to additional costs (capital expenditure and operational expenditure)	1. Locate industry in the planned industrial zone 2. Infrastructure resilient to extreme weather.	
6	**Cumulative Aspects**		1. Undertake periodic checks from raw material input to product output should to ensure that process	

			material losses and resource wastages are eliminated. 2. Responsible waste management and disposal	
5	**Land use conflicts**	Availability of land to plant trees for oil (palm, sun flowers)	Planting more trees for oil and reducing erosion.	1. Planting trees like palm which sequestrate CO2

3.2. TOOLS TO MAINSTREAM CLIMATE CHANGE IN MANUFACTURING INDUSTRIES

The key to successful mitigation and adaptation is determining the magnitude of the risk, and identifying what actions are available and should be taken into account to respond to the risk *(Sussman & Freed, 2008*). It will be prudent to take climate change into account if it materially affects a company's operations, its value chain, or its broader commercial environment. Hence, more systemic changes in resource allocation need to be considered, such as targeted streamlining and diversification of production systems.

These tools aim to bring to the fore; the risks posed by climate change, and eliminate excess that will accelerate the impact of manufacturing industry on climatic change and the other way round. At the same time, there has been a recent emphasis on developing more dedicated tools which have an explicit focus on screening for climate change risks and on facilitating adaptation *(Hammill & Tanner, 2011).* Adaptation tools can assist users in raising awareness, identifying current and future vulnerability and climate risks, assessing and selecting adaptation options, and evaluating the success of adaptation.

In assessing impacts, vulnerability and adaptation to climatic change, a large array of methods and tools pertain to specific sectors, scales of analysis, environmental and social economic context.

In the context, questions arise such as; how can the current effect of climatic change be detected, is climatic change already having a discernable effect, how do you unequivocally identify a climatic change signal in indicators of change in abiotic and biotic systems. How can the future effects of climatic change be anticipated, estimated and integrated.

In intensely human managed systems, the direct effect of climatic change may be either buffered or so completely confounded with other factors that they become impossible to detect. Conversely in systems with little human manipulation, the effects may be most transparent.

In considering and assessing the climatic change impact and therefore evaluating which tools to apply for mitigation and adaption, the following factors have to be taken into account, that most often there large scale effects, there are transient effects in methods and tools, there are human managed systems where manufacturing industry is largely considered.

There are a number of tools used including:

i. ***Process guidance tools*** which guide users through one or several steps of processes; these include screening and assessment tools; Screening is undertaken to establish relevance to climate change and justify further examination of climate risks, whereas assessment is a detailed examination of the nature of climate risk and of possible risk management strategies.
    1. Tool Table 5 1; Our environmental situation,
    2. Tool table 5-2 Establishing the process resource in and output for a given industry
    3. Tool Table 5-4: Main raw and process materials
    4. Tool Table 5-8: Possibilities of minimizing waste and emissions in the company
    5. Tool Table-5-9: Analysis of strengths/weak points
    6. Tool table-5-10: Contents of an environmental policy – thematic focuses
    7. Tool table-5-15: Conversion units and heat consumers
    8. Tool table-5-17: Heat losses
    9. Tool table-5-17: Energy saving options
    10. Tool table-22: Formation of indicators
    11. Tool table-23: Monitoring report
    12. Tool table-24: Overview of the waste management system
    13. Tool table 27: Audit form
    14. Tool table 28: Product description

ii. ***Data and information provision tools,*** which generate or present information for use in other steps;
    1. Operations consent form; consenting procedure;
    2. Tool table 5.3 Guidelines Compliance/performance Checklist,
    3. Tool table 5-5: Energy data,
    4. Tool table 5-6: Main types of waste and emissions and
    5. Tool table 5-1; Our environmental situation,
    6. Tool table-5-9: Analysis of strengths/weak points
    7. Tool table-5-11: Idea pool
    8. Tool table-5-12: Water data sheet

9. Tool table-5-13: Material tracing sheet
10. Tool table-5-14: Meters and measuring instruments
11. Tool table-5-16: Electric consumers
12. Tool table-5-19: Environmental evaluation of the most important products and services
13. Tool table-20: Evaluation of suppliers
14. Tool table-21: Register of hazardous materials
15. Tool table-24: Overview of the waste management system
16. Tool table-25: Waste description – Non-hazardous waste

iii. ***Knowledge-sharing tools,*** which allow users to share knowledge and experiences that will inform and refine adaptation.

1. Tool table-5-9: Analysis of strengths/weak points
2. Tool table-5-10: Contents of an environmental policy – thematic focuses
3. Tool table-5-11: Idea pool
4. Tool table-5-17: Energy saving options
5. Tool table-5-19: Environmental evaluation of the most important products and services
6. Tool table-20: Evaluation of suppliers
7. Tool table-22: Formation of indicators
8. Tool table-24: Overview of the waste management system

The tools at all stages aim to begin with and continuously assess the resources such as the raw materials, the energy, water usage relations from the start and continuously the environmental status of a given manufacturing process up to waste generation and all the overlaps for example waste generated at every stage. Overall the tools aim to ensure the manufacturing system resource use efficiency and as less emission of greenhouse gases as possible through process mitigation measures that maintain a balance between the source of materials and waste that include waste and sink or the less utility of the former for an equal or more of the later for the same unit of production.

Of specific attention in the application of the tools are;

- **Building and other manufacturing process facilities;** Check whether buildings used in the manufacture or storage are of suitable size, design and construction to permit unobstructed orderly storage of materials, sanitary operation, and proper cleaning and maintenance, which should ultimately result into efficiency of production.

- **Equipment**; Check whether equipment used in processing, holding, transferring and packaging are of appropriate design, material and workmanship to prevent corrosion, build-up of material, dirt or sanitizing agent.

- **Personnel;** Check whether the personnel supervising or performing the manufacture or control of the process has the education, training and/or experience to perform the assigned functions.

- **Raw Materials;** Raw materials and primary packaging materials are stored and handled in a manner which prevents their mix-up, contamination or decomposition from exposure to excessive heat, cold, sunlight or moisture, and then polluting substances. Materials are sampled and tested or examined in conformance with procedures assuring the absence of substandard and efficient application and operation to the extent to ensure observance of process carbon emission minimization. Materials not meeting acceptance specifications are properly identified and controlled to prevent their use in the manufacturing processes.

- **Production**, check whether manufacturing and control have been established and written instructions, that is formulations, processing, transfer and packaging instructions, in-process control methods are being maintained and no leakages along the process lines leading to carbon accumulation. Determine whether such procedures require that;

- **Weighing and measuring** of raw materials is checked by a second person, and containers holding the materials are properly identified.

- **Laboratory Controls**. Check whether: Raw materials, in-process samples and finished products are tested or examined to verify their identity and determine their compliance with specifications for physical and chemical properties, microbial contamination, and hazardous or other unwanted chemical contaminants, and possible environmental pollutants.

- **The water supply**, particularly the water used as an ingredient, is measured to ensure that the amounts used are not in excess of what would be required for specific outputs in addition to tests for conformance with output specifications.

- **Records**, check whether control records are maintained of:

- Raw materials and primary packaging materials, documenting disposition of rejected materials. Manufacturing of batches, documenting the Kinds, lots and quantities of material used. Processing, handling, transferring, holding and filling.

- Sampling, controlling, adjusting and reworking.

Internal Audit to determine whether effective procedures for internal audits are followed. At a minimum, internal audit procedures should provide that:

- Internal audits occur regularly or on demand
- Internal audits are conducted by individuals who do not have direct responsibility for the matters being audited
- All observations made during the internal audit are evaluated and shared with appropriate management, production, quality control, and/or lab personnel; and
- Internal audit follow-up confirms the satisfactory completion or implementation of corrective actions for GHG minimization or elimination for climatic change adaptation.

CHAPTER 4. STRATEGIC ACTIONS FOR MAINSTREAMING CLIMATE CHANGE IN MANUFACTURING INDUSTRIES

This chapter introduces the strategic actions for mainstreaming climate change in manufacturing industries. The objective of this chapter is to portray key issues or challenges, key strategic actions to address them, indicators to measure their achievement and key stakeholders to implement them.

4.1.STRATEGIC ACTIONS

Following the trends, it has now become apparent that for manufacturing industries have to perform their climate change-prone operations in a more vigorous and risky environment where institutional, resource-based, supply chain and stakeholder views are all important to characterize and understand corporate strategic responses to a sustainability issue. The key strategic actions are presented in the table below:

Table 19: Key Strategic Actions for mainstreaming climate change Mitigation and Adaptation in Industries

Key Issues	**Key Strategic Actions**	**Indicators**	**Timeframe**	**Key stakeholders**
The need to adopt resource efficient approaches thus reducing emissions, waste and would help manufacturing become more productive and hence profitable. Ecosystem restoration and sustainable utilization of raw materials in order to	**Technology Innovation Actions:** 1. *Undertake technology needs assessment (TNA) for various categories of industries* **2.** *RRECPC to support technically industries to comply with various standards.* **3.** *Develop a*	Number of TNA reports developed Number of Industries supported by RRECP Number of Green Industries	Quick win Big Win Quick win	MINICOM, NIRDA, RRECPC, REMA, RSB, PSF, RDB and MINALOC, International partners

reduce waste.	*framework of recognizing green industries to incentivize or award them regularly*	awarded		
Companies are faced with three major climate related risks (operational risks, supply chain risks and regulatory or reputational risk), therefore building capacity of manufacturers in climate risk assessment and management is key	**Capacity Building Actions:** **1. Develop PSF capacity building plan on climate change mitigation and adaptation.** **2. Exchange visit with different green industries in different countries**	Capacity building plan developed Number of exchange visits conducted	Quick win Big win	MINICOM, PSF, RDB , MINALOC, International partners
In order to ensure that business become more competitive, they require quality indicators that would result from mitigation and adaptation to	**Standardization Actions:** 1.Branding of products through internationally recognized 2.Putting in place a standard guide on supply chain that would ensure that	Number of standards developed Standard guide on supply chain established	Big Win Quick win	MINICOM, RSB, PSF, RDB, NAEB

climate change.	all Rwanda exports and services follow specific quality standards ▪			
There is need to expand the modes of information flow to all actors.	**Communication and Knowledge Management Actions:** 1.Strengthen dissemination of information from early warning systems (EWS) to enable industries integrate such information in their production systems. 2.Support financially PSF to disseminate information to its members through various means of communication. 3. Fully utilize climate change portal as a channel of getting information related to climate change and communicating their best	EWS strengthened Number of information dissemination initiatives supported	Big win Quick Win	MINICOM, PSF, RDB, RMA, REMA, MIDMAR, MINEDUC

	practices.			
Access to finance still a challenge to SMEs and industries.	**Financing Actions:** *1.*Develop a handbook on access climate finance, economic and tax incentives for industries using green technologies. 2.Develop a framework for funding additional activities to green different industries since sustainability has its own cost which is expensive than business as usual.	Number of handbook developed Number of industries which received extra funds to green their business	Quick Win Big win	*MINECOFIN, RRA, BNR, FONERWA, BRD, …*
There is a need of self-monitoring to comply with standards and laws instead of waiting for fines and other consequence of non compliance	**Monitoring and Evaluation Actions:** 1.Develop a participatory monitoring and evaluation framework to assess performance	Monitoring and evaluation framework developed	Quick win	*PSF, MINICOM, RDB, Research institutions, …*

4.2. IMPLEMENTATION FRAMEWORK

The proposed implementation framework should include several stakeholders including the following:

- ***Ministry of trade and industries (MINICOM)*:** as a ministry in charge of industrial development. Considering its nature and responsibilities, MINICOM can contribute mainly to all strategic actions stipulated in the above mentioned table, They can take as well the lead in mainstreaming climate change adaptation and mitigation through policy direction and general guidance in implementation and evaluation.
- ***Rwanda Meteorological Agency (RMA)*:** Provision of weather information and provide early warning messages to various stakeholders.
- ***Rwanda Environment Management Authority (REMA)*:** being an authority in charge of environmental protection and pollution control, their role are also very crucial in developing specific guidelines to be used for industries. Additionally, REMA as a champion of all climate change activities in the country, It should contribute to various strategic actions and manage well climate change portal.
- ***Rwanda Resource Efficient and Cleaner Production Center (RRECPC)*:** It will also have an important role especially in the mainstreaming of climate change mitigation and adaptation as they are currently involved in technology transfer to industries.
- ***Rwanda Standard Board (RSB)*:** with its mandate to ensure standardization, RBS will also play an important role in the implementation as they will certify if technologies to be used are up to standards and can be easily adapted in Rwanda. They will also play an important role in developing relevant standards to be used in the implementation process and eco-labeling.
- ***Rwanda Utility Regulatory Authority (RURA)***: being the regulatory authority, their role is also crucial as they will be regulating utilities and incorporating the aspect of green industry before issuing their permit, this is mainly applicable to energy developmental companies (type of technologies are they using), water and wastewater treatment technologies to be applied here, telecommunications technologies amongst others
- ***Private Sector Federation (PSF)*:** being the organ looking for the private sector, industries inclusive, their role is very crucial as they represent them at the decision making level.
- ***Rwanda Development Board (RDB)*:** being the organ in charge of development and having first contact with investors in the country, they role is also important as they should encourage investment which are climate sensitive.
- ***Ministry of local government (MINALOC)*:** awareness raising on climate sensitive activities

- ***District Local Governments*:** as government implementers for different initiatives, including industries approval before being implemented, they should also own the policy and participate in its development as well as its implementations.
- ***Ministry of economic planning and Finance (MINECOFIN)***
- ***Ministry of Education;(MINEDUC)***
- ***Rwanda Revenue Authority (RRA)***
- ***Ministry of disaster management and refugee affairs (MIDIMAR)***
- ***Fund for Environment and climate change (FONERWA)***
- ***Universities and research institutions*:** their inputs will mainly be on research perspectives where low carbon technologies and benchmarking through Center for innovation and technology transfer, incubation centers, center of excellence, etc..
- ***International organizations such as UNIDO and UNEP***: their input will mainly be giving the international global perspective on climate change and what have been already done in other countries as a benchmark for our case.

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ANNEXES

ANNEX 1: GREEN INDUSTRY CONCEPT

1. BACKGROUND

The Green Industry Initiative is an initiative of the United Nations Industrial Development Organization (UNIDO). Its objective is the mainstreaming of social and environmental considerations into the operations of enterprises in all countries and regions through the more efficient use of energy and raw materials, innovative practices and applications of new green technologies. The initiative was launched in September 2009 at the International Conference on Green Industry in Asia in Manila, Philippines. (UNIDO[a], 2011).

Green Industry is industrial production and development that does not come at the expense of the health of natural systems or lead to adverse human health outcomes.. It provides a platform for addressing global, interrelated challenges through a set of immediately actionable cross-cutting approaches and strategies that take advantage of emerging industry and market forces.

It promotes sustainable patterns of production and consumption i.e. patterns that are resource and energy efficient, low-carbon and low waste, non-polluting and safe, and which produces products that are responsibly and sustainably managed throughout their lifecycle. The Green Industry agenda covers the greening of industries, under which all industries continuously improve their resource productivity and environmental performance (UNIDO[a] , 2011).

It also aims to create green industries, that deliver environmental goods and services in an industrial manner, including, for example, waste management and recycling services, renewable energy technologies, and environmental analytical and advisory services.

The greening of industries has become a core determinant of economic competitiveness and sustainable growth. Since resource inputs represent an important production cost for industries, improving efficiency gives industries a competitive advantage. The greening of industries also plays a role in poverty alleviation, through promoting energy security, health and safety, jobs, and reducing costs through increased productivity.

1. RELEVANCE OF GREEN INDUSTRY

Developing countries like Rwanda need to expand their industries, which may result in unsustainable economic growth from resource depletion and severe environmental degradation. In addition, production and consumption patterns may outpace the renewal capacity of natural resources and the capacity of local governments to manage waste products. The greening of

industries by the government will therefore be a proactive way to decouple environmental pressures from economic growth.

More over with green industry there are several advantages. These include:

1.1 ECONOMIC BENEFITS

For most industries, increasing resource efficiency in production is not a response to environmental concerns or objectives. It has become a core determinant of economic competitiveness and sustainable growth. Since resource inputs represent an important cost of production for industries, efficiency improvements can be a significant lever for competitive advantage (UNIDO[b], 2011) . Moreover, reductions in production costs can result in lower prices for consumers.

Some of the economic arguments behind resource efficiency as a means of transforming and stimulating the economy are highlighted by the Natural Edge Project (Weizacker et al 2009). First, investments in resource productivity, such as building energy efficiency have a higher economic multiplier than general expenditure. This is because in addition to improving productivity, resource efficiency investments provide a tangible financial return on investment.

Secondly, investments in improving resource efficiency and recycling reduce the demand for energy, water and virgin resources, thus reducing the need to invest billions on new energy and water supply infrastructure and new extractive industries.

1.2 CREATING JOBS

Jobs are created through the greening of industries. The number of green jobs is already on the rise with the most rapid expansion being seen in the renewable energy sector. For example, current employment in renewable and supplier industries stands at a conservatively estimated 2.3 million worldwide (UNIDO[b], 2011). Basic manufacturing industries such as steel, aluminum, cement and paper are starting to stimulate green jobs through scrap use, greater energy efficiency, and reliance on alternative energy sources.

1.3 ALLEVIATING POVERTY

The greening of industry has an important role to play in poverty alleviation. First, greater efficiency in resource use over the life cycle of goods and services results in improved productivity and consequently, reduced costs.

Growth in consumer demand for sustainable products can provide sustainable producers in developing countries with access to new markets (e.g. environmental goods and services), job opportunities, and price premiums for their products – all of which can facilitate the transition

towards a green economy. Moreover, the greening of industry can provide development opportunities in instances where labor intensity (and associated employment) replaces a high dependency on inputs or energy-intensive mechanized processes. Environmental sustainability initiatives can also be part of a wider shift towards socially and economically responsible production and consumption, which can further strengthen poverty alleviation benefits.

2.4 ENVIRONMENTAL PROTECTION

It is well understood that the development of green industry concept will highly contribute to sustainable environmental protection when is properly implemented. The green industry will contribute to the protection of natural resources (water, air, land or any other resources) by providing better strategies and techniques used in minimizing gaseous emissions and waste (solid and liquid).

2. CHALLENGES TO GREEN INDUSTRY

There are three major barriers to green industry concept:

- Lack or insufficient knowledge and skills: Numerous enterprises and industries do not have the necessary skills to deal with greening process. They are also not aware of the business opportunities linked to the production of sustainable products.
- Lack of an adequate external support system: Even where enterprises and industries are aware of the business opportunities the green industry concept opens up for them, they do not have at hand the necessary specialized industry support institutions to assist them.
- Lack of consistent policy framework: Governmental policies are not creating sufficient incentives to allow enterprises to take on and overcome challenges to take advantage of the business opportunities available.
- Lack of Science and technology framework: It is easier for industrial enterprises to green themselves if they are backed up by a science and technology framework that encourages green innovation as well as the transfer, development, adaptation of cleaner process technologies, recycling technologies, renewable energy technologies, and other environmentally sound technologies (UNIDO, 2009).

3. APPROACH AND METHODOLOGY

As explained earlier, Green Industry is an important pathway to achieve sustainable industrial development; this will be achieved through a two-pronged strategy; in order to create an industrial system that does not require the ever-growing use of natural resources and pollution for growth and expansion.

The two strategies to achieve green industry are "Greening of the existing industries" and "creation of green industries".

- **Greening of existing industry:** Enable and support all industries regardless of their sector, size or location, to green their operations, processes and products by using resources more efficiently; transforming industrial energy systems towards greater sustainability by expanding renewable energy sources; phasing out toxic substances; and improving occupational health and safety at the industrial level.
- **Creating green industries:** Establish and expand (new) green industries that deliver environmental goods and services. Green industry is a rapidly expanding and diverse sector that covers all types of services and technologies that help to reduce negative environmental impacts and resource consumption. This includes material recovery, recycling, waste treatment and management, as well as the provision of environmental and energy consulting and services, such as energy service companies and companies that provide monitoring, measuring and analysis services.

4. STRATEGIC ACTIONS TO ACHIEVE GREEN INDUSTRY

Strategic actions to achieve green industry as explained above are summarized below:

Table1: Strategic actions for green industry

Element of Green Industry	***Strategic Actions for Green Industry***	***Description***	***Responsible institutions***
Both Greening of industries and creating	**Integrated framework to support the greening of industries**	*Green Industry Policy:* the greening of industries will requires effective and coordinated governance system to champion and support the implementation of green industry policies and initiatives. Clear government	MINICOM, NIRDA, RRECPC, REMA, RSB, PSF, RDB and MINALOC, International partners

green industries		commitment needs to come from the top, with supporting leadership throughout the public sector. The green industry policy will give clear roadmap on how to achieve it and embedded in the Industrial development strategies. *Policy and institutional integration* is paramount, and this can be supported by clear processes for integrating environmental, social, and economic goals, along with national strategies for implementing goals across responsibility areas. Policy integration should take place both "vertically" between different tiers of government; and "horizontally", between different sectors of government. To develop this policy not only the government should be involved but there should be collaboration with the community, non-governmental organizations (NGOs), industry, private sector, and any other relevant stakeholders. Finally, the government needs to be innovative and think strategically in developing policies targeted towards the greening of industries.	
Both Greening of industries	**Creating an enabling environment**	*Financial institutions* are important for supporting new business opportunities and the development and dissemination of new	MINICOM, NIRDA, RRECPC, REMA, RSB, PSF, RDB and MINALOC, International partners

and creating green industries		technologies. For instance FONERWA and BDF can be a good window for government environmental financing as an instrument for promoting resource efficiency measures through financial institutions or independent funds. *The provision of infrastructure* to support the greening of industries (e.g. wastewater treatment, recycling facilities, and sustainable energy supplies) should be a priority for our government. Mobilizing resources for infrastructure development remains a considerable challenge for governments, and therefore, efforts should be made to leverage financing from private sector partnerships, Foreign Direct Investment (FDI), and country cooperation. *Education and Training:* Finally, the greening of industries is encouraged through supporting local communities that are well educated about the environmental, social, and economic benefits of resource efficiency, cleaner production, and responsible life cycle analysis. Education and training for resource efficiency should be undertaken as a continuing commitment throughout the educational curriculum.	

Greening of industries	***Supporting industry-led initiatives***	*Rwanda Resource Efficient and Cleaner Production Centre reinforcement:* The government of Rwanda can positively influence the internal decision-making processes within enterprises through policies and incentives that promote improved production efficiencies and environmental management. Long-term partnerships between the government and business are important in fostering improved efficiencies and environmental management. For instance this has been already initiated through RRECPC where they are currently working with 70 industries. Such initiative should be strengthened and expanded with bigger capacity. *Industry-led initiatives such as eco-labeling*, environmental management systems, standards, corporate social responsibility and environmental accounting can be promoted by governments through incentives and funding support. Policies should be designed to promote pro-active actions, rather than providing means of avoiding compliance. The government can promote responsible life cycle analysis through initiatives such as extended Producer responsibility and	MINICOM, NIRDA, RRECPC, REMA, RSB, PSF, RDB and MINALOC, International partners

		through standards and assessments required for green supply chain networks.	
Both Greening of industries and creating green industries	***Harnessing environmental technologies***	*Science and technology* plays a vital role in encouraging manufacturing industries towards using sustainable patterns of production and economic growth. Since most developing countries make technological advancements by adapting pre-existing technologies, government assistance programmes should facilitate both the absorption and diffusion of new technologies. *Capacity development and technology transfer* can be achieved through the provision of information, demonstration projects, technical assistance programmes, workforce training, and the support of technical institutions (e.g. RRECPC, TVET program etc). The Government can facilitate knowledge transfer and the diffusion of environmental technologies through infrastructures such as science parks, clusters, incubators, global networks etc. Financial support instruments, such as Research & Development (R&D) grants, tax-breaks, and venture capital funds are important for supporting the development and widespread use of environmental technologies. The Government should support	MINICOM, NIRDA, RRECPC, REMA, RSB, PSF, RDB and MINALOC, International partners

		strategic R&D programmes linked to green industry, as a means of providing science platforms to leverage new environmental technologies. *Integrated and strategic science system* is needed to support the greening of industries, which includes coherence between environmental and innovation policies. The Government can employ techniques such as environmental scanning to keep abreast of new technological breakthroughs.	
Both Greening of industries and creating green industries	***Instrument mixes to promote the greening of industries***	The government needs to ensure that they have an optimal mix of instruments in place, which are supported by national strategies and integrated policy frameworks. Policy instruments need to be championed, designed, adopted and implemented by all levels of government – i.e. at the local, national and international levels and across all relevant policy sectors. Furthermore, instrument mixes should be flexible and broad-based, and should not overlap in their application. Policy frameworks targeting the greening of industry should comprise a mix of market-based, regulatory, voluntary, and information-	MINICOM, NIRDA, RRECPC, REMA, RSB, PSF, RDB and MINALOC, International partners

		based instruments. Governments should consider Market-Based Instruments (MBIs) such as taxes, charges, tradable permits as least-cost policy instruments, which spur technological innovations. Moreover, successful implementation of MBIs requires a system of monitoring, revenue collection and enforcement. Regulatory policies (e.g. norms, standards and abatement policies) forms the basis of most environmental management regimes. To be effective, regulatory policies should be flexible and well-designed so not to stifle technological innovations. Information-based instruments (e.g. eco-labeling, public disclosure) can strengthen the effectiveness of other policy measures, such as environmental taxes. Environmental monitoring and reporting systems should be established to identify violations and to assess whether policies have been effective over the long-term. Indicators should form part of all monitoring and enforcement regimes, as a tool to simplify, quantify, and	

		communicate environmental data. Effective compliance regimes should include a combination of promotion, monitoring, and enforcement tools, which are mutually supportive. Methods to promote compliance, such as education, training and outreach, are an important feature of enforcement and compliance regimes.	

1. IMPLEMENTATION FRAMEWORK

The implementation framework of Green Industry Concept should follow the figure below:

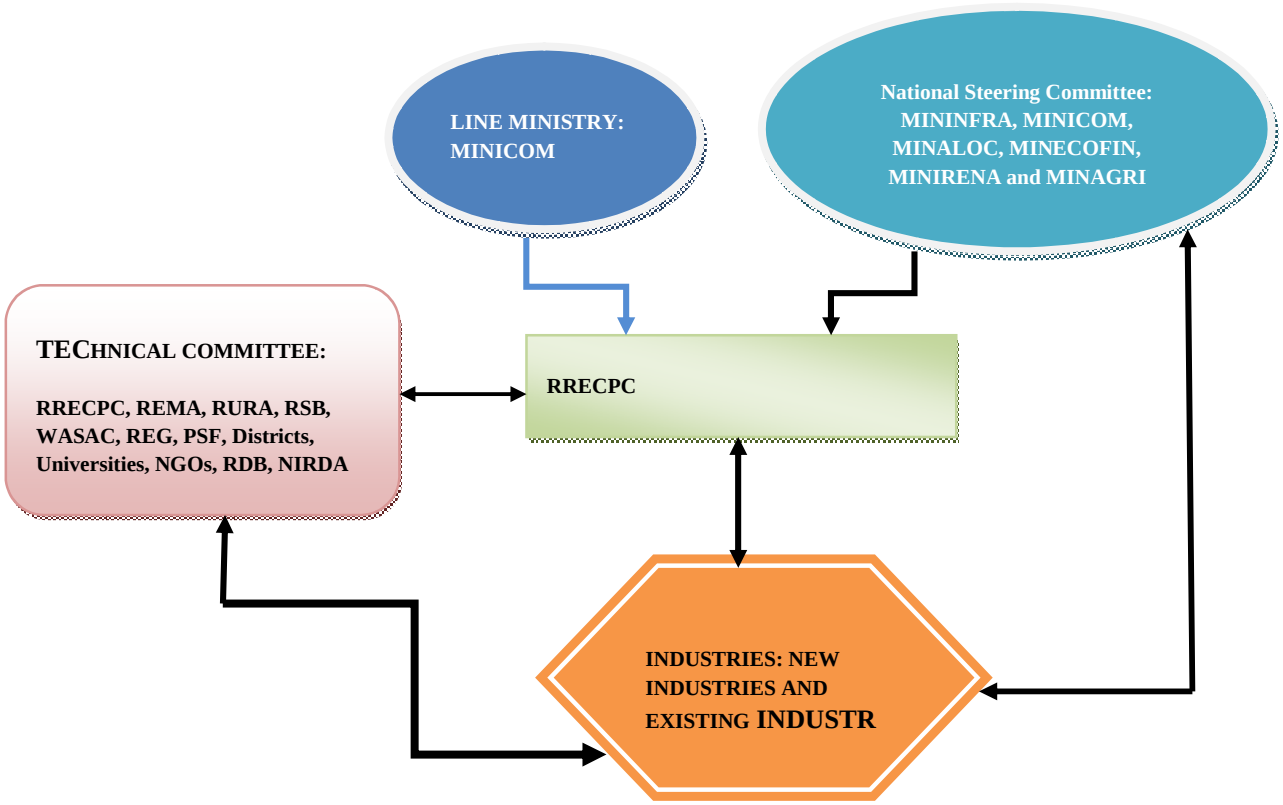

Figure1: Coordination chart for Green Industry Concept

From the above chart, the coordination will be done by RRECPC as this being a center working closely with industries, it will impact more positively than having a stand - alone unit. In addition to its attributions, RRECPC will make sure that the following functions are fulfilled:

- Coordination of the Inter-Sectoral Technical Committee. Coordinate the decentralized Green Industry structures, including two-way vertical coordination and horizontal coordination for sharing innovations;
- Prepare the Annual National GI Report and the Annual National GI Action Plan, which will be integrated into sector plans. Promote and establish sustainable sectoral and inter-sectoral Green Industry agreements and partnerships between Government, donors and private sector organizations;
- Guide the development of Pre- and In-Service Cleaner production Training Systems through maximising the use of existing institutional resources and establishing effective partnerships with institutions of higher education;
- Design and manage the GI Monitoring and Evaluation System and coordinate Applied Research Projects in the area of GI. Prepare and implement the strategic plan for Green Industry.

NATIONAL STEERING COMMITTEE:

The Green Industry concept and its Strategic Plan implementation will be governed by both political and operational structures. At the political level, a National Steering Committee composed of a core group of Ministers will provide overall leadership and guidance on the implementation of the Strategic Plan and the achievement of the Green Industry concept Actions.

Roles and responsibilities of each line ministry are as follows:

MINICOM: The ministry of commerce and Industrial development shall chair the national steering committee of Ministers and shall be the champion of the Green Industrial Concept and have the overall national over-sight and working closely with the inter-ministerial committee on approval of strategic plans and policies.

MINIRENA: The Ministry of Natural Resources will ensure development of strategies to promote partnership and enhance capacity of private sector and attract operators to invest in activities of environment and natural resources for sustainable economic development.

MININFRA: The Ministry of Infrastructure will ensure that the developed policies and strategies reflect a green industry concept which will facilitate the implementation for any other organs/institutions/private sector.

MINAGRI: The Ministry of Agriculture and Animal Husbandry will ensure transformation of Agriculture from subsistence to a productive high value; market oriented farming that is environmentally friendly and has an impact on other sectors of the economy.

MINALOC: The Ministry of Local Government shall be responsible of good coordination at local administrative entities by ensuring that green industry policy and strategies are well implemented.

MINECOFIN: The Ministry of Finance and Economic Planning will mobilize financial resources for the implementation green industry concept.

TECHNICAL COMMITTEE

The Technical Committee will be composed by staff from different Ministries, and Government agencies such as RRECPC, REMA, RURA, NIRDA, RSB, WASAC, REG, PSF, Districts, Universities, NGOs, RDB who will meet on a regular basis to agree upon specific actions and will report to the National Steering Committee on progress and plans. The Technical Committee will work closely with the RRECPC for the implementation of the Green Industry Concept and Strategic Plans.

Specific roles of each lines agency are as follows:

RRECPC: Rwanda Resource Efficient and Cleaner Production Center will have an important role especially in the implementation of the green policy as they are more linked to the industries in encouraging them to use resource efficiently and clean production technologies. They will therefore chair and coordinate all activities of Technical Committee.

REMA: Being the authority in charge of environmental protection and pollution control, its role is very crucial in developing specific guidelines to be used for industries and contributing to the development of the green industry policy.

RSB: With its mandate to ensure standardization, RSB will play an important role in the implementation of green industry strategy as they will certify if technologies to be used are up to standards and can be easily adapted in Rwanda. They will also play an important role in developing relevant standards to be used in the implementation process and eco-labeling.

RURA: Being the regulatory authority, its role is important as it will be regulating utilities and incorporating the aspect of green industry before issuing the permit, this is mainly applicable to

energy developmental companies (type of technologies they are using), water and wastewater treatment technologies to be applied here, telecommunications technologies etc…

PSF: Being the organ representing the private sector industries inclusive, their role is very crucial in the implementation of green industry policy and strategies.
RDB: Being the organ in charge of development and having first contact with investors in the country, they role is important as they should encourage investment which are green industry oriented. For that they have to advise investors who come to them on what are the expectation of Rwanda toward greening its industries.

WASAC & REG: As institutions in charge of provision of water , sanitation and energy, their role is important as they will need to have environmental oriented technologies- green industries for their water treatment, wastewater treatment plants, and their energy producing plants.

DISTRICTS: Because policy implementation is mainly through decentralized structure of governance, the RRECPC shall follow Government industrial initiatives through a decentralized system and this shall involve working closely with the Districts in the establishment of District Industrial parks, Special Economic Zones and follow up of implementation of the policy and strategies

UNIVERSITIES: Their inputs will mainly be on research perspectives on green technologies as well as knowledge transfer through Center for innovation and technology transfer, incubation centers and center of excellence.
NGOs: Their role will mainly be on advocacy and promotion of green technologies and cleaner production methods.

ANNEX 2: TOOLS

Form 1: Operations consent form; consenting procedure

INFORMATION TO BE SUBMITTED IN A NOTIFICATION FOR AN AGREED WASTE MANAGEMENT OR ANY OTHER OPERATION SYSTEM INSTALLATION

Notification for a system installation should contain at least following information:

(1) the name and address of the operator of the installation;

(2) a description of the process applied to the system activity, the relevant standards used, and the design options produced by this process;

(3) a description of the selected system concept in relation to the major hazard scenarios for the particular installation and its location, and the primary risk control features;

(4) a demonstration that the concept reduces likely major environmental hazard risks to an acceptable extent;

(5) a description of the system installation and the conditions at its location;

(6) a description of the types of the major possible environmental hazards in operations to be carried out;

(7) a general description of the safety management system by which the intended major hazard risk control measures will be maintained in good effect, including the scheme of independent verification.

INFORMATION TO BE SUBMITTED IN A MAJOR HAZARD REPORT AFTER OCCURRENCE OR SYSTEM VERIFICATION

Major Hazard Report for a System installation shall contain at least following information:

(1) a description of the account taken of the competent authority's response to the notification;

(2) a summary of any worker involvement in the preparation of the major hazards report;

(3) a description of the installation and connected infrastructure and any other structures connected to it;

(4) demonstration that all the major hazards have been identified, their likelihood and consequences assessed, and that their control measures are suitable so as to reduce risks of a major hazard event to persons and the environment to an acceptable extent;

(5) details of the types of operations with major hazard potential to be carried out, and the maximum number of persons that can be on the installation at any time;

(6) details of plant and arrangements to ensure system operation control, process safety, containment of hazardous substances, prevention of fire and explosion, protection of the workforce from hazardous substances, and protection of the environment from an incipient major hazard event (in line with the internal emergency plan);

(7) details of the arrangements to protect persons on the platform from major hazards, and to ensure their safe evacuation and recovery and for the maintenance of control systems to prevent damage to the installation and the environment in the event all personnel are evacuated;

(8) relevant codes, standards and guidance used in the construction and commissioning of the installation;

(9) information on the safety management system for operations, maintenance, modification, and verification schemes, including the main operational limitations of the installation to be controlled by the selected management system;

(10) any other relevant details, for example where two or more installations operate in combination in a way which affects the major hazard potential of either or all installations;

(11) a description of the aspects of the environment likely to be significantly affected, an assessment of the identified potential environmental effects, in particular releases of pollutants to the environment, and a description of the technical and non-technical measures envisaged to prevent, reduce or offset them, including monitoring.

Tool Table 5-1; Our environmental situation

Company: Name:				
Use of raw materials				
Use of energy				
Wastewater				
Pollution prevention				
Waste separation				
Exhaust air				
Smell				
Noise				
Conditions imposed by the authorities				
Neighbours				
Motivation of the management				
Motivation of the workforce				
Conditions at the workplace				
Transport/traffic				

Tool Table 5-1a: Our environmental situation

Company:	
Goal	**Quantification**
Disposal costs	
Reduction of	
Savings of raw	
Savings of energy	
Reduction of	
Reduction of	
Noise reduction	
Improved relations	
Company image	
Motivation of the	
Motivation of the	
.....	

Tool Table 5-2 Establishing the process resource in and output for a given industry

R	P*	Form	Cost, $	Process purpose	F *	Quantity	Quality	1st GHG Character	Adaptive intervention	2nd GHG Character
Raw Materials										
A- example Cotton		Raw			once				Organic planting	High yield per capita

B-										
C										
D										
E										
Water										
Energy										
Waste										

Key; Frequency of need, P- Period, Day/week

Tool Table 5.3 0

Process stage	**GHG recorded**	**Environmental Resource up taken**	**Recommended action**	**Observation**	**Comment**
Raw Material Extraction					
Raw material transportation					
Process in feed					
Mid process, material mixing					
Product output					
Packaging					
Distribution					

No.	Product or service/purpose	Annual quantity	Unit
1			
2			
3			

Tool Table 5-4: Main raw and process materials

	Company:				**Responsible:**		
No.	**Material**	**Annual quantity**	**Unit**	**Specific costs in …….**	**Total costs in ……**	**Purpose/use**	**% incorporated into the product**
1							
2							
3							

Tool Table 5-5: Energy data

No.	**Energy**	**Annual amount**	**Unit**	**Spec. costs**	**Conversion into kWh**	**Consumption in kWh**	**Share in %**	**Total costs in ….**	**Share in %**
1	Electricity Peak load		kWh kW						
2	District heating Peak load		GJ kW						

3	Oil		Kg						
4	Gas		Nm³						
5	[19]……								
6	…….								
7	……..…								
8	……..…								
9	Fuels: Diesel Petrol		Litre Litre						
10	…….								
	Total:						100 %		100 %

Company: Responsible:

Tool Table 5-6: Main types of waste and emissions

Company Responsible:

Page:

No.	Waste or liquid or gaseous emissions	Annual quantity	Unit	Spec. disp. costs	Purchasing costs	Disposal costs	Total costs
1							
2							
3							
4							
5							
6							

[19] Other energy sources such as: coal, liquid gas, wood, pellets, solar energy, etc.

7							
8							
9							

Tool Table 5-8: Possibilities of minimizing waste and emissions in the company

Company: Responsible:

Page:

Waste/emission/problem areas	Which possibilities are available in our company?

Tool Table-5-9: Analysis of strengths/weak points

Company: **Period:**

Issue	Strengths	Weak points	Potential for optimization	Indicator for evaluation
Use of raw materials				
Use of energy				
Wastewater				
Waste avoidance				
Waste separation				
Exhaust air				
Smell				
Noise				

Company: **Period:**

	Strengths	Weak points	Potential for optimization	Indicator for evaluation
Permits/ Authorizations				
Neighbours				
Motivation of the management				

Motivation of the employees				
Conditions at the workplace				
Transport/traffic				

Tool table-5-10: Contents of an environmental policy – thematic focuses

Company: **Period:**

▪ Common strategic orientation of the company ▪ Saving of resources ▪ Compliance with legislation ▪ Communication and information to the public ▪ Responsibility and training of employees ▪ Commitment to continuous improvement ▪ State of the art technology ▪ Specific company-related environmental effects ▪ Commitment of the management	

Tool table-5-11: Idea pool

Company:

Idea pool			
Idea from workshops	**Area**	**Problem in company**	**Reason for taking action**

Specific idea	Cause	Objective/improvement	Specific measure

Tool table-5-12: Water data sheet

Balance scope: Balance period:

No. [1]	Water input	Quantity	Unit[2]	Data source[3]/notes
			m³	
			m³	

Company:

No. [1]	Water consumer	Quantity	Unit[2]	%	Data source[3]/notes
			m³		
			m³		
			m³		
			m³		
			m³		
			m³		
			m³		
			m³		

No. [1]	Water output	Quantity	Unit[2]	Notes
	Wastewater discharge O direct		m³	Important materials: Important limit values: Description of on-site wastewater treatment:
			m³	
			m³	

[1] = Position no. from flowchart 3-1 [2] = Balance in m³ not precise (general assumption: density 1 kg/l)
[3] = EDP, books, routine measurement, own measurement, information from production, documentation of equipment, calculation, estimate, etc.

Tool table-5-13: Material tracing sheet

Material:

Company:

Balance scope: Balance

No. [1]	Material input	Quantity	Unit[2]	Data source[3]/notes

period:

No. [1]		Quantity	Unit[2]	Data source[3]/notes

No. [1]	Material output	Quantity	Unit[2]	Data source[3]/notes

[1] = Position no. from flowchart 3-1 [2] = Balance should be drawn up in kg
[3] = EDP, books, routine measurement, own measurement, information from production, documentation of equipment, calculation, estimate, etc.

Tool table-5-14: Meters and measuring instruments

Company:

Energy flow measured	Type of measurement and place	Meter no.	Current recording frequency	Recorded by:	Future recording frequency

Tool table-5-15: Conversion units and heat consumers

Company: **Period:**

	No.	Name	Energy carrier	Power ($kW_{thermal}$)	Consumption in	Operating hours per year	Parameter (p,T)
Heat	1						
	2						
	3						
	4						

	No.	Name	Power ($kW_{electric}$)	Power ($kW_{thermal}$)	Electr. consumption. in kWh	Operating hours per year	Notes
	1						
	2						
	3						

	No.	Name – use	Power ($kW_{thermal}$)	Operating hours per year	Consumption (power x hours, kWh)	Notes
Heat consumers	1					
	2					
	3					
	4					
	5					
	6					
		Total: **Percentage of total consumption:**				

Tool table-5-16: Electric consumers

Company: **Period:**

No.	Consumer – use	Year of constr.	Power in kW	Operating hours per year	Consumption (kWh/y)	Notes
1						
2						
3						
4						
5						
6						
7						
	Total:Percentage of total consumption:					

Tool table-5-17: Heat losses

Company: **Period:**

Exhaust gases, wastewater, etc.

Name of the heat flow	Flow rate		Temperature	Notes
	[m³/h]	**[m³/y]**		

Chilling units, cooling units, etc.

Name of the unit	Heating power	Temperature	Notes

Tool table-5-18: Energy saving options

Company:

Option	Expected savings	Date	Responsible

Tool table-5-19: Environmental evaluation of the most important products and services

Company: Period:

Product name: …….	Little env. friendly			Very environmentally friendly		Points
	1	2	3	4	5	
Hazardous ingredients						
Pollutants, air						
Pollutants, wastewater						
Pollutants, soil						
Raw materials						
Utilization of waste material						
Packaging						
Service life/shelf life						
Easy to repair						

Returnable						
Energy consumption						
Water consumption						
Recycling possibilities						

n.c.: not considered; n.a.: not applicable

Product name: ……	**Little env. friendly**			**Very environmentally friendly**		**Points**
	1	**2**	**3**	**4**	**5**	
Noise pollution						
Product declaration covers health **protection and** protection of **the environment**						
Special training for operators required						
Eco-label/quality label						
Additional criteria and information						
Total:						

n.c.: not considered; n.a.: not applicable

Tool table-20: Evaluation of suppliers

Company: **Period:**

Name of the supplier	**Does not meet requirements**	**Meets requirements**	**Points**

	1	2	3	4	5	
Site certification of the supplier (ISO 14001/EMAS)						
Information on product and material properties						
Consultancy on environmental aspects of the products						
Suggestions on environmentally friendly alternatives						
Product range includes environmentally friendly products						
Use of multi-way systems						
Multi-way packaging material						
Environmentally friendly transport						
Supplier from the region						
Customer service						
Price						
Total:						

n.c.: not considered; n.a.: not applicable

Tool table-21: Register of hazardous materials

Company: **Period:**

No.	SDS[20].	Product name	Use	Hazardous ingredient(s)	Classification according to GHS	Container volume	Maximum of quantity stored	Storage area
1								
2								

Tool table-22: Formation of indicators

Prepared by: **Date:**

Company: **Turnover:**

Production:

Relevant basic value[1]	Amount	Unit[2]	Relevant basic value	Amount	Unit[2]

Items[3]	Amount	Unit[2]	Description of indicator	Value of indicator	Unit	Planned indicator[4]

[20] SDS = safety data sheet

[1] Examples: produced amount in tons or units, production value in currency units, number of workers, area in the company, hall area; preferably enter the figure on which the target value depends; probably the amount of waste, emissions or wastewater generated, if there are legal provisions for the concentration of harmful substances.

[2] kg (raw materials, process materials), kWh (electrical energy), currency, m³, pieces, running metre, m², etc.

[3] Items are material flows with particularly high environmental relevance (defined by legislation or own estimates) causing significant costs. They include the general expenditure of the company for environmental activities. Use Worksheet 1-2 Main raw and process materials from Volume 1 as a guideline.

[4] Planned figures are derived from the environmental policy and the environmental targets, as well as from corporate optimization in general.

Tool table-23: Monitoring report

Date: **Prepared by:**

Next report:

Item	Total consumption absolute/year	Indicator	Actual indicator	Planned indicator	Deviation
Problems identified		**Measures**			

Tool table-24: Overview of the waste management system

Company: **Period:**

Position number	Plant area	Description of activity	Types of waste	Collecting system for hazardous waste

Tool table-25: Waste description – Non-hazardous waste

Company: **Period:**

Non-hazardous waste

Waste type	Position no.	Waste code	Annual waste volume [kg]	Disposal company	Collection intervals	Annual disposal costs […..]	Annual revenues […..]

Tool table 27: Audit form

Company:

Audited department		**Date:**
Auditor(s)		**Employees present**
Employees actually working	YES/NO	
Audit emphasis:		

The following documents were requested and reviewed:	**Work instructions, dosage recipes, etc.**	

No.	AUDIT Guide (Questions were taken from the checklist of Volume 9)	Rating of the process (10 perfectly organized, no waste, no optimization potential)				
	The following processes were reviewed:	2	4	6	8	10
1						
2						
3						
	x					
4	**Are clear work instructions available?**					
5	**Are working clothes in good condition? Is protective equipment in good condition and is it used?**					
6	**Are waste segregation logistics functional and used on site?**					
7	**Are the workstations clean?**					
8	**Are hygiene rules observed?**					
9	**Are the on-site security measures observed?**					

Deviations, defects, suggestions discussed on site:	**Implementation until/by:**	
Suggested measures for improvement:		
Positive findings and results:		

Signatures of the auditors:			
Discussed in the environmental team:			**Post audit required: YES/NO**
Measures implemented on the (date):			**Checked by:**

- **In the discussion, an atmosphere of confidence should prevail between the auditor and staff.**
- **Statements in the audit always have to be based on facts and not on assumptions or opinions of the auditors.**
- **If prescribed requirements or processes are not observed this is a deviation. Deviations and their causes must always be corrected.**
- **Suggestions are opportunities for improvement which do not represent deviations from the existing system.**
- **The implementation of the measures and/or the agreed correction of the deviations have to be checked by the auditors.**
- **Put the original and the supplements into a folder, submit copies to the environmental representative and the audited department**

Tool table 28: Product description

Process category: **Product:**	
1. Common name	
2. How is it to be used?	
3. Type of package	
4. Shelf life and at what temperature	
5. Where will it be sold? Consumers Intended use	
6. Labelling instructions	
7. Is special distribution control needed?	

ANNEX 3: LIST OF INTERVIEWED PEOPLES AND VISITED INDUSTRIES

No	Name	Tel Number	Position	Institutions
1	Mood Zeheeruddin	0785659867	General Manager	SteelRwa
2	Carine Mukashyaka	0788589454	Investment expert	EWSA
3	Nderelimana Vincent	0788621506	Hydropower expert	EWSA
4	Jean Mutabazi	0788304640	General Manager	Kitabi Tea Factory
5	Rutaganda Juvenal	0788300491	Operation Manager	CIMERWA
6	Robert Stephen	robert@sulfo.com	Soap operation manager	SULFO RWANDA
7	A.S Natarajan	0788433748	Cosmetic Manager	SULFO RWANDA
8	Steven Niyonzima	0788306742	National Coordinator	Rwanda Ressource and Cleaner Production Center
9	Ritesh Patel	0778303031	Chief Financial Officer	UTEXRWA
10	Mugwiza Telesphore	0782494406	Director Industry	MINICOM
11	Tuyishime Jean Rene Marius	0788400863	Environmental focal point	MINICOM
12	Robert Bayigamba	0788301309	Chairman	Manufacturing association/PSF
13	Ivan Twagirishema	0788303959	Chairman	Industries chamber/PSF
14	Kalimba Jean Marie	0788307510	Production manager	AMEKI Color
15	Rusirare Jacques		CHAIRMAN	Ameki Color
16	Nicholas Hitimana	enhitimana@yahoo.co.uk	Managing Director	Ikirezi Natural Product
17	James Biseruka	0788304966	Plant Director	Inyange Industries
18	David Mutangana	0788612977	Administrative Manager	Karongi Tea Factory

19	Kagoyire Jeanne Francoise	0788358686	Technician	SKOL
20	Habimana Andre		Country Manager	UNIDO
21	Huseein Mansour	0788504243	Managing Director	Rwanda Oxygen
22	Kinyogote Cyrillo	0788304831	Managing Director	Kigali Maize Factory
22	Ngamije Lambert	0788304627	Operation Manager	MINIMEX
23	Nkubito Alphonse	0788623804	Technician	SADOLIN
24	Modeste Nkuranga	0788498407	Plant Manager	ROKA RWANDA
25	Alexis Dushimire	0788537647	Technician	SAFINTRA
26	Ntaganira Celestin	0788350109	Technical Director	BRALIRWA
27	John Mutabazi	0788302820	Managing Director	Rwanda Mountain Tea
28	Kayitare Georges	0788301395	Chairman Association	Kibondo Milk Collection Center
29	Kananura Rene	0788305690	Managing Director	Caferwa
30	Chantal Maweya	0788301669	Chairman	Kigali Textile Designer
31	Evariste Karenzi	0788520279	Operator	Rugezi hydropower Plant
32	Vincent Rusanganwa	0788771842	Plant Manager	Keya hydropower Plant
33	Justin Hategekimana	0782895495	Cooperative Member	Cooperative ADARWA-Gakinjiro/Wood Manufacturing