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Supporting the improvement
of the development strategy and policy for

ETHIOPIA'S TECHNOLOGY-BASED CHEMICAL INDUSTRY

INCLUSIVE AND SUSTAINABLE INDUSTRIAL DEVELOPMENT

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Abbreviations

AACCSA	Addis Ababa Chamber of Commerce and Sectoral Association
AfDB	African Development Bank
CCIIDI	Chemical and Construction Inputs Industry Development Institute
CIDD	Chemical Industry Development Directorate
COMESA	Common Market for Eastern and Southern Africa
CSA	Central Statistics Agency
ETB	Ethiopian Birr
FDI	Foreign Direct Investment
GDP	Gross Domestic Product
GTP	Growth and Transformation Plan
ICT	Information and Communication Technology
IDSP	Industrial Development Strategic Plan
ILO	International Labour Organization
IMF	International Monetary Fund
ISO	International Organization for Standardization
MOI	Ministry of Industry
MOST	Ministry of Science and Technology
MSMEs	Ministry of Micro, Small and Medium Enterprises
NCS	National Competency Standards
NTRM	National Technology Roadmap
OECD	Organization for Economic Co-operation and Development
R&D	Research and Development
SDG	Sustainable Development Goal
SMEs	Small and Medium-sized Enterprises
STI	Science Technology and Innovation
UN	United Nations
UNCTAD	United Nations Conference on Trade and Development
UNDP	United Nations Development Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNIDO	United Nations Industrial Development Organization
USD	United States Dollars
WHO	World Health Organization
WTO	World Trade Organization

Contents

Figures

Tables

Preface

Ethiopia has become a fast-growing African country with high economic growth since 2007. In light of its economic achievement, the Government of Ethiopia produced an Industrial Development Strategic Plan (IDSP) (2013-2025) to achieve structural change in the economy by increasing the industrial sector share and transform Ethiopia into a middle-income country by 2025. Ethiopia is now in the third year of the 2nd Growth and Transformation Plan.

As the economy has grown, the chemical industry is increasing its importance in Ethiopia as a core industry to provide inputs for other domestic industries like textile, leather, food and agriculture, and accordingly strengthen inter-industrial linkages. However, even though Ethiopia has had some notable progress until now including the design of the current Chemical Technology Roadmap, the chemical sector in Ethiopia is in still an infant stage suffering from lack of finance, shortage of skilled labor force and out of date technology.

Ethiopia has formulated its development strategy and policy for the chemical sector along with the development objectives and goals. It seems, however, not to be at an implementable level and lacks clear linkages between objectives, strategies and project. In this regard, it is required to improve their current chemical development strategy and policy in a more feasible and future-oriented way to support the rapidly growing economy of the country.

Following the suggestions from the Ministry of Trade and Industry of Ethiopia, this report covers researches and policy recommendations for the improvement of the development strategy for Ethiopia's technology-based chemical industry; Analysis of the current development status and policy framework in Ethiopia's chemical industry, Research on sector selection and prioritization in Ethiopia's chemical industry, R&D policies with its international experience and National Innovation System in Ethiopia, Development strategy for technology-based chemical industry of Ethiopia, and Recommendation for the Ethiopia's Chemical National Technology Roadmap. Our specialized chemical experts gathered the initial data and then collected primary data by undertaking field-studies, interviews, and local market analysis in chemical industry in Ethiopia. Our work was a combination of primary, secondary research data and cooperation with the relevant government officials in Ethiopia. Nonetheless, it must be stressed that there were limitations and difficulties due to the lack of available data in Ethiopia.

We hope that this report will contribute to Ethiopia chemical industry's successful transformation towards technology-oriented development to meet the domestic demands from the rapidly growing economy and compete with the foreign products. UNIDO is pleased to accompany the country in their future endeavour of designing detailed action plans to realize the recommendations addressed in this report.

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CHAPTER I

OVERVIEW OF ETHIOPIA'S CHEMICAL INDUSTRY

1. Introduction

Ethiopia, which is officially known as the **Federal Democratic Republic of Ethiopia**, is located in the Horn of Africa. It is the second most populous nation in Africa, with over 82 million inhabitants, and the tenth largest African nation with a land area of 1,126,829 km^2. It is the world's 27th largest country, comparable in size to Bolivia. The country lies between latitudes 3° and 15°N, and longitudes 33° and 48°E. Ethiopia, whose capital city is Addis Ababa, is a landlocked nation bordering Eritrea in the north, Djibouti and Somalia in the east, Sudan and South Sudan in the west, and Kenya in the south. It is thus also the most populous landlocked nation in the world.

The governance system consists of a federal structure, comprising the federal government, nine regional states and two chartered cities. It has a written constitution, with a bi-cameral parliament composed of the House of People's Representatives and the House of Federation. The term of house members is five years.

Industry emerged as an economic activity in Ethiopia at the turn of the 20th century. The establishment of a strong central government, the expansion of cities associated with the installation of railways and the strengthening of foreign relations increased the demand for imported manufacturing commodities. This provided stimulus to the establishment of import-substituting factories. As a result, modern manufacturing enterprises began to emerge in the 1920s[1]. After a brief disruption in the Second World War period, Ethiopia's manufacturing sector regained momentum in the 1950s. During this period, a number of new industries contributed significantly to the development of the national economy. In that period, a comprehensive plan was developed to stimulate and guide the country's industrial and economic development.

Ethiopia has become a fast-growing, non-oil-dependent African economy since 2007. It has experienced more than a decade of high economic growth with an average growth rate of 8.1 per cent in GDP per capita, and an average economic growth rate of 11 per cent over the last decade, repositioning the country in the top five countries in the world in terms of GDP growth rate. Driven by global competitiveness, the Government of Ethiopia prepared an Industrial Development Strategic Plan (IDSP) (2013-2025). The IDSP's overall goal is to accelerate the country's economic transformation by advancing industrialization. It aims to achieve structural change in the economy by increasing the industrial sector share as a percentage of GDP from currently 13 per cent to 27 per cent by 2025, as well as increasing the manufacturing sector's share from currently 4 per cent to 17 per cent by 2025. The Plan became the source for developing a national manufacturing strategy intended to increase the share of industrial output from currently 33 per cent to 63 per cent, transforming Ethiopia into a middle-income country by 2025. It is now in the third year of the 2nd Growth and Transformation Plan. The industrial and manufacturing sectors are expected to lead and underpin inclusive and sustainable economic

[1] In 1927, about 25 factories for wood, clay, tanneries, soap, edible oil, ammunition, brewery, tobacco, cement, and grain milling were set up in some major cities. Most of the factories were owned by foreigners. Between 1928 and 1941, over ten new manufacturing plants were established in Ethiopia by Armenian and Greek settlers.

growth. The IDSP strategy of economic development can be summed up as a “two-pronged strategy” based on export promotion and import substitution.

1.1 Demography & Human Development

Ethiopia is a predominantly agricultural country. More than 80 per cent of the population lives in rural areas, i.e. are in the early stages of a demographic transition. The infant, child and maternal mortality rates have dropped sharply over the past decade, with the total fertility rate declining more slowly and the population continuing to grow. The rising age of marriage and the increasing proportion of women who are remaining single have contributed to the reduction of the fertility rate. While the use of modern contraceptive methods among married women increased significantly from 6 per cent in 2000 to 27 percent in 2012, the overall rate is still quite low.

Table 1 Ethiopia: Health Profile

1	Population (2017)	105,350,020
2	Birth Rate (2017)	36.5 birth /1000 population
3	Death Rate (2017)	7.7 deaths/1000 population
4	Infant Mortality Rate (2016)	49.6 deaths/1000 live births
5	Maternal Mortality Rate (2015)	353 deaths/100,000 live births
6	Fertility Rate (2017)	4.99 births/woman

Source: CSA

Ethiopia’s rapid population growth is placing increasing pressure on land resources, intensifying environmental degradation and vulnerability to food shortages. With over 40 per cent of the population below the age of 15 and a fertility rate of over 5 children per woman (and even higher in rural areas), Ethiopia must address its family planning needs if it is to achieve the age structure necessary to reap a demographic dividend in coming decades.

Table 2 Ethiopia: Demographic Profile

1	Sex Ratio (2016)	0.99 men/women
2	Median Age (2017)	17.9 years
3	Population Growth Rate (2017)	2.5 per cent
4	Mother’s Mean Age at Birth (2016)	20 years
5	Literacy Rate (2017)	49.1 per cent
6	School Life Expectancy (2017)	8 years
7	Child Labour (between 5-14 years) (2005)	53 per cent
8	Net Migration Rate (2017)	-0.2 migrants/1000 population

Source: CSA

1.2 Infrastructure

While the Ethiopian government has been formulating policies to support specific industries, the federal budget, for the better part of the past 20 years, has been framed around infrastructure policies that are more "horizontal" in nature. Infrastructure contributes nearly 0.6 per cent to Ethiopia's annual per capita GDP over the last decade. As already mentioned, Ethiopia is a predominantly rural country. Addis Ababa is by far the largest urban centre in the country. The population and agricultural activity are concentrated in the central and northern areas of the country, and the far south and east are only sparsely inhabited. Ethiopia's infrastructure development is centred in Addis Ababa and spreads outward from there. The existing literature indicates that infrastructure constraints are responsible for an estimated 50 per cent of the productivity barriers Ethiopian firms face.

Table 3 Ethiopian Infrastructure Sector: Overview of Achievements & Challenges

Sectors	Achievements	Challenges
Air Transport	One of the top three airline carriers in Africa. Major regional hub.	Improving air traffic control at Addis Ababa Bole Int. Airport. Developing domestic air transportation.
ICT	96% of rural Ethiopia is covered by the telecom network.	Modernize the regulatory framework. Award a second mobile license. Rebalance ICT tariffs in line with costs.
Power		Launch large investment programme. Address under-pricing of power.
Surface Transport	Major investment required in trunk network. Sound road fund in place for maintenance.	Improve rural connectivity. Concession railway.
Water Resources		Develop additional water storage. Develop viable area for irrigation.
Water & Sanitation	Rapid expansion coverage.	Address utilities inefficiencies.

Source: UNIDO elaboration based on information from various referred literature listed in the bibliography

The road network expanded from 26,550 km in 1997 to 53,997 km in 2011. Rural road accessibility is still very low. According to a GIS-based analysis, only 10 per cent of Ethiopia's rural population lives within two kilometres of an all-weather road. As approximately 76 per cent of Ethiopia's population lives in rural areas, the degree of isolation is quite high.

Ethiopia is a landlocked country, and its rail corridor is at the same time its freight link with the rest of the world, including its neighbours. Ethiopia depends on the Port of Djibouti to process 95 per cent of its trade. The total length of the country's railway is 759 km, of which 754 km run between the two terminal stations at Sebeta and the Port of Doraleh. The remaining five kilometres are used for shunting operations. A total of 666 km of the railway line is in Ethiopia, while 93 km is in Djibouti. The rail corridor between Addis Ababa and the Port of Djibouti has deteriorated and fallen into disuse due to better road connectivity and the cheaper cost of transportation. Due to intense competition with the road sector and relatively low volumes of freight traffic overall, the Ethiopian government has generally failed to raise adequate revenues to finance major rail corridor development and rehabilitation programmes.

From a very low base, access to improved water and sanitation is rising rapidly. The majority of Ethiopia's population lacks access to clean water and sanitation. Close to 68 per cent use surface water for drinking purposes and 62 per cent practice open defecation, representing a major public health risk. The water deficit is largely explained by the very low reliance on boreholes (10 per cent in Ethiopia compared with 38 per cent for the benchmark). The poor sanitation is largely explained by the low coverage of traditional latrines (35 per cent in Ethiopia compared with 48 per cent for the benchmark).

The country is set to quadruple its power generation capacity once the Grand Ethiopian Renaissance Dam on the Nile becomes fully operational. As one of the largest hydroelectric power stations in the world, the dam will generate 6,000 MW. Ethiopia currently has one of the most underdeveloped power systems in sub-Saharan Africa. Its installed generation capacity is less than 10 MW per million population. Power consumption at 33 kWh per person per year and access to electricity at 12 per cent is below the already low benchmark for LICs in Africa. Urban access to electricity is actually exceptionally high at 86 per cent. Ethiopia ranks second behind the Democratic Republic of Congo in terms of potential hydropower reserves, and has the capacity to become Africa's largest exporter of power.

1.3 Economy

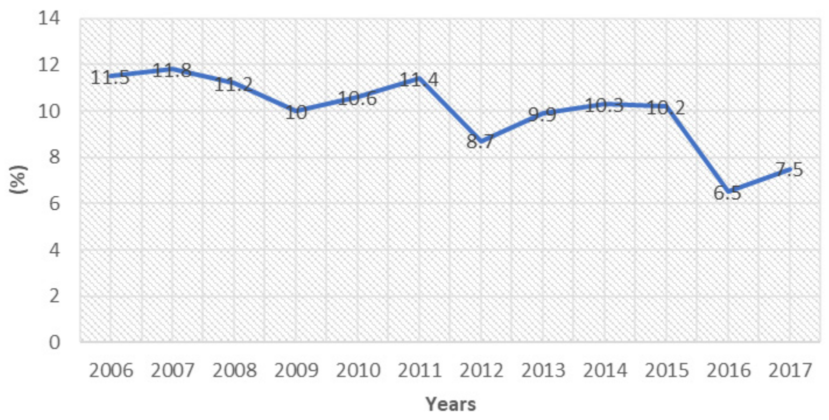
Despite fast growth in recent years, Ethiopia has a low GDP per capita worldwide, and the economy is characterized by a number of serious structural problems. Ethiopia has the lowest level of income inequality in Africa (and in fact, one of the lowest in the world), with a Gini coefficient comparable to that of Scandinavian countries. Yet despite the progress that has been made towards eliminating extreme poverty, Ethiopia remains one of the poorest countries in the world, due both to rapid population growth and a low starting base. Changes in rainfall associated with worldwide weather patterns resulted in the worst drought in 30 years in 2015-16, creating food insecurity for millions of Ethiopians.

Ethiopia's economy experienced strong, broad-based growth averaging at 10.5 per cent per annum from 2005/06 to 2015/16 compared to the regional average of 5.4 per cent. The expan-

[2] The benchmark level for Low Income Countries in Africa
[3] Ibid.

sion of services and agriculture accounted for most of this growth, with manufacturing growth remaining modest. Private consumption and public investment explain demand-side growth during this period, the latter assuming an increasingly important role. Due to the higher economic growth, a positive trend in poverty reduction was visible in both urban and rural areas.

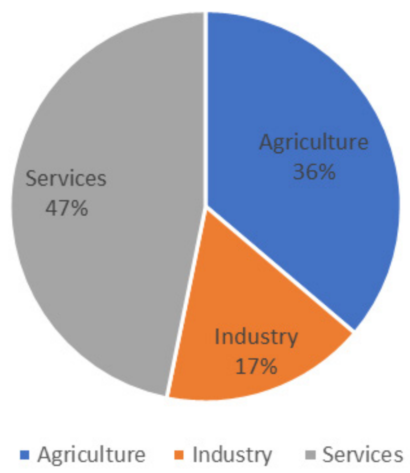
Figure 1 GDP Growth Rate



Source: UNIDO elaboration

The current GDP per capita is USD 830 (current prices) against USD 2071 (PPP). However, Ethiopia remains among the 20 poorest countries of the world. The country's economic growth is struggling to keep pace with the rising population; and the country spends more on importing goods than it earns from exports. Inflation has caused rising costs of living. In 2000, 55.3 per cent of Ethiopians lived in extreme poverty. By 2011, however, this Figure decreased to 33.5 per cent. According to a World Health Organization (WHO) study, nearly 40 per cent of Ethiopia's population lived below the international poverty line, earning less than one dollar per day. Recently, the economic growth rate has declined to about 8 per cent due to the contraction of the global economy.

Figure 2 GDP Composition by Sector (2016)



Source: UNIDO elaboration

Agriculture accounted for nearly 36 per cent of GDP and almost 80 per cent of exports in 2016. Eighty per cent of the population are employed in agriculture. Ethiopia is often ironically referred to as the "Water Tower" of Eastern Africa because of the many rivers (14 major rivers) that run through the high tableland. It also has the largest water reserves in Africa, but only few irrigation systems to make use of them exist. Only 1 per cent of the water is used for power production and 1.5 per cent for irrigation purposes. Consequently, agricultural productivity remains low, and frequent droughts continue to beset the country's economy.

The 10 per cent annual economic growth in the last decade is indicative of the effectiveness of the government's policies. Despite these improvements in the economy, the social structure is weak and the urban and rural population remains in abject poverty. Other economic activities such as marketing, processing, and agricultural exports depend considerably on agricultural output. The majority of agricultural production is carried out by small-scale farmers and small enterprises. The large share of commodity exports can be attributed to the small agricultural cash-crop sector. Principal crops include coffee, pulses (e.g. beans), oilseeds, cereals, potatoes, sugarcane and vegetables. Export shares are dominated by agricultural commodities, and coffee is the largest source of foreign exchange earnings. Ethiopia is Africa's second biggest maize producer and has the largest livestock population in Africa.

Ethiopia's industrial sector accounted for 17 per cent of GDP. This growth can primarily be attributed to the country's construction boom. Manufacturing has also been crucial. Ethiopia emerged as the third largest cement producer of Africa. This sector grew at 11 per cent annually and manufacturing exports increased more than eleven-fold. This was largely due to the increasing export earnings of the footwear and apparel industries. One reason for this increase is the strong linkages of these industries with the agricultural sector as they use inputs from livestock and cotton sectors. As both the footwear and apparel industries are labour intensive, they have absorbed labour from the agricultural sector. They have significant export potential and low entry barriers. Ethiopia's industrial sector nonetheless ranks below the African average in terms of diversification, export competitiveness, productivity and technological upgrading.

Mining also contributes to the share of industrial exports. By 2015, Ethiopia had produced 9,000 kg of gold, equivalent to USD 343 million in export earnings. The government aims to increase its gold production to 25,370 kg by 2019. The country only has one mine, Lega Dembi, which is owned by Midroc Gold, a Saudi company. The Ethiopian subsoil furthermore contains precious stones, copper, potash and tantalum. Tantalum is a rare earth metal used in the production of electronic parts.

The government is currently implementing the second phase of its Growth and Transformation Plan (GTP II). GTP II, which runs until 2019/20, aims to continue the development of the country's physical infrastructure through public investment projects and to transform Ethiopia into a manufacturing hub. The Plan's targets include an annual average GDP growth rate of 11 per cent and an average growth rate of the industrial sector by 20 per cent, thereby creating more jobs in the sector.

Services accounted for 47 per cent of GDP. The major push in services came from the expanding telecom industry. However, the telecom service is government controlled in the assumption that the private sector has no incentive to expand these services to rural areas. Ethiopian Airlines, a state-owned enterprise, is one of the few airlines in Africa to have contributed positively to the government budget. Tourism is another major industry, accounting for 33 per cent of total export earnings. Other services include banking and investment.

Ethiopia's foreign exchange earnings are dominated by the services sector. Ethiopian Airlines, which is state-run, is one of the major sources of foreign exchange earnings. While coffee remains the largest source of foreign exchange earnings, Ethiopia is diversifying its exports, and commodities such as gold, sesame, khat, livestock and horticulture products have gained in significance. Manufacturing represented less than 8 per cent of total exports in 2016, but this Figure is expected to rise considerably in future years due to a growing international presence.

1.4 Foreign Investments

The Ethiopian government has committed itself to a programme of economic reform and liberalization. However, it continues to exercise full control over the services sector, with a state monopoly on the telecommunications market, and virtually full control over the financial sector and local banks.

Table 4 Business Setup Procedure: Doing Business in Ethiopia (2016)

Setting up a Company	**Ethiopia**	**Sub-Saharan Africa**
Procedures (Numbers)	14.00	7.80
Time (Days)	35.00	27.30

Source: Doing Business

There are a number of constraints to foreign investment, including high state interference in the economy, poor infrastructure, difficulties related to land acquisition, strict foreign exchange controls, very high transaction costs and weak institutions. The government's interventionist policies, which do not focus on developing the private sector, have also proven to be a major obstacle.

On the other hand, significant progress has been made in improving transport infrastructure and electricity production to increase Ethiopia's attractiveness. The FDI inflows to the country have accelerated in recent years, amounting to USD 3.1 billion in 2016, up from USD 1.3 billion just four years earlier (UNCTAD, World Investment Report, 2017). Ethiopia ranks 159th (out of 190 economies) in the World Bank's 2017 Doing Business report, a similar position it held in 2016.

The banking, insurance, telecommunications and micro-credit industries are restricted to domestic investors, but Ethiopia has attracted roughly USD 8.5 billion in foreign direct investment, mostly from China, Turkey, India and the EU. The US FDI is around USD 567 million. Infrastructure, construction, agriculture, horticulture, agricultural processing, textiles, leather and leather products have attracted foreign investments.

Table 5 Foreign Direct investment in Ethiopia

Foreign Direct Investment in Ethiopia	2014	2015	2016
FDI Inward Flow (million USD)	1,855	2,193 (2017)	3,196
FDI Stock (million USD)	8310.50	10503.20	13699.60
Number of Greenfield Investments	34.0	30.0	16.0
FDI Inward Flow (in % of GFCF)	8.8	30.0	11.4
FDI Stock (% of GDP)	15.0	16.2	18.9

Source: UNCTAD

Note: The UNCTAD Inward FDI Performance Index is based on a ratio of the country's share in global FDI inflows and its share in global GDP. The UNCTAD Inward FDI Potential Index is based on 12 economic and structural variables such as GDP, foreign trade, FDI, infrastructure, energy use, R&D, education and country risk. Green field investments are a form of foreign direct investment where a parent company starts a new venture in a foreign country by constructing new operational facilities from the ground up. Gross fixed capital formation (GFCF) measures the value of additions to fixed assets purchased by business, government and households less disposals of fixed assets sold off or scrapped.

China has significantly increased its investment in the country over the past decade, notably in the construction, textile, power generation and te lecommunications industries (significant investments were made in the latter in 2013). Agriculture (particularly horticulture) and leather goods attract the highest amount of FDI. Renting of agricultural land also attracts foreign investors. Moreover, the country took advantage of the crisis that afflicted the Bangladeshi textile industry (following a disastrous collapse of a factory building in 2013) to attract foreign companies to the textile industry. The main investors are Saudi Arabia, China, the United States, India and Turkey.

1.5 Manufacturing Sector

Manufacturing is a crucial sector and is probably the most important engine of long-term growth and development. As a country's economy transforms from a primary agricultural-based economy to one of manufacturing, job creation and more sustainable revenue for growth is secured. The manufacturing sector developed in the 1920s in Ethiopia with a simple processing technology that produced agriculture-based goods. This sector remains at infancy level, however, even by African standards. Several reinforcing elements have conspired to prevent the emergence of a stronger manufacturing base in the country.

Ethiopia's manufacturing sector, according to the IDSP, is among the most productive sectors of the economy, which can stimulate economic growth and development because of its immense potential for wealth creation, employment generation and poverty alleviation. The manufacturing sector makes an important contribution to the economy in terms of value creation, and employed around 173,000 persons in 2012/2013. In that same year, the manufacturing sector consisted of approximately 2,610 manufacturing firms mainly operating in eight broad industries: food and beverages, textile and apparel, leather and leather products, wood and pulp products, chemical and chemical products, rubber and plastic products, other non-metallic minerals and metals and engineering products.

The top two manufacturing industries, food and beverages and metals and engineering products accounted for 51 per cent of the manufacturing sector's GDP. Food and beverages alone accounted for 38 per cent of employment in the manufacturing sector in 2012/2013. Its total contribution to GDP was around 4.8 per cent. The performance of the manufacturing sector has, however, been adversely affected by low worker productivity and the use of obsolete technologies, which is further compounded by poor infrastructure, limited access to finance, limited research and development, poor institutional framework, and inadequate managerial and technical skills.

Table 6 Status of Medium & Large Enterprises in Ethiopia (2012-13)

Sectors	Numbers of Units	Numbers Employed
Food & Beverages	670	67,000
Non-metallic Mineral Products	544	17,230
Metal & Engineering Products	433	13,238
Wood & Paper Products	196	14,064
Rubber & Plastics	154	10,984
Chemicals & Chemical Products	143	9,801
Leather & Leather Products	141	14,019
Textile & Textile Products	104	19,233

Source: CSA (2014)

Production and Value addition - According to the Addis Ababa Chamber of Commerce and Sectoral Associations (AACCSA), the gross value of production by manufacturing industry was valued at around ETB 113 billion in 2012/2013 and the value added generated in the same year was estimated at ETB 32 billion, i.e. approximately 4 per cent of the net value addition to the entire economy. The food and beverages industry had the highest value addition (ETB 8 billion), followed by the non-metallic mineral industry (ETB 4.3 billion) and metals and engineering (ETB 3.9 billion). The textile and apparel industry had the lowest value addition (ETB 396 million).

Sources of Finance - The total value of fixed capital assets in Ethiopia's manufacturing sector amounted to approximately ETB 40 billion in 2012/2013 and new investments in fixed capital for the same fiscal year was around ETB 3.7 billion and investment in food and beverages was highest at around ETB 1.6 billion. Annual wages and salary expenditures reached around ETB 10 billion that same year. Domestic banks were major sources of financing of most projects in Ethiopia's manufacturing sector. Additional sources of financing included own saving, foreign investment/partners and the domestic capital market.

Market Structure and Export Trade Destinations - The majority of products produced by the manufacturing sector were intended for domestic consumption. The manufacturing sector also, however, exported some domestically produced goods to several African nations. Only few joint ventures and large producers exported their products to North America, Western Europe and Asia. The major share of manufactured goods exports included leather, textile and agro-processing products.

Material Inputs Availability - Raw materials and intermediate inputs utilization depended primarily on the nature of manufacturing industries. Industries such as food and beverages, textile and leather predominantly utilized domestic raw materials and manpower resources. On the other hand, industries such as metals and engineering, chemicals and plastic mainly depended on imported material inputs for production. These industries are affected by a shortage of supply of managerial and technical expertise in the labour market.

Ethiopia undoubtedly has the means to address these factors such as cheap labour, a well-educated and trainable labour force and supply of utilities. Similarly, the policy framework is conducive to manufacturing development – it proposes the promotion of manufacturing growth based on vertical and horizontal links to the rich agricultural and mineral resource base, both of which have solid growth prospects in their own right.

2. Chemical Industry

The chemical industry contributes to nearly all manufactured products. The chemical industry converts petroleum and natural gas into intermediate materials, which are ultimately converted into products that are used and consumed on a daily basis. With over 20 million people employed and annual sales of USD 5 trillion, the global chemical industry serves as the backbone of many end-market industries such as agriculture, automotive, construction and pharmaceuticals. The chemical industry is considered the backbone of manufacturing and the supplier of inputs to all major industries.

2.1 Introduction & General Overview

The chemical industry creates a wide range of products that touched on virtually every aspect of our lives. It is one of the most diversified of all industrial sectors. While many of the products, such as detergents, soaps and perfumes, are directly purchased by the consumer, but 70 per cent of manufactured chemicals are used as raw materials or intermediate goods to make products by other industries. According to the UN's "International Standard Industrial Classification", the chemical industry covers more than 140,000 product lines.

Table 7 Rev.3.1 Code 24: Manufacture of Chemicals and Chemical Products

241	**Manufacture of basic chemicals**
2411	Manufacture of basic chemicals, except fertilizers and nitrogen compounds
2412	Manufacture of fertilizers and nitrogen compounds
2413	Manufacture of plastics in primary forms and of synthetic rubber
242	**Manufacture of other chemical products**
2421	Manufacture of pesticides and other agrochemical products
2422	Manufacture of paints, varnishes and similar coatings, printing ink and mastics
2423	Manufacture of pharmaceuticals, medicinal chemicals and botanical products
2424	Manufacture of soap and detergents, cleaning and polishing preparations, perfumes
2429	Manufacture of other chemical products n.e.c.
243	**Manufacture of man-made fibres**
2430	Manufacture of man-made fibres

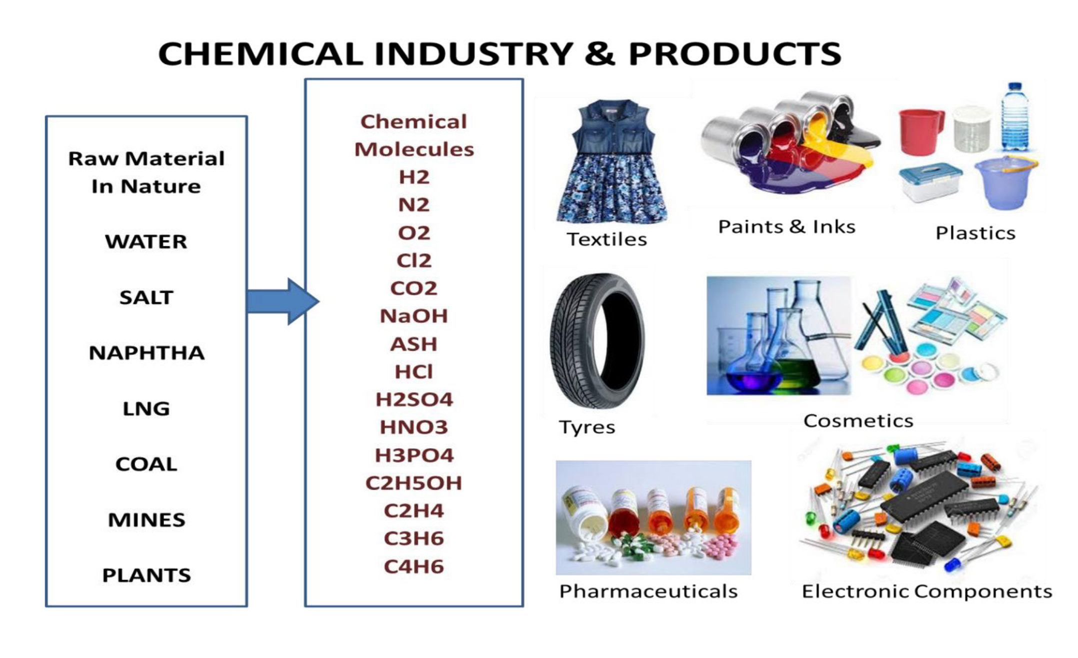
Source: http://unstats.un.org/unsd/cr/registry/regcs.asp?Cl=17&Co=24&Lg=1

The diversified and multi-utility product lines of the chemical industry can be categorized as:

a) Basic Chemicals - Basic Inorganics, Polymers and Petrochemicals
b) Specialty Chemicals - Crop protection chemicals, Colorants and Paints
c) Consumer Chemicals - Soap, Detergents and Toiletries.

Basic chemicals are the most important and diversified category of the chemical industry. These comprise chemicals derived from oil (petrochemicals, polymers and basic inorganics). These chemicals are mainly inputs in the chemical and other industries before developing into final products for the general consumer. Hydrocarbons, which are extracted from crude oil and gas, are converted into alkanes and aromatic hydrocarbons. They are converted into a very wide range of basic chemicals that are immediately useful (petrol, ethanol, ethane-1, 2-diol) or are subjected to further reactions to produce useful end products like phenol to make resins and ammonia to develop fertilizers. Another important variant of basic chemicals include "inorganics", which are relatively low cost chemicals, such as chlorine, sodium hydroxide, sulfuric and nitric acids and chemicals for fertilizers.

Figure 3 Chemical industry & products



Source: http://web-material3.yokogawa.com

Specialty chemicals cover a wide variety of chemicals for crop protection, paints, inks and colorants (dyes and pigments). They include chemicals used by industries as diverse as textiles, paper and engineering. An everyday example is household paints which have evolved from being organic solvent-based to being water-based. Another example of specialty inks is that developed for ink-jet printers.

Finally, consumer chemicals are directly sold to the public, which include detergents, soaps and other toiletries. The search for more effective and environmentally safe detergents has increased over time, particularly in terms of finding surfactants capable of cleaning anything from sensitive skin to large industrial plants. Additionally, much effort has been put in producing a wider range of synthetic chemicals for toiletries, cosmetics and fragrances.

The chemical industry thus plays a dominant role in the economy's overall development and represents the backbone of industrial and agricultural development. The chemical life cycle begins with the extraction of raw materials and includes mining, the extraction of oil and natural gas and other activities. These raw materials are used in chemical manufacturing, processing or refining. The manufactured bulk chemicals are then combined with one another and used to make a wide variety of downstream chemical products. These chemical products are, in turn, used as feedstock for chemical products further downstream for a variety of industrial activities and services, as individual chemicals, in preparations or used to make consumer products. At the end of the life cycle, chemicals may be released into the environment, recycled for continued use, disposed of in hazardous waste facilities or in other ways.

2.2 Chemical Industry in Ethiopia

Ethiopia's chemical industry is still at a nascent stage. There is strong demand to develop the chemical industry to meet the requirements of the rapidly growing Ethiopian economy. Currently, imports fulfil domestic demand for chemicals. As mentioned earlier, chemicals are inputs to a wide variety of products like detergents, soaps, plastics, etc., which touch every aspect of human life.

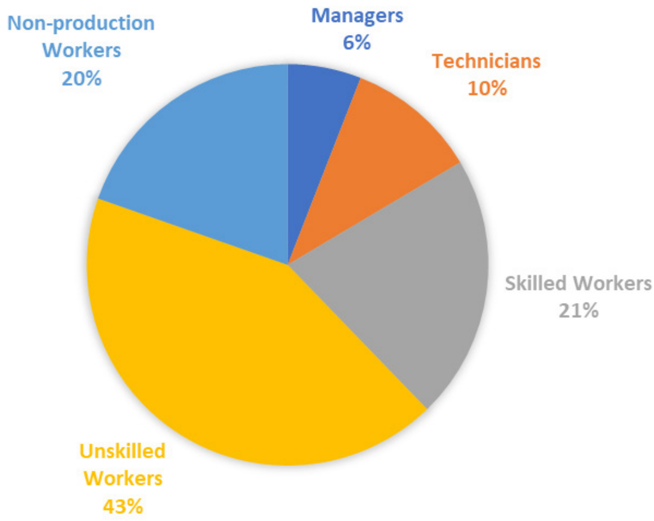
2.2.1 Introduction & Overview

The chemical industry in Ethiopia produces basic chemicals based on local raw materials, including PVC granules from ethyl alcohol, formaldehyde from methanol, the production of caustic soda and chlorine-based chemicals, carbon black, activated carbon, precipitated calcium carbonate, ball-point ink, the manufacturing of pharmaceuticals, and medicinal, chemical and botanical products in the form of tablets, capsules, syrups and injectables.

There are a total of 153 chemical and chemical-related product manufacturers according to CSA's raw data for the year 2014. These industries account for 5.7 per cent of total manufacturing industries in Ethiopia, most of which are concentrated around Addis Ababa (81 establishments) and Oromia (60 establishments). Although the number of firms in the chemical industry dropped in 2010/11 (from 99 firms to 75), it has grown tremendously since 2012/13.

The domestic chemical industry provides essential inputs for economic and social growth in the agricultural and health sectors. For example, fertilizers are an output of the chemical industry used as inputs in the agricultural sector to increase farmers' outputs. Similarly, the health sector as well as other economic sectors benefit from the chemical industry's outputs. Estimates show that Ethiopia's chemical industry was worth around ETB 9.7 billion in 2012/2013, which makes it the fourth largest industry in terms of total income generation compared to others. The industry's value added amounted to ETB 2.8 billion in 2012/13. The major share of production is used by the fertilizer and pharmaceutical industries.

Figure 4 Occupation distribution in chemical sector (%)



Source: UNIDO elaboration based on AACCSA Report

The chemical industry's total value of fixed capital assets was around ETB 1.9 billion and the new investment in fixed capital for the 2012/2013 fiscal year was around ETB 253 million. Annual wage and salary expenditures reached around ETB 434 million. There were 11,028 persons employed in the chemical and chemical products industries in 2011/2012, dropping to 9,801 persons in 2012/2013 based on CSA's raw data for the year 2014. In 2012/2013, the chemical industry paid over ETB 434 million in wages and salaries.

The chemical and chemical products markets rely on outputs from local industries and derive substantial volumes from imports. Exports from local industries to the rest of the world are negligible. According to CSA data (2014), only ETB 68 million (only 0.7 per cent) from the total amount of production (ETB 9.7 billion) was exported to foreign markets, implying that nearly all production outputs from this industry were consumed by domestic industries and residents.

2.2.2 Scenario for Ethiopia's Chemical Industry: Demand & Availability

Both the government and individual investors have invested in Ethiopia's chemical industry, which is made up of firms in different sizes, using different levels of technology, production systems and market strategies. Although the chemical industry is at a nascent stage, it creates variety very wide range of products. While many of the industry's products such as detergents, soaps, perfumes, etc. are directly purchased by the consumer, much of the chemicals produced are used in the production of goods by other industries. Chemical products that are locally produced can be divided into (i) basic chemicals and (ii) consumer chemicals. However, the major share of chemical inputs and chemical products are still being imported for local manufacturing and often for direct consumption.

Basic chemicals, produced in large quantities, are mainly sold within the chemical industry and to other industries before being further developed into products for general consumption.

Formic acid, hydrochloric acid, nitric acid, etc., for example, are used as primary inputs for all industrial and manufacturing processes. Likewise, consumer chemicals are produced as consumer products sold directly for consumption purposes, for example, soaps, detergents and cosmetics. Hot caustic alkali solutions, such as caustic soda, and natural fats or oils, such as tallow or vegetable oil, are used to produce sodium fatty acid salt (soap) and glycerine (or glycerol).

Both the public and private sectors coexist in the chemical and chemical products manufacturing sector. There are currently eight public enterprises and 43 firms in the private sector operating in two major regions in Ethiopia, namely Addis Ababa and Oromia (AACCSA, 2015)[4]. Most public sector enterprises are located in the Oromia region. All enterprises produce for the domestic market, except the public sector company Natural Gum Processing & Marketing Enterprise, which exports 80.6 per cent of its total production. Other public sector firms are engaged in the production of paints, caustic soda, aluminium sulphate, soda ash, magnesium oxide, pesticides and fertilizers. The private sector's dominance in most product categories is quite visible and it competes with the public sector in the domestic market on equal footing.

Table 8 Public-sector Enterprises in the Chemical & Chemical Products Industries

S.No	Company	Region	Product	Employees	Annual Prod. Cap. in (ETB '000)
1	Awash Melkasa Aluminium Sulphate	Oromia	Aluminium Sulphate	226	17,682
2	Zeway Caustic Soda	Oromia	Caustic Soda	269	27,547
3	Abiyata Soda Ash Factory	Oromia	Soda Ash	231	6,053
4	Adola Magnesium Oxide Factory	Oromia	Magnesium Oxide	73	55,385
5	Adamitulu Pesticide Factory	Oromia	Pesticides	212	136,192
6	Nifas Silk Paints	Addis Ababa	Paints	162	74,693
7	Zemenawi Building Industries	Oromia	Paints	255	95,801
8	Natural Gum Processing & Marketing Enterprise	Amhara	Gum	105	20,365

Source: UNIDO elaboration based on AACCSA Report

[4] The AACCSA & CIDD provided the details on type of enterprises, number of employees, annual production capacity and capacity utilization; market and input imports are given in its Annex-I for reference purposes.

In terms of production capacity, the private sector dominates the Ethiopian market. For instance, the private sector firm Rainbow Paint Factory has the highest production capacity with a capacity utilization of 67.6 per cent. Only eight enterprises operate at 100 per cent capacity utilization, highlighting the limitations of production processes and continuity in the supply of inputs. Only six companies, all of which are private sector firms, operate at less than 50 per cent capacity utilization. The majority of enterprises operate at 60 per cent to 80 per cent capacity utilization. Many firms claim that the main reason for their low capacity utilization is inadequate availability and the poor quality of raw materials.

The public sector employs 1,533 employees (skilled and unskilled labour). The private sector employs around 80 per cent of the total workforce (skilled and unskilled) in the chemical and chemical products industries. The current IDSP identifies the poor human resource development system and the shortage of highly qualified labour as one of the major challenges for the manufacturing sector.

The imported inputs of most enterprises, both in the public and private sector, are quite high. Of the 51 public and private sector enterprises that produce chemicals and chemical products, 21 have imported inputs of 100 per cent. Many of the other enterprises also have a significant share of imported inputs of more than 50 per cent. Only four enterprises rely exclusively on local inputs with no imported inputs.

The Government of Ethiopia has specifically focussed on the chemical industry for import substitution in the manufacturing sector to save precious foreign exchange. It formulated and implemented a five-year Growth and Transformation Plan (GTP) from 2010/11-2014/15. The 2nd GTP is currently underway and the chemical industry is identified as a priority industry. The IDSP clearly stated that the private sector is considered to be the industry's engine of growth.

Table 9 Major Chemical Imports in Ethiopia

		Net Weight (Tonnes)			CIF Value (Birr)		
Sn	Chemicals	2009	2010	2011	2009	2010	2011
1	Formic acid	81,490.76	471,197.31	290,733.02	908,916.42	5,587,002.51	6,777,327.45
2	Hydrochloric acid	649,571.91	1,243,592.22	1,344,964.97	2,618,803.46	6,634,421.91	7,842,102.25
3	Nitric acid	329,4 24.34	992,374.69	372,887.21	1,981,856.01	7,515,818.86	3,555,752.32
4	Potassium chloride	15,962.87	26,217.00	18,479.33	237,916.21	358,757.62	3,287,740.76
5	Potassium nitrate	175,549.63	28,478.00	576,792.44	1,985,808.24	469,121.34	7,807,292.14
6	Magnesium chloride	14.45	19.10	238.50	429,532.48	429,532.48	1,933,220.36
7	Polyethylene	4608.00	9750.00	8063.00	67,619.199	123,049.939	154,846.036
8	Calcium carbide	665,921.12	759,692.22	551,374.85	4,565,907.00	5,840,218.73	6,472,688.01
9	PET	5226.00	7271.00	5283.00	76,258.405	98,207.153	103,783.582
10	Talc	647,045.00	1,072,166.00	648,015.90	2,516,612.64	5,903,168.66	4,532,621.21
11	Titanium oxide	1002.878	838.03	1065.7	17,065,291.04	15,984,718.18	19,122,912.60

Source: Ethiopian Customs Authority

To support and facilitate investment flows in the chemical industry, the government established the Chemical Industry Development Directorate under the Ministry of Industry.

The above table demonstrates that imports of basic chemicals have witnessed a significant increase in quantity and value over time. Based on past experience, the CIDD has identified the following major chemicals for import substitution:

1. Formic acid
2. Hydrochloric acid
3. Nitric acid
4. Potassium chloride
5. Potassium nitrate
6. Magnesium chloride
7. Polyethylene
8. Calcium carbide
9. Polyethylene terephthalate (PET)
10. Poly vinyl chloride (PVC)
11. Talc, and
12. Titanium dioxide.

The IDSP's import substitution strategy is based on inviting foreign direct investments as well as private investments into the production of the identified basic chemicals for building domestic production capacities. It also defined opportunities in consumer chemicals, such as calcium carbonate and lime, candle wax (artificial wax), car paint, carbon black, cellulose acetate, detergent powder, disinfectants, essential oils, ethyl acetate, fatty acid, formaldehyde, gelatine, glucose, glycerine, herbicide and fungicide, industrial adhesive, lactic acid, low density polyethylene (LDPE), liquid detergent, natural adhesive, polish (shoe and floor), polyethylene resin (HDPE), PVC and resin.

This priority list is based on the demand for basic chemicals and the availability of raw materials locally. For instance, Magnesium chloride brine, which is one of the raw materials needed to produce hydrochloric acid, is available in unlimited quantities in the Afar region in north-eastern Ethiopia. There is also a large deposit of magnesium oxide ore in the Adola area. Hydrochloric acid is a strong inorganic acid used in nearly all parts of the industry, where the quality of the hydrochloric acid is the decisive factor for the type of application.

Ethiopia has great potential to develop its chemical industry. The Government of Ethiopia plans to support this industry by introducing radical changes and by increasing its competitiveness in the international market. The development of the chemical industry will not only foster the manufacturing sector on the whole, but import substitution also saves valuable foreign exchange. The government also aims to rationalize the country's customs tariff structure to support the competitiveness of locally manufactured materials.

2.2.3 Investment Policies & Incentives

The Government of Ethiopia has now adopted the free market system to boost its manufacturing sector by inviting foreign investments and allowing the private sector to become the driver of economic growth. In this context, the IDSP aims to create an environment conducive to the promotion of the private sector's role in this regard. Today, trade and investment are interlinked and interconnected in many countries. The key objective is therefore to increase the competitiveness of private entrepreneurs' products and services in terms of price and quality, as well as the timely supply of goods and services in order to maximize and benefit from the global market.

To encourage the inflow of the latest technological knowledge, of capital resources and advanced managerial skills, the Government of Ethiopia has adopted a proactive foreign investment policy and announced fiscal incentives to attract private investments. These include:

Incentives for Foreign Investments

A foreign investor can make investments either as sole proprietors or jointly with domestic investors.

(1) The capital requirement for foreign investors (as sole proprietors) is USD 200,000 for a single and wholly foreign owned investment; USD 100,000 for projects involving engineering, architecture, accounting and audit services, project studies and consultancy services.
(2) The capital requirement for investments in partnership with domestic investors is USD 150,000 per project; USD 50,000 for projects involving engineering, architecture, accounting and audit services, project studies and consultancy services.
(3) There is no capital requirement for investors who reinvest their profits or dividends generated from an existing enterprise.
(4) Land is leased out by the government.
(5) Repatriation and remittances are granted to foreign investors to be transferred into convertible foreign currency at the prevailing exchange rate on the date of remittance.

Guarantees

(1) The Constitution of Ethiopia and the Investment Proclamation and the legal system protect private property.
(2) Ethiopia is a member of the Multilateral Investment Guarantee Agency (MIGA) which issues guarantees against risks to entrepreneurs who invest in signatory countries.
(3) Ethiopia has signed bilateral investment promotion and protection agreements as well as avoidance of double taxation agreements with many countries.

Fiscal Incentives

(1) Customs duties incentives - 100 per cent exemption from payment of import customs duties and other taxes levied on imports on all investment capital goods, such as plant machinery and equipment, construction materials as well as spare parts up to 15 per cent of the value of capital goods imported.

(2) Income tax incentives - Exemptions announced for the chemical and chemical products industry:

(a) Any investor who invests in the establishment of a new enterprise in Gambela, Benshangul/Gumz, Afar, Somali, Guji & Borena Zones (Oromia), and in certain zones in the Southern Nations, Nationalities, and Peoples' Region (SNNP) shall be entitled to an income tax deduction of 30 per cent for three consecutive years after the expiry of the income tax exemption period.

(b) The period of exemption for income tax shall commence from the date of production or the provision of service by the investor.

(c) An investor who has incurred loss within the period of income tax exemption shall be allowed to carry forward such loss for half of the income tax exemption period after the expiry of that period.

Table 10 Income Tax Exemption for Chemical & Chemical Products

Investment Area	Special Zones of Addis Ababa & Oromia	Other Areas
Manufacture of basic chemicals (including ethanol)	5 years	6 years
Manufacture of plastic and/or synthetic rubber in primary forms Manufacture of pesticides, herbicides or fungicides	3 years	6 years
Manufacture of paints, varnishes or similar coating, printing, writing and painting inks and mastics	2 years	4 years
Manufacture of soap and detergents, cleaning and polishing preparations, perfumes and toilet preparations	2 years	4 years
Manufacture of man-made fibres	5 years	6 years

Source: Investment Opportunities in Chemical Sector (2015)

(3) Export incentives

- Duty drawback scheme: Duty paid at the port of entry and locally on raw materials used in production commodities is refunded by 100 per cent, upon the exportation of the commodity processed.
- Voucher scheme: This printed document is to be used for recording the balance of duty payable on raw materials imported for use in the production of goods for the external market. The beneficiaries of the voucher scheme are also exporters.
- Bonded manufacturing warehouse: Producers fully engaged in exporting their products who are not eligible to use the voucher scheme and who have a license that enables them to operate such a warehouse.

Land Lease

In Ethiopia, land is public property. Both urban and rural land is available for investment on a lease basis. Lease rights over land can be transferred, mortgaged or sub-leased together with on-build facilities. The period of lease may also be renewed. The rental value and the lease period of rural land are determined and set by the land use regulations of each regional state.

Tax Regime

Table 11 Tax Regime

Type of Tax	Rate (%)
Direct	
Corporate income tax	30
Personal income tax	0 up to 35
Business income tax	0 up to 35
Custom duties	0 up to 35
Withholding tax	2
Export tax	-
Royalty tax	5
Dividend tax	10
Interest income	5
Indirect Tax	
Value added tax	15
Excise tax	10 up to 100
Turnover tax	2 and 10

Source: Investment Opportunities in Chemical Sector (2015)

3. Value Chain & Key Issues

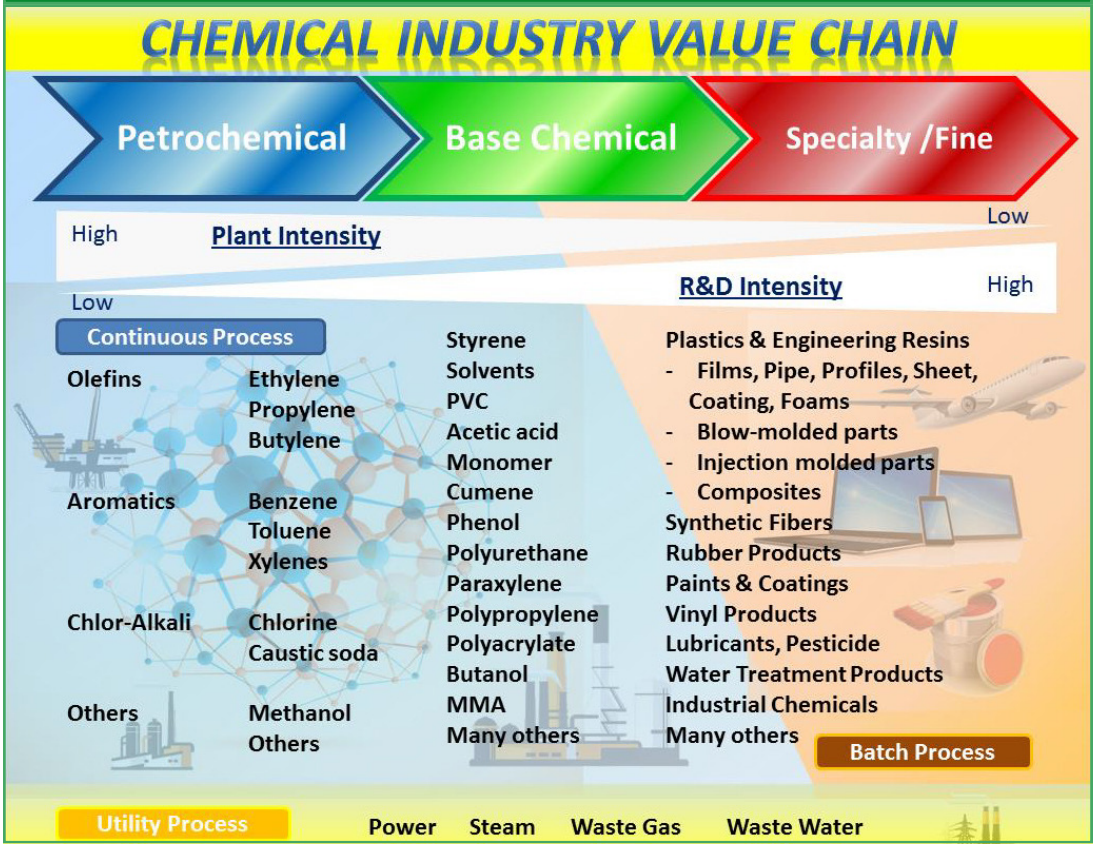
A value chain "disaggregates a firm into its strategically relevant activities in order to understand the behaviour of costs and the existing and potential sources of differentiation"[5]. The value chain consists of a "set of activities that are performed to design, produce and market, deliver and support its product" (ibid). Those activities can be distinguished as:

- Primary activities: Inbound logistics, operations, outbound logistics, marketing and sales, service in the core value chain creating direct value; and
- Support activities: Procurement, technology development, human resource management, firm infrastructure supporting value creation in the core value chain.

3.1 Value Chain: An Overview of the Chemical Industry

The value chain of the chemical industry starts with "petrochemicals", moves into "basic chemicals", advances to "polymers" and specializes in "specialties". The products become more complex and varied at each stage of the value chain, i.e. value is added to each step in the chain.

Figure 5 Chemical industry & products



Source: http://web-material3.yokogawa.com

[5] Porter (1985).

Value Chain: Stage 1: Raw Materials/Petrochemicals: The first stage of the value chain is raw materials, which are used to produce basic chemicals. These raw materials primarily consist of metallic or non-metallic minerals and ores, oils and natural gas extracted and beneficiated from mining. Value is added to these activities to produce basic chemicals. This step primarily involves raw material procurement, R&D and patenting of new innovative chemicals and chemical processes. The first step usually involves the refinement of oil and gas (or some other type of raw mineral) into petrochemicals. Petrochemicals are derived from crude oil, crude products or natural gas. Petrochemicals are used in the manufacture of numerous products such as synthetic rubber, synthetic fibres (e.g. nylon and polyester), plastics, fertilizers, paints, detergents and pesticides. It is the basis for most organic chemicals. Products manufactured in this stage include olefins, such as ethylene and propylene, polyolefins, such as polyethylene and polypropylene and industrial gases.

Value Chain: Stage 2: Basic Chemicals: The second stage of the value chain produces basic chemicals. Base/basic chemicals processing is the second step in the chemical industry's value chain. In this stage, basic chemicals are produced from raw materials. These basic chemicals are used as raw materials by many manufacturers from different industries to produce a wide variety of commercial products such as dyes, detergents, chemicals for household cleaning, plastics materials, paints, drugs and fertilizers. Basic chemical processing includes synthesis, distillation, thermal cracking and polymerization. Basic chemical processing is carried out by chemical manufacturers and is closely tied to R&D activities. Products manufactured during this stage include intermediates, such as tetrahydrofuran and hexamethylene diamine and inorganics, such as ammonia.

Value Chain: Stage 3: Polymers: The third stage involves the manufacturing of polymers. Polymers, which are primarily used to produce plastic goods, constitute about 80 per cent of the chemical industry's production output. They are the most widely used material per unit volume, used more than steel, copper and aluminum combined. Polymers are used by industry (e.g. in the manufacturing of film and in aerospace, automotive and electronic equipment) and by the general public (e.g. in milk and shampoo bottles). Polymers are used in products from plastic bottles to plexiglass. Polymer manufacturing is a hybrid of batch and continuous processing, and polymer manufacturing plants are typically very large, capital intensive, costly to operate and dif ficult to change.

Raw materials for polymers, often referred to as 'feedstock', are by-products of petroleum or natural gas production, such as ethylene and propylene, which is generally produced in stage 2 of the value chain. Polymer customers are typically manufacturers that process the polymer into plastic products (e.g. plastic containers such as milk and shampoo bottles), which are then sold to other manufacturers (e.g. consumer packaged goods companies), which in turn are used for a consumer product (e.g. milk or shampoo) and sold to retailers. The final users are thus fourth-tier customers. Other polymer customers produce parts that will be used in electronics or aerospace equipment.

Value Chain: Stage 4: Specialties: The most complex chemicals are produced in the fourth stage known as 'specialties'. Specialty chemicals are used for a variety of purposes and include additives, coatings, pharmaceuticals and vitamins. Fine chemicals are complex, single, pure chemical substances. They are produced in limited volumes and at relatively high prices, mainly by traditional organic synthesis in multipurpose plants. Fine chemicals are used as starting materials for specialty chemicals, particularly pharmaceuticals, biopharmaceuticals and agrochemicals. The products are primarily used as building blocks for proprietary products.

Marketing, distribution and sales of final products is the next step in the value chain. This includes the marketing, wholesale distribution and sales of the final chemical product and related products to other manufacturers in agriculture, automotive, pharmaceuticals and textiles. Manufacturing firms from different industries go on to produce different consumer goods and products using the final chemical products.

3.2 SWOT Analysis

A SWOT analysis aims to identify the key internal and external factors that are deemed essential to achieving an objective. A SWOT analysis groups crucial pieces of information into two main categories:

Internal factors: the strengths and weaknesses internal to the organization;
External factors: the opportunities and threats the environment external to the organization present.

The entire discussion on the chemical industry's value chain analysis determines the baseline for its SWOT analysis. The analysis may view the internal factors as strengths or as weaknesses, depending on their effect on the industry and the objective of import substitution. The external factors may include macroeconomic issues, technological change, the global market, international environment regime, sociocultural changes as well as changes in the market or in competitive positions.

Table 12 SWOT Analysis of the Chemical Industry in Ethiopia

Strengths	Weaknesses
• Availability of easily trainable workforce at low cost • The existence of an industry development strategy and the selected priority in the industry • Improved export performance of the manufacturing sector in recent years	• Lack of joint planning, coordination and collaboration among different public and private institutions • Limited capacity of the existing institutions to implement policies and strategies • Limited strategic linkage between industry and agriculture

- Rising share of the manufacturing sector in the national economy
- Creation of conducive environment for investment by adopting proactive investment policy
- Establishment of the Chemical Industry Development Directorate under the Ministry of Industry to act as a nodal agency for the development of the chemical industry
- Massive investments on infrastructure (road, communication and power generation for industrial development)
- Availability of incentives to attract local and foreign investments, and increased trend of investment in the industries
- Growing number of enterprises of all sizes , and the potential to link SMEs with medium and large enterprises
- Improving the role of the private sector

- Lack of strong marketing strategy at the national and sectoral level
- Limited quality service delivery of public institutions
- Limited FDI flow compared to the need for industrialization
- Limited working capital provision
- Weak transport and logistics services
- Limited capacity of the existing HEI,TVET and R&D institutes to train qualified professionals
- Inadequate alignment of the training system with the demands of the manufacturing sector
- Unavailability of effective industrial zones and agro-processing parks
- Lack of input/output quality control and standardization system
- Slow growth in the upgrading of the existing SMEs to climb up the value chain
- Absence of technological innovation and application of indigenous technology
- Inadequate technology transfer and low capacity utilization of the manufacturing sector
- Lack of machinery maintenance, rehabilitation, modification and replacement

Opportunities	Threats
• Existence of stable and peaceful socio-political environment and supportive macroeconomic policies • Sustainable industrial development strategy • High government investment in capital intensive industries • Transformation of the agricultural economy to industry-led economic development • The shift of labour intensive manufacturing factories from developed to developing countries • Vast international and preferential market access to the EU, USA and regional markets • Relatively large domestic market expansion of educational infrastructure • Improvements in hydroelectric power, wind and geothermal electric power • Railway and road projects across the country as well as the building of ICT infrastructure • Improved relationship with the private sector and international development partners	• Inflation and global financial crises • Unavailability of FDI as needed • Weak university-industry linkages • Inadequate rural infrastructure to access agricultural inputs • Increasing costs of import-export transportation and logistics • Relatively slow development of social overhead capital (SoC) compared to the urgency for industrialization • Lack of adequate supply and value chain management • Global climate change

3.3 Key Issues & Challenges

The vision of the industrial development strategy is "building an industrial sector with the highest manufacturing capability in Africa which is diversified, globally competitive, environmentally-friendly, and capable of significantly improving the living standards of the Ethiopian people by the year 2025"[6]. The overall goal of the industrial development strategy is to achieve structural change in the economy through industrial development. Specifically, it aims at increasing the share of the industry by a percentage of GDP from currently 13 per cent to 27 per cent by 2025, and increase the manufacturing sector's share as a percentage of GDP from currently 4 per cent to 17 per cent by 2025. Specific strategic objectives are set in accordance with this overall goal.

The Government of Ethiopia has identified the following five strategic objectives that guide the implementation strategies and programmes:

- To further expand and develop the existing priority industries;
- To diversify the manufacturing sector to include new industries;
- To enhance enterprise cultivation and entrepreneurship;
- To increase public, private and foreign investment; and
- To develop and operate industrial zones and cities.

A number of key strategies that need to be pursued to achieve the stated visions and objectives are:

- Guaranteeing a conducive business environment;
- Acquiringcompetent human resource;
- Acquiring quality industrial inputs for value addition;
- Developing and diversifying local, regional, and global markets;
- Enhancing technology transfers; and
- Developing and providing institutional support.

The macroeconomic factors that are considered to be major constraints to harnessing Ethiopia's potential to achieve the stated objectives and the implementation of key strategies are:

1) Inadequately developed business enabling environment

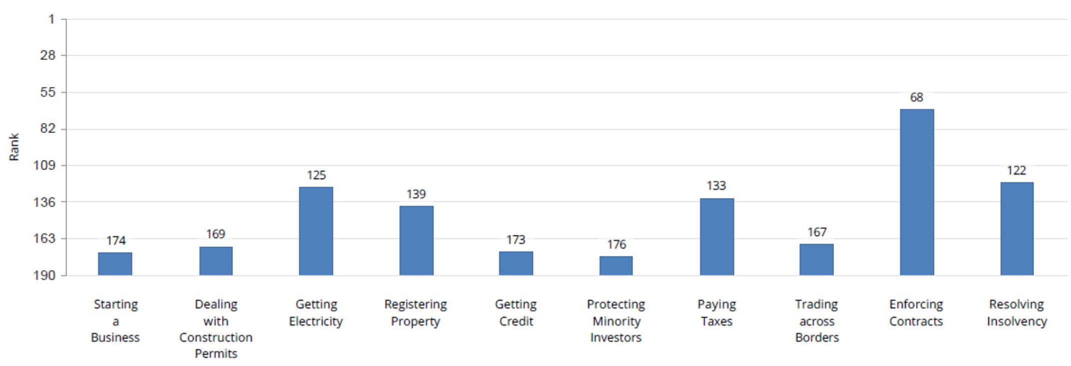
Ethiopia is one of the lowest ranked nations in the IMF's assessment on "Doing Business". It tanks 161th among a total of 190 nations (Doing Buisness, 2018). "Doing Business" is an objective method of assessing a country's business environment relative to the rest of the world. The assessment captures several important dimensions, such as regulation for starting a business, dealing with construction permits, access to electricity, registering property, obtaining credit, protecting minority investors, paying taxes, trading across borders, enforcing contracts

[6] Ethiopian Industrial Development Strategic Plan (IDSP) (2013-2025) from the Federal Democratic Republic of Ethiopia Ministry of Industry.

and resolving insolvency. Doing Business also measures features of labor market regulation.

Ethiopia's business environment was assessed to be considerably lower than the regional sub-Saharan average. Its southern neighbour Kenya is relatively better positioned in all assessed parameters. However, Ethiopia achieved a relatively better score in terms of the overall businesss environment than its northern neighbour Eriteria. With the exception of enforcement of contracts, Ethiopia is ranked quite low in the various indicators compared to other countries. For instance, Ethiopia ranks 174th out of 190 for starting a business.

Figure 6 Rankings on Doing Business topics - Ethiopia



Source: Ease of Doing Business (2018)

The Figure illustrates the fundamental restrictions, red-tapism and fiscal anomalies (particularly as regards taxation and obtaining credit, etc.) that are characteristic of Ethiopia's business environment. However, the country's legal system represents a silver lining and restores potential investors' confidence in Ethiopia's business environment by maintaining higher standards than other countries in the enforcement of contracts.

2) **Poor human resource development system and shortage of highly qualified human resources**

Human resources are the backbone of an industrialized society. The Human Development Index (HDI) is an established measure of human development. Ethiopia ranks 174th among 188 nations (Human Development Report, 2016), highlighting the country's relatively poor human resource development. The adult literacy rate is 49.1 per cent, which means that over 50 per cent of the economically active population does not have adequate reading and writing skills. With a mean of 2.6 years of schooling, it is difficult to transform the agricultural economy into an industrialized one. Manufacturing requires a continuous flow of scientific and technical personnel.

Ethiopia's higher education infrastructure has only developed over the last 15 years. One of the principal outcomes of Ethiopia's Agricultural Development Led Industrialization strategy (ADLI) has been a rapid expansion of the country's higher education system, yet without due attention being paid to the quality of education and the labour market. In 2000, there were only two universities, but since then, the country has established 29 private and public universities and more are being planned. These institutions have, however, experienced cuts in funding, frequently have unqualified party-loyal lecturers, and shoddily built structures. Technical and vocational education and training (TVET) provides an opportunity for youth to acquire marketable and entrepreneurial skills. However, in Ethiopia, both public and private TVETs have failed to link education and training with the skills and quality of skills required by the labour market, and have failed to monitor graduates' subsequent employment. In 2013, 9,185 engineering students graduated, but their training did not meet employer requirements. A HERQA survey in 2010 revealed that employers viewed graduates in engineering, medicine and management as not sufficiently qualified for the required work. Thus, the employability gap has degenerated the potential to harness the only advantage of cheap qualified workers in Ethiopia.

To achieve the objectives, the industrialization strategy must not only aim to develop light and medium industries, but also establish high-tech industries, which calls for the country's higher education system to produce highly qualified engineers and specialists. It furthermore requires the establishment of research and development centres and other support institutions to promote high-tech industries and build technology transfer capabilities.

3) Insufficient industrial inputs and infrastructure development

The manufacturing sector's dependence on imported raw materials been increasing. The degree of dependence on imported raw materials differs by industry. It is relatively lower in agri-industries such as food, beverages, textile, apparel, leather, tobacco and furniture, accounting for a maximum of 50 per cent, i.e. below average. On the other hand, the chemical, plastic and rubber, basic iron and engineering industries heavily depend on imported inputs, ranging from 70 per cent to 99 per cent of total costs of raw materials. The apparel, leather and non-metallic mineral products industries, which traditionally depended less on imported raw materials, have shown increasing dependence on raw material imports in recent years. The declining share of exports and simultaneous increase in import dependence implies that the manufacturing sector's export coverage of imported raw materials has fallen over time. The total export coverage of imported raw materials in the medium- and large sized manufacturing firms dropped from around 53 per cent in 2002/03 to 12 per cent in 2009/10. In other words, there is a lack of domestic linkages, particularly between the manufactung and the agricultural sectors.

The Ethiopian government currently spends 10 per cent of GDP (about USD 1.3 billion annually) on infrastructure, which is by far the highest in Africa in terms of share of GDP[7]. A ten-year Road Sector Development Program (RSDP) was implemented in two phases from 1997 to 2007. The programme was extended up to 2010 under a third phase. A substantial part of the projects aimed at improving the connections with neighbouring countries and particularly seaports. Huge investments were also made by the government for the development of the power and telecommunication industry in the PASDEP period. The GTP (2010-15) introduced far more ambitious targets for the power and telecommunication industries. Despite huge and continued investments in its infrastructure, Ethiopia, as a landlocked country, remained one of the most difficult spots in the world from which to engage in the global economy due to the absence of a competitive network of global logistics. According to the World Bank Trade Facilitation indicators, Ethiopia ranked 123rd out of 155 countries in the world in the Logistics Performance Index (LPI) in 2009[8]. The country also ranks among the lowest in terms of use of information and communication technology (ICT). For example, the number of mobile subscribers and internet users per 100 inhabitants in Ethiopia was 16.7 and 1.10, respectively, which was especially low compared to other countries in sub-Saharan Africa. The quality of telecommunication and power services in Ethiopia is even more concerning and is often clamed for the absence of competition. These indsutries have not yet been privatized and the government continues to be the sole investor and service provider of both services.

4) Lack of well-established investment and technological development

To date, access to credit has been the Achilles heel of industrial development. The total value of fixed capital assets in Ethiopia's manufacturing sector was an estimated ETB 40 billion in 2012, and new investments in fixed capital for the same fiscal year amounted to around ETB 3.7 billion. Domestic banks were major sources of finance for the majority of projects in Ethiopian manufacturing industries. Addis Ababa Chamber of Commerce and Sectoral Association (AACCSA) carried out a grassroot survey in 2015. The survey results revealed that of the total 270 manufacturing firms interviewed, about 62 per cent reported that domestic banks remained their main financier, followed by own saving (16.8 per cent), foreign investment/partners (9.5 per cent) and domestic capital market (5.7 per cent).

The banking system operates under a tight monetary policy regime. The interest rate has deliberately been kept low over the last decade. With soaring inflation, the real interest rate was virtually negative for most of the years since 2002. This indicates the huge sum of implicit financial subsidies provided to investors who borrowed from the formal banking sector. After a major devaluation in 1992, the exchange rate of the Birr was determined through an auction. The rate was stable and the difference to the parallel market was relatively lower for a long period. The government restricted the outflow of foreign exchange due to rising domestic inflation. In response to the increasing overvaluation, the government devalued the Birr several times, for example, by around 23 per cent in 2009 and 20 per cent in 2010. Lack of foreign exchange and volatility of interest rates subdued the industrialization process.

[7] http://www.africaportal.org/articles/2012/10/10/ethiopia-underestimatedregional-power

[8] Trade logistics include the various processes and activities involved in getting goods to market: transportation, warehousing, cargo consolidation, border clearance, distribution in the destination country and payments (WDI various years).

Table 13 Price, Interest Rate and Exchange Rate Pattern in Ethiopia (1998-2010)							
Year	Minimum deposit rate	Lending rate min-max	General inflation rate	Real interest rate	Exchange rate parallel market	Interbank weighted market-rate	Real effecive exchange rate
1998/99	6	10.5-13.0	4.3		7.69	8.12	115.3
1999/00	6	10.5-13.5	5.4	3.8	8.31	8.22	100.0
2000/01	6	10.5-15	-0.3	17.6	8.79	8.46	93.9
2001/02	3	8-10.5	-10.6	12.7	8.68	8.566	91.1
2002/03	3	8-10.5	10.9	-5.1	8.709	8.6	104.1
2003/04	3	7-10.5	7.3	3.0	8.675	8.63	105.8
2004/05	3	14	6.1	-2.6	8.71	8.66	100.4
2005/06	3	14	10.6	-4.1	9.026	8.69	109.9
2006/07	4	14	15.8	-8.3	8.96	9.03	129.6
2007/08	4	8-15	25.3	-17.1	9.56	9.61	145.6
2008/09	4	8-16.5	36.4		11.81	11.3	197.3
2009/10	4	8-16.5	2.8		13.68	13.53	151.8
2010/11	5	7.5-16.3	18.1		16.52	16.11	

Source: 1 WDI (various years); others from National Bank Of Ethiopia Annual Reports 2009/10 and 2010/11.

One of the alternative ways of improving investments in industry is by inviting foreign direct investment and attracting private investments. This will require a revitalization of competition in the banking sector through a liberal monetary policy.

Technology is the key to attaining competitiveness. Lack of indigenous technology generators (academic, research and development institutions and laboratories) is a major shortcoming in technological development and adversely affects the competitiveness of Ethiopia's maufacturing sector. Research and development institutes will need to be established and work in collaboration with universities, industries and overseas benchmarked research and development (R&D) institutions to enhance and play a pivotal role in adopting and disseminating appropriate technologies that support the industrialization process.

One alternative to bridging the technology gap is a transfer of technology. The easiest way to transfer technology is through the foreign direct investment route, which will require reforms in investment policy. Since FDIs in Ethiopia have remained low, room for technology transfers is very limited. Technology transfer and development require technology adoption and adaptation, enhancement of local technology, establishment of technology parks, reverse engineering and setting innovation and technology transfer systems.

5) Inadequate market diversification and development

Ethiopia's manufacturing sector currently mainly serves the domestic market. Inadequate market diversification leaves the manufacturing sector free from pressures of global competition. To attain manufacturing prowess, Ethiopia should strive to become competitive at the local, regional and global level. It is therefore important to devise an appropriate marketing strategy to further expand and enter new markets, particularly domestic, regional and international markets. Not all industries can follow a similar strategy, which implies that each industry must define its own markets, segment them, and position its products and services to get higher returns.

Entering new markets within COMESA and the African continent represents a huge opportunity for the development of Ethiopia's manufacturing sector. However, appropriate timing and caution must be heeded to reap the benefits of entering COMESA's free market without endangering the development and maturity of the manufacturing sector. The outputs of the manufacturing sector should by and large target demand and the required standards of the market at different levels.

The success of industrial diversification and the development of high-tech industries is highly dependent on the level of competitiveness of local products in local and international markets. In this regard, enhancing local and global competitiveness by developing a sound marketing strategy, marketing research capabilities, creating local and global market access, and diversifying the regional and international market are some of the key factors that will be addressed to improve the competitiveness of the manufacturing sector at large. To diversify local and global market opportunities, the existing industries' competitiveness must be enhanced by establishing a computerized market information system; maintaining strong regulatory systems that oversee the quality and standards of products before they reach the market; improving local, regional and global market linkages with improved distribution outlets and improved infrastructure; and reducing illegal business activities and transforming the informal sector into a formal sector.

6) Inadequately developed institutional support and enterprise cultivation

Currently, there are 18 government agencies that regulate the manufacturing sector in Ethiopia. The government has implemented a wide range of institutional reforms since the early 2000s, with the aim of addressing the bottlenecks for private sector development. One of the well-known initiatives was the Civil Service Reform Program (CSRP) that was launched in 2001 under the broader National Capacity Building Program (NCBP). Service delivery was one of the five key areas of CSRP and a 'special programme' of Performance and Service Delivery Improvement Policy (PSIP) was introduced in priority ministries and agencies that directly collaborate with the private sector. During this period, the government also implemented other reforms such as business registration, substantial revision of the investment code, modernization of the tax regime and introducing value added tax (VAT), establishment of competition policy and partially reforming the customs administration[9].

Civil service reforms, and particularly the BPR's have led to a substantial restructuring of government bodies that deliver services to the private sector. Service delivery has improved as a result. Ethiopia could not, however, retain this level of improvement, and its ranking has consequently dropped in recent years. This deteriorating performance can be attributed to steps taken by the government to introduce and enforce a number of erratic regulations to allegedly curb 'rent-seeking' and discipline the 'rogue' private sector. With the onset of the financial crisis in 2009, the government closed down 94 warehouses of coffee exporters and revoked their license and accusing them of hoarding. In response to the soaring inflation, the government made a failed attempt to control the price of some essential consumer goods in 2011 by introducing price caps. It also issued new regulations for business registration to purportedly reduce the monopoly of a few entrepreneurs, mainly importers, to ease the pressure of inflation. This resulted in slow and lengthy periods of business registration and renewal. Similar regulations were implemented for land administration (the real estate sector and the overall lease system), customs administration and the private banks[10]. These actions are thought to have eroded the confidence of the private sector and the predictability of policies.

There is a long-standing complaint by the private sector that the state-owned and party-affiliated enterprises (endowments) benefit from privilege access to policymakers. They are perceived to have received preferential treatment, for example, in terms of credit, government contracts and foreign exchange allocation, which the government however firmly denies. The issue of the party-affiliated enterprises has been particularly sensitive politically. A survey report of the World Bank, found that state-owned enterprises are more likely to have access to public procurement and finance than their private counterpart, but that there is no strong evidence of such favouritism towards party-affiliated firms. The report concluded that the issue in large part (complaint about party-affiliated enterprises) is one perception of the credibility of Ethiopia's commitment to provide a level playing field.

3.4 Chemical Industry - Specific Issues

This industry has the potential of providing a high degree of economic growth and drive subsequent industries with locally available raw material inputs, coal being a strategic energy source that drives all other industries. There is great potential for growth in the chemi-

[9] World Bank (2009)

[10] For example, starting in 2011, private banks were forced to purchase National Bank of Ethiopia bonds at 27 per cent of their lendable capital in an effort to finance massive public investments. It has been claimed that this was started to crowd out the private sector from access to credit.

cal industry, with new licences being granted that are likely to see the growth of other value chains extending into the petrochemical, agricultural and other chemical value chains. Ethiopia needs to develop new value chains in view of increasing consumer demand. These industries have not been receiving support on the same scale as other industries in the mining of raw and bulk mineral products. There has been little legislative policy and the capital financing for the development of traders and processors to start or develop business.

Unreliable data on production yield levels, potential areas for increased production and feasibility studies on establishing new value chain players or factories exacerbates the situation. Lack of a clear government strategy or guidelines in the past have not helped the industry attain a critical mass. The operations of most players in the industry is on a downward scale. There is a lack of information among producers and traders about prices and potential markets, which creates uncertainty with regard to margin and profitability. In an atmosphere of uncertainty, traders must include larger margins to cover potential risks observed in the supply chains not controlled by organizations.

3.4.1 Issues Related to Fertilizers

Electricity and raw material costs have been the major cost drivers of fertilizer production in Ethiopia. Increases in global prices of raw material inputs considerably erode the competitiveness of local producers. Capacity utilization is another major issue. The transportation network's failure to consistently deliver and the low uptake of phosphate rock by fertilizer producers has resulted in costs to skyrocket. Unreliable orders from the government have led to firms scaling down their production operations. Fertilizer prices have increased on account of a number of factors such as lack of raw materials, energy and labour costs.

3.4.2 Issues Related to Industrial and Other Chemicals

The limited natural chemical resource base and small market explain why economic investment remains the main constraint for this industry. Other major constraints in this industry include shortage of local raw materials, shortage and interrupted supply of imported raw materials, weak domestic market demand, weak export market demand, heavy competition abroad, breakdown of machinery, shortages of spare parts for machinery, cash flow difficulties and labour disputes.

3.4.3 Issues Related to Consumer Care Products

Overreliance on imports in this industry is attributable to the deterioration of the value chain as evidenced by the closure or partial closure of some the key firms in the value creation process. Some firms in the value chain have resorted to importing finished goods from import markets and selling them locally. Another factor that has a negative impact on the value chain is the decline in the quality of products made locally vis-à-vis imports from the developed world. The quality of products has been affected by the obsolete plant and machinery that requires replacement in light of new developments in the technological sphere. Another challenge firms in the value chain face is the low productivity of workers compared to that of other companies abroad.

3.4.4 Issues Related to Cement Producers

Cement and lime processes are highly energy intensive. In a typical cement factory, energy accounts for 30 per cent of the cost of production, with coal comprising the largest share. Increases in the cost of energy could be mitigated by optimizing operational efficiency and through technology improvements. However, the estimated increases in energy costs in the medium term are likely to outstrip the industry's ability to adapt to market changes. The key issue therefore is energy supply constraints. Supply constraints have considerably affected capacity utilization and competitiveness. It is important to note that these supply constraints are not limited to electrical energy, but also expand to coal and other liquid fuels. The only appropriate response to these challenges is to address the issue of energy security as a macroeconomic issue.

3.4.5 Issues Related to Glass Producers

Glass production is energy intensive and this industry therefore also suffers from energy supply constraints. This indusry requires new packaging and labelling technologies and has had difficulties in identifying new market opportunities. Consequently, local producers lack competitive edge over international ones. Working capital to finance operations would be required at a far cheaper rate than currently being offered by the formal banking system. Ethiopia has limited foreign exchange liquidity to provide recapitalization for the glass production industry and to introduce the latest machinery and new innovations. Entry into external markets is one opportunity that the industry needs to tap into.

3.4.6 Issues Related to Specialty Chemicals (Plastics & Rubber)

Lack of technology and technological development makes it difficult to be competitive in this industry. Another problem producers face is the lack of working capital. The formal banking institutions charge high lending rates on working capital. Imports from the region provide stiff competition. High operational costs and expensive input imports means lo cal production cannot invest into modern quality management systems, thus further eroding the industry's competitiveness.

CHAPTER II

SECTOR SELECTION AND PRIORITIZATION IN ETHIOPIA'S CHEMICAL INDUSTRY

1. Introduction
2. An Overview of Ethiopia's Infrastructure
3. Industry & Sectoral Level Assessment
4. Dynamism and Revealed Comparative Advantage Analysis
5. Assessment of Production Capacity and Export Competitiveness: Chemical Sub-Sectors of Ethiopia
6. General Assessment of the Potential of the Chemical Sub-Sector: Logical Matrix

1. Introduction

There is ample empirical research demonstrating that the manufacturing sector plays a key role in growth, particularly when countries are at a relatively low income level, as is the case of Ethiopia. Manufacturing offers the possibility of higher levels of productivity, more rapid productivity growth and greater technological change than agriculture, or below a certain income, many parts of the services sector. In addition, it can generate jobs that offer higher wages due to the higher level of productivity. Hence, there is usually an association between the growth of an economy and the size and growth of its manufacturing sector[11]. Consequently, resources could be optimally allocated to maximize the social welfare function.

The objective of developing an action plan for Ethiopia's chemical industry was driven by the need for inclusive industrial development so that all parts of society benefit from industrial advancements. It should help reduce absolute poverty and inequality and provide dignified employment to both women and men. The key issue in policy terms is to ensure that manufacturing activities grow more rapidly to create both direct and indirect jobs through linkage effects. The globalization of production processes and consumption have accelerated the specialization of manufacturing tasks, and contributed to inequalities in the labour market in terms of differences in wages and employment opportunities between skilled and unskilled labour and between men and women. Whilst manufacturing alone cannot resolve all problems of inclusion, an approximate negative correlation between the share of manufacturing in a country's GDP and the levels of both poverty and inequality does exist. Bringing more people into formal employment is not a sufficient condition for inclusive development, it is also equally important for the spillovers of manufacturing to percolate down to the rest of the economy. A country's industrial structure is endogenously determined by its factor endowment structure (i.e. structure of labour and capital)[12].

Consequently, the initial endowment provides comparative advantage and optimal industrial structure for some but not all industries. Among the high-tech industries, the chemical industry not only increases manufacturing value added rapidly through fast growth of labour productivity—similar to machinery and equipment and electrical machinery and apparatus—at late stages of industrial development, but may also emerge at an early stage of industrial development due to the mixed characteristics of the chemical industry, which seem to reflect the fact that it includes the production of a broad range of products with diverse technological and value-added content (including basic chemical products for basic human needs). In this sense, the chemical industry assumes a special role amongst manufacturing industries as it not only caters to humans' basic needs, but also contributes to the creation of formal manufacturing jobs with decent wages across development stages. Moreover, the chemical industry serves as an incubator and accelerator of other manufacturing activities and manufacturing-related services such as the biotech and pharmaceutical industries. For Ethiopia, sustainable development also necessitates eliminating the remaining incidences of extreme poverty and reducing regional disparities within the economy. For this reason, UNIDO promotes the con-

[11] UNIDO (2015).
[12] Lin (2012).

cept of Inclusive and Sustainable Industrial Development (ISID), which is closely related to the United Nations Sustainable Development Goal 9[13]. Growing labour productivity without accompanying higher market demand limits the spillovers of industrial development. This requires Ethiopia to upscale the basic chemical industry to lay the foundation before diversifying its chemical industry from low technological and value-added content into a dynamic and more sophisticated structure.

There is no single path to development, but cross-country experiences reveal general patterns and trends, which can be attributed to country-specific sectors. There is, however, one consistent finding of normal development patterns, namely when an agro-based economy transforms into a manufacturing-driven economy, its per capita income grows. Due to agglomeration effects, high levels of population density tend to be associated with relatively high levels of manufacturing. On the other hand, countries with large levels of natural resources have lower than expected levels of manufacturing for their income level. Available natural resources impart advantages, but absolute advantages in manufacturing require both skills and technology. Similarly, countries with high labour costs and poor governance have lower levels of manufacturing than expected. Whilst there may be some developing countries that have a significant potential in high productivity activities, such as tourism services or mineral processing, a need will eventually arise in most countries to develop some form of manufacturing. This requires that adequate support for manufacturing is available and that key aspects of the investment climate, like high quality infrastructure, training activities and a stable macroeconomic environment, are in place.

Two low-income economies, the Republic of Korea and Malaysia, emerged as major chemical producers in the 1960s by adopting a focused approach to support manufacturing. The 'Miracle on the Han River' was marked by rapid industrialization, technological advancement, urbanization, democratization and globalization, which transformed the resource-poor Republic of Korea from a nearly zero to a trillion dollar economy. Likewise, the oil-rich Malaysia also followed a focused approach to emerge as a chemical manufacturing giant in less than a decade. Their cross-country experience is a useful example of the allocation of resources, which could help transform Ethiopia's economy into a chemical manufacturing hub in the region. The assessment of the industry's production capacity is also an essential element that is considered in the selection because the export of manufactured products to new destinations requires a thorough analysis of production capability, market demand and cost competitiveness, alongside robust testing and certification procedures to ensure product quality. As governments always have limited resources to invest in hard and soft infrastructure, identification is necessary because specialization, agglomeration, and clustering are vital for reducing transaction costs in any given industry, including the chemical industry. Based on an export competitive analysis, a country's chemical industry's cost competitiveness (i.e. competitive unit labour costs and strong market demand) could be prioritized for upscaling.

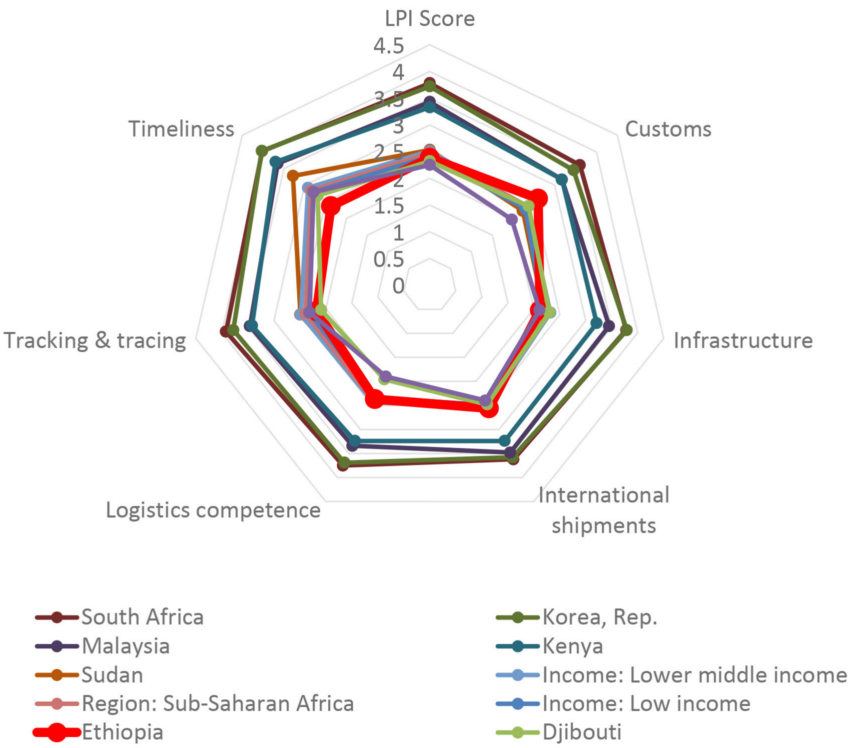
[13] UNSDG 9 is dedicated to building resilient infrastructure, promoting inclusive and sustainable industrialization and fostering innovation.

2. An Overview of Ethiopia's Infrastructure

According to the World Bank (2011), infrastructure has contributed 0.6 percentage points to Ethiopia's annual per capita GDP growth over the last decade. Raising the country's infrastructure endowment to that of the region's middle-income countries could add an additional 3 per cent to infrastructure's contribution to economic growth. The country's greatest infrastructure challenge lies in the power industry, where an additional 8,700 megawatts of power generation capacity are needed over the next decade, implying a doubling of the current amount. The transport industry is afflicted by low levels of rural accessibility and inadequate road maintenance. Ethiopia's ICT industry currently suffers from a poor institutional and regulatory framework. Addressing Ethiopia's infrastructure deficit requires a sustained annual expenditure of USD 5.1 billion over the next decade. The power industry alone requires USD 3.3 billion annually, with USD 1 billion needed to facilitate regional power trading. Improving road maintenance, removing inefficiencies in power (notably under-pricing) and privatizing ICT services could reduce the gap. A significant increase in Ethiopia's already proportionally high infrastructure funding is necessary and careful handling of public and private investments for timely infrastructure development.

In addition to production factors, improved logistics and basic infrastructure could also facilitate industries' development. Increased investments in infrastructure could lay a solid foundation for the growth of manufacturing and other manufacturing related-service industries to facilitate Ethiopia's structural growth.

Figure 7 Quality of infrastructure: Comparison with selected comparators and income groups



Source: World Bank's Logistics Performance Index (The World Bank, 2018)

The Logistics Performance Index (LPI) is an interactive benchmarking tool created by the World Bank to help countries identify the challenges and opportunities they face in their performance on trade logistics and what they can do to improve their performance. As highlighted in Figure 7, the performance of Ethiopia in hard infrastructure is almost at par with that of countries in the low- to lower middle-income group.

- Ethiopia's FDI inflow experienced an approximately three-fold increase between 2008 and 2016 (Ethiopian Investment Commission, 2018), particularly in those labour-intensive industries that often emerge in the early stage of industrial development in which the existence of quality infrastructure is key for competitiveness and integration into global production networks.

- The Chinese Huajian group has stepped up investments in Ethiopia with the "Ethiopia-Huajian International Light Industry City" which is a success story that it is expected to generate annual revenues of USD 2 billion and create 50,000 to 60,000 local jobs (UNIDO, 2017).

Considerable progress has been made in the improvement of customs and international shipments infrastructure in Ethiopia compared to neighbouring comparators and those in the same income group, which has contributed to the recent increase in foreign direct investment (FDI). Ethiopia, however, still lags far behind in terms of timeliness in comparison to other landlocked comparators, i.e. Bolivia, Sudan and Djibouti.

3. Industry & Sectoral Level Assessment

This section examines the production and employment dimensions which are crucial to inclusive and sustainable industrial development. Sustaining industrial growth and generating employment are crucial to UNIDO's mandate on SDG 9 (build resilient infrastructure, promote sustainable industrialization and foster innovation). This section provides information that policymakers can use in support of evidence-based industrial strategies or policies, the slope and turning points of the curves in Figure 8 and Figure 9 represent:

- The level of GDP per capita associated with the sunset or sunrise of the manufacturing sector. Countries that are developing medium- to long-term strategies may find it useful to understand and formulate the skills, infrastructure and interventions needed to upgrade the performance of emerging industries.

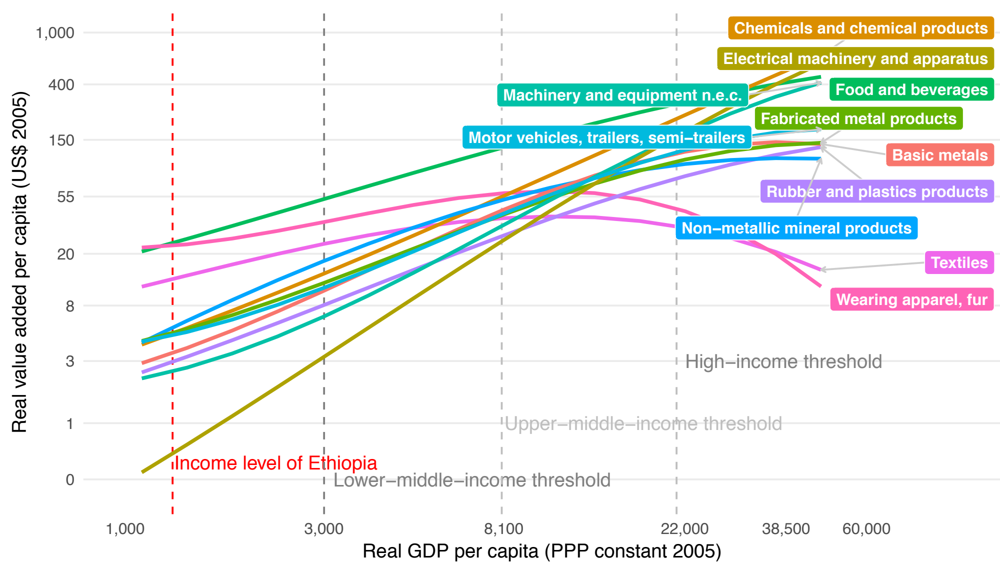
- The speed of structural change is the time needed for a given industry to transition from sunrise to sunset. The GDP per capita range characterizes the length, i.e. an industry's life cycle. The speed and length are useful information for the policymaker to understand how long certain manufacturing industries will continue to provide the expected value added and employment impact.

- Policymakers may be interested not only in industries with emerging potentials (the levels of the curves), but also in the speed, length and tipping points of pattern lines. For example, low-income, large countries that are developing labour-intensive industries may want to know the extent of the potential range of income these industries can attain and at which stage they will decline, and particularly whether such changes in the trend could occur in a relatively short income range.

3.1 Potential of Value Creation

A crucial indicator that highlights an industry's prowess in the national economy is its potential value creation. Value addition in its most common understanding describes the value a company adds to its product or service before offering the product to customers. On the other hand, the contribution of a private industry or government to overall gross domestic product (GDP) is an industry's value addition. If all stages of production occurred within a country's borders, the total value added at all stages is counted towards the country's GDP. The total value added is the market price of the final product or service, and only counts production within a specified time period. The value added of an industry is the difference between the total revenue of an industry and the total cost of inputs purchased from other businesses within a reporting period. An industry's total revenue or output consists of sales and other operating income, commodity taxes, and inventory change. Inputs that were purchased from other firms to produce a final product include raw materials, semi-finished goods, energy and services.

Figure 8 The potential of value added creation across development stages



Source: UNIDO elaboration based on UNIDO INDSTAT2 rev.3 (2018)

Figure 8 highlights that at low- to lower middle-income levels below USD 5,000 (constant 2005 PPP), there are commonly three industries that dominate the manufacturing sector: (i) Food and beverages, (ii) Textile, and (iii) Wearing apparel. These industries achieve the highest level of manufacturing value added per capita. They are closely related to basic human needs, and usually exist before industrialization "takes off". In this "early" stage of economic development, labour-intensive industries[14] clearly have higher levels of manufacturing value addition, and their growth rates are also not much lower than those of emerging capital-intensive industries.

Countries at the income level of Ethiopia typically have comparative advantages in food and beverages, textile, wearing apparel, non-metallic mineral and certain chemical industries. Once countries have reached lower- to upper middle-income levels, their propensity to gradually lose out in terms of cost competitiveness in the textile and wearing apparel industries and other labour-intensive economic activities increases due to rising labour costs. Due to factor accumulation and broad categories of products with diverse technological content in the chemical industry, it typically remains the biggest contributor next to food and beverages until a fairly late stage of development.

The chemical industry is a broad manufacturing industry at a low- and lower middle-income level, with basic chemicals sub-sectors emerging to supply household and agro-chemical products and meet domestic demand including soaps, cleaning and cosmetic preparation products and fertilizers, just to name a few. The chemical industry is contributes to a country's value added output and employment, especially in those countries that have undergone economic structural transformation from an agrarian economy to sectors with higher productivity and complexity. A certain level of demand for basic chemical products, i.e. agro-chemical and fertilizers to modernize agricultural practices and colouring matters and tanning agents, serve as primary materials to the textile and wearing apparel industries, both of which are major contributors to value addition at early stages of industrial development.

- Large domestic markets nurture industries for which economies of scale are important. In addition, multinational corporations tend to build manufacturing and refinery plants in large countries and turn them into a regional hub to serve smaller countries in the region through exports. For instance, neighbouring Eritrea, Djibouti, Somalia and South Sudan are among the top-importers of Ethiopia's chemical products.
- Ethiopia could also benefit from its geographical proximity to South Asia and Middle East markets. As these countries gradually develop, they tend to lose comparative advantage in certain labour-intensive chemical sub-sectors. This gives Ethiopia the opportunity to enter international market spaces that are opening up due to loss of competitiveness among comparators. Furthermore, there is potential for a relocation of firms from comparator countries to Ethiopia, together with their knowledge and access to international markets[15].

[14] In order to determine labour intensity, employment per unit of value added was estimated at USD 5,000 and USD 20,000 GDP per capita (constant 2005 PPP) because labour intensity changes with income levels. If an industry's labour intensity was higher than the median for 18 manufacturing industries at both income levels, it was considered labour intensive. Among the industries presented here, the food and beverages, textile and wearing apparel industries are labour intensive while the others are relatively capital intensive.

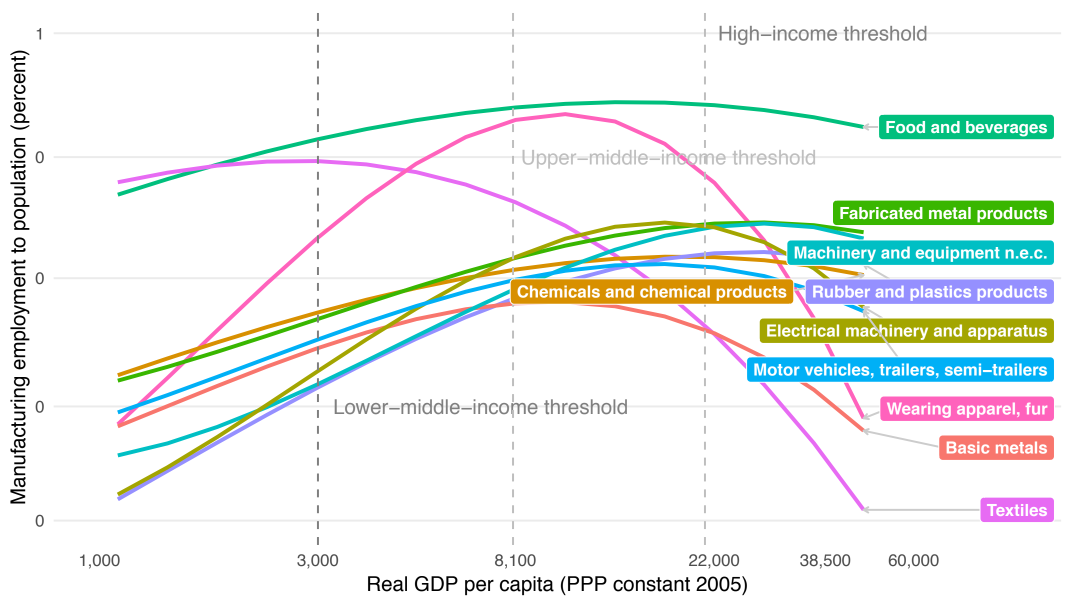
[15] The Chinese Huajian group has stepped up investment in Ethiopia with "shoe city" being one of the success stories in the footwear industry.

It should be noted that in large countries with a population of about 100 million like Ethiopia, depending also on geographic location and proximity to major markets, the chemical industry (especially sub-sectors supplying domestic-oriented chemical products) has the potential to become one of the largest industries in middle stages of development.

3.2 Potential of Employment Creation

A significant body of research claims that earnings from employment are the most important driver of poverty reduction[16]. The World Development Report 2013 argues that "jobs are the most important determinant of living standards around the world", serving to "boost living standards, raise productivity, and foster social cohesion." The importance of jobs for development and poverty reduction is a critical argument in favour of sustainable economic development. While the quantity of jobs created is an overwhelming priority for many governments, including Ethiopia's, the quality of those jobs is also an important issue. The ILO's Decent Work Agenda sets out to increase access to full and productive employment with rights at work, social protection and social dialogue. The ILO estimates that 60 per cent of the workforce in developing countries works in the informal sector, with 34 per cent earning below USD 2 per day. This situation is even worse in the sub-Saharan region. In Ethiopia, agriculture continues to be the major employer. Over half of Ethiopia's population have vulnerable job conditions[17]. This is a critical indicator for determining the contribution of the manufacturing sector in employment generation.

Figure 9 The potential of employment generation across development stages



Source: UNIDO elaboration based on UNIDO INDSTAT2 rev.3 (2018)

[16] Baulch (2011).
[17] http://www.ilo.org/global/about-the-ilo/decent-work-agenda/lang--en/index.htm

As highlighted in Figure 9, manufacturing value added pattern lines are useful to detect the comparative advantage of manufacturing industries and their growth prospects. Employment pattern lines are useful to identify the most labour-intensive industries and the possible paths of employment given a certain level of GDP per capita. Labour-intensive industries seem to be crucial for the development of employment opportunities at low incomes and early stages of industrial development. As the labour force moves from agriculture to formal paid employment, labour-intensive industries offer a pivotal opportunity by facilitating shifts in the labour force and accommodating the productive absorption of excess labour. It is therefore important for countries at Ethiopia's income level to lay a solid foundation for the development of more capital-intensive chemical sub-sectors to gradually diversify and upgrade their industrial structure.

- Countries experiencing a transition from lower- to upper middle-income show a tendency to experience declining value added and employment in labour-intensive industries, especially in the textile and wearing apparel industries and certain chemical sub-sectors due to rising factor costs.

The employment pattern in Figure 9 indicates that the food and beverages, textile and wearing apparel industries are the three major sources of formal manufacturing employment, at least up to a middle stage of economic development. Typically, the chemical industry is relatively domestic-oriented at the early stages of industrial development with a large share of a country's final output consumed in the domestic market.

During the early stage of industrial development, there is opportunity for factor accumulation, especially human capital. This is particularly true in the case of the chemical industry, which includes the production of a broad range of products with diverse technological content. As emphasized earlier, such structural transformation does not happen overnight; only continuous improvements in factor endowment, such as skilled labour, will make a difference at a later stage of industrial development.

In other words, the chemical industry's competitiveness (in particular, the labour-intensive chemical sub-sectors at early stages of industrial development) is an indicator for successful early stage industrialization and reflects the fact that the creation of formal manufacturing employment can sustain long-run growth in employment, whereas both textiles and wearing apparel face rapid declines in employment at middle stages of economic development. Ethiopia's chemical industry has already achieved a certain critical mass in the labour-intensive chemical sub-sectors like soap, detergents, paints, etc. However, a competitive wage structure and a young labour force could be assets for achieving cost competitiveness. Being labour intensive, cost competitiveness in these industries would be a decisive factor for success. Ethiopia's competitive wage level and abundant trainable labour force already provide the country with a distinct advantage, which is not available in many countries, especially in small sub-Saharan African countries.

3.3 Potential for Exports of Ethiopia's Chemical Products

Traditionally, Ethiopia has a strong agricultural base and, consequently, its exports are dominated by agro-based industries. The vegetables industry alone accounts for an export value of USD 2.3 billion, accounting for nearly 75 per cent of total exports. Coffee, sesame seeds, cut flowers and pulses rank high among Ethiopia's agro-exports and markets for these products can be found around the world. However, these industries have failed to raise the share of exports in GDP to 22.5 per cent as targeted by the GTP I plan. Currently, the economy is strongly focused on agricultural commodities that are subject to price fluctuations. Only 14 per cent of Ethiopia's exports are semi- or fully processed. Due to the narrow export basket and the lack of manufactured exports, price fluctuations cannot be adequately compensated. Accordingly, the GTP II plan highlights "improving production capacity, utilizing the opportunities in the international market and encouraging the manufacturing sector to engage in the production of manufactured exports".

The top-three market destinations for Ethiopia's chemical sub-sectors are presented in Table 14. As this analysis shows, Ethiopia's major trading partners are neighbouring countries and those in the region with whom Ethiopia maintains strong trade connections in several key chemical sub-sectors, such as basic chemicals, agro-chemical, soap and cleaning products.

Table 14 Ethiopia's major import partners for trade (chemical sub-sectors in 2016)

Country	Export values (US$)	Share of resp. sector exports	Share of Ethiopian exports in imports of trading partner	Rank of Ethiopia among importers
Basic chemicals except fertilizers				
Israel	750,482	0.044180%	0.05946%	42
Malaysia	136,046	0.008010%	0.00306%	54
Sudan	39,765	0.002340%	0.04473%	31
Plastics in primary forms; synthetic rubber				
Djibouti	63,454	0.003740%	0.06788%	21
Turkey	18,047	0.001060%	0.00025%	65
Vietnam	1,374	0.000081%	0.00003	61
Pesticides and other agro-chemical products				
Turkey	75,415	0.004440%	0.02127%	38
Djibouti	16,124	0.000949%	0.13544%	14
Oman	29	0.000002%	0.00012%	35

Paints; varnishes; printing ink and mastics				
Somalia	73,422	0.004320%	0.68426%	7
Djibouti	9,468	0.000557%	0.09466%	21
Germany	12	0.000001%	0.00000%	80
Pharmaceuticals; medicinal chemicals; etc.				
Niger	550,586	0.032410%	0.71831%	11
Senegal	356,559	0.020990%	0.13590%	19
Angola	200,322	0.011790%	0.08771%	20
Soap; cleaning & cosmetic preparations				
Sudan	364,518	0.021460%	0.36480%	22
United Kingdom	123,828	0.007290%	0.00179%	65
Saudi Arabia	107,401	0.006320%	0.00879%	56
Other chemical products n.e.c.				
Hong Kong, SAR	375,566	0.022110%	0.00799%	43
Zambia	269,266	0.015850%	0.25498%	20
India	238,055	0.014010%	0.00673%	66
Man-made fibres				
Portugal	221,384	0.013030%	0.09655%	30
Morocco	70,054	0.004120%	0.06225%	24
Algeria	61,755	0.003640%	0.11700%	22

Source: UNIDO calculations based on UN Comtrade (2018))

The results of the analysis in Table 14 are indicative of the fact that Ethiopia still belongs to the top-50 ranked exporters in the three largest markets for Ethiopia's chemical sub-sectors.

- The soap, cleaning & cosmetic preparations industry has particularly strong trade connections with Sudan.
- Similar observations can be made for the chemical sub-sectors of (i) Paints, varnishes, printing ink and mastics (ii) Pharmaceuticals; medicinal chemicals; etc. (iii) Ethiopia ranks among the top-30 exporters of man-made fibres to Somalia, Djibouti, Niger, Senegal, Angola, Portugal, Morocco and Algeria.

- On the other hand, when looking at the export shares and rankings in the top-three markets, Ethiopia is still not a major exporter in those sub-sectors promoted by the country's Tech Roadmap, i.e. the basic chemicals sub-sector.
- Performing at 0.06 per cent of total imports in Israel's basic chemical products market brought revenues of USD 750,500 to Ethiopia. By contrast, 0.06 per cent of total imports in Morocco's man-made fibres products market brought revenues of USD 70,000 to Ethiopia.

In terms of trade size, there is still untapped potential in the international market of basic chemical products for Ethiopia to further develop under the Tech Roadmap. Malaysia and Sudan are the second and third largest markets after Israel.

Ethiopia's trade balance suggests that the chemical sub-sectors (i) Basic chemicals, (ii) Fertilizers and nitrogenous compounds, (iii) Plastics in primary forms and synthetic rubber, (iv) Pharmaceuticals, medicinal chemicals, etc., are among the sub-sectors with the highest trade balance deficit in 2015, which amounted to USD 2.3 billion and accounted for 74 per cent of the trade deficit in Ethiopia's chemical industry alone. In other words, domestic demand in all categories outstrips the potential need for exports. Table 15 highlights the improved performance of the chemical industry in terms of exports. The export Figures are negligible compared to imports in each category. With the exception of for fertilizers, the exports under each category in value terms have experienced an increasing trend.

Table 15 Ethiopia's trade balance (chemical sub-sectors)

Year	Total gross exports (US$)	Total gross imports (US$)	Trade balance (US$)
Basic chemicals except fertilizers			
2014	270,303	437,000,000	-
2015	54,368	408,000,000	(408,000,000)
2016	958,053	215,000,000	(214,000,000)
Fertilizers and nitrogen compounds			
2014	-	478,000,000	-
2015	56	429,000,000	(429,000,000)
2016	-	546,000,000	-
Plastics in primary forms; synthetic rubber			
2014	278,647	532,000,000	(532,000,000)
2015	39,626	699,000,000	(699,000,000)
2016	84,389	382,000,000	(382,000,000)

Pesticides and other agro-chemical products			
2014	44,939	90,700,000	(90,700,000)
2015	1,521	102,000,000	(102,000,000)
2016	91,568	116,000,000	(116,000,000)
Paints; varnishes; printing ink and mastics			
2014	3,430	41,100,000	(41,100,000)
2015	13,689	48,900,000	(48,800,000)
2016	82,903	40,400,000	(40,400,000)
Pharmaceuticals; medicinal chemicals; etc.			
2014	977,633	468,000,000	(467,000,000)
2015	998,262	746,000,000	(745,000,000)
2016	1,743,594	822,000,000	(821,000,000)
Soap; cleaning & cosmetic preparations			
2014	1,775,347	219,000,000	(217,000,000)
2015	1,701,859	227,000,000	(226,000,000)
2016	982,398	145,000,000	(144,000,000)
Other chemical products n.e.c.			
2014	425,705	290,000,000	(289,000,000)
2015	412,683	368,000,000	(368,000,000)
2016	1,117,846	638,000,000	(637,000,000)
Man-made fibres			
2014	1,134,377	50,600,000	(49,500,000)
2015	995,693	58,500,000	(57,500,000)
2016	452,807	41,700,000	(41,200,000)

Source: UNIDO calculations based on UN Comtrade (2018)

- Macro conditions, such as the exchange rate, credit challenges and price volatility of chemical products may have an impact on the chemical industry's terms of trade which have deteriorated considerably over the course of three years (2014-2016).

- For low-income countries in particular, export variety is a crucial growth determinant, however, this is not the case for Ethiopia. In Table 15, five of nine chemical sub-sectors, namely (i) Basic chemicals, (ii) Fertilizers and nitrogen compounds, (iii) Plastics in primary forms; synthetic rubber, (iv) Pesticides and other agro-chemical products, and (v) Paints; varnishes; printing ink and mastics registered export values less than USD 100,000 on average.
- Sub-sectoral heterogeneity may also play a role in the variation of trade values, for instance, the structure of production among sub-sectors varies, and higher technological content and capital goods are often attributable to higher gross value per unit. The trade balance captures the aggregated gross value of trade, but not the country's industrial specialization.

    - This heterogeneity can be further studied by examining the terms of trade (product unit price aggregated at sub-sectoral level using a weighting method), the sectoral decomposition of relative prices of exports can capture the quality of chemical exports.
    - International trade theory shows that relative prices determine industrial specialization and welfare gains resulting from trade openness. Export and import price indices are useful instruments for assessing trade performance in terms of quality and volume within Ethiopia and among comparators.

However, it is not just the variety of products that countries export that plays a role – technical change and upgrading are also necessary. Upgrading the existing production structure may prove a better strategy once the developing country has attained higher quality levels in the products it already exports. It can then diversify into more sophisticated and technologically intense varieties (typically exported by industrialized economies) by entering these product classes on the low quality, low price-end of the quality ladder.

It is generally believed that an improvement in the terms of trade increases a country's economic welfare. The terms of trade represent the extent to which exports of locally produced goods at higher export prices and the purchase of foreign produced goods at lower prices is expected to increase welfare. This has a certain caveat, however[18].

- The terms of trade are an important indicator of aggerate trade and its measure helps global imbalances at the world level. It can also be applied to sub-sectoral analyses (Gaulier, Martin, Mejean & Aignago, 2008).
- The terms of trade (ToT_t) are represented by the ratio of the weighted export price index ($PEXP_{\frac{t}{0}}$) to the weighted import price index ($PIMP_{\frac{t}{0}}$):
- $ToT_t = \frac{PEX}{PIM}$
- The export and import weighted price indices are calculated based on the Paasche method using Ethiopia's external trade unit values from UN Comtrade (2018). In this formula,

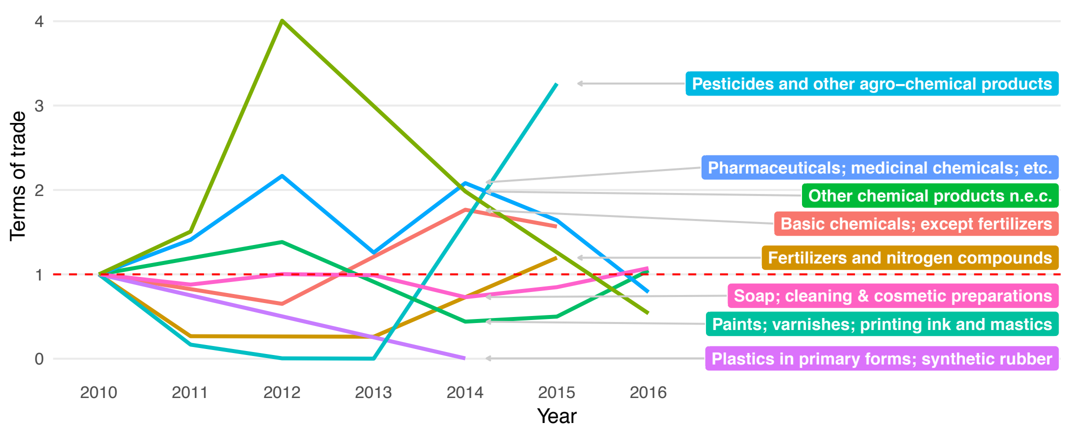
[18] Volume and price effects are lined and must be analysed together, as changes in export volumes are related to changes in prices and vice versa. For instance, if a sub-sector that produces homogeneous products expands its export volumes, this is likely due to a decrease in price, which implies a decline in the terms of trade. If the export price per unit increases simultaneously with export volume, technical change and product upgrading (higher value added per product) play a pivotal role.

an increase in the price ratio reflects an improvement in the sub-sector's terms of trade.

- The terms of trade explain the aggregated and sectoral trade price indices of Ethiopia's chemical sub-sectors. These indices are computed using unit values derived from UN Comtrade (2018) at the HS 4-digit level. The product unit values are aggregated based on the trade value weight at time with 2010 as the base year.
- The Paasche index aggregates the price changes of products using current period weights. It thus better captures changes in the structure of trade. It is an harmonic average of elementary indices weighted by the share of each product in the current traded value for the export price index and import price index:
- $PEXP_{\frac{t}{0}} = \frac{\sum_k p_{k,t} q_{k,t}}{\sum_k p_{k,0} q_{k,t}} = \sum_k w_{k,t} \frac{p_{k,0}}{p_{k,t}}$
- $PIMP_{\frac{t}{0}} = \frac{\sum_k p_{k,t} q_{k,t}}{\sum_k p_{k,0} q_{k,t}} = \sum_k w_{k,t} \frac{p_{k,0}}{p_{k,t}}$

To assess the terms of trade of Ethiopia's chemical sub-sectors, Figure 10 illustrates the development of relative trade prices of eight sub-sectors of Ethiopia's chemical industry.

Figure 10 Terms of trade (chemical sub-sectors of Ethiopia, 2010-2016)



Source: UNIDO elaboration based on UN Comtrade (2018)

Despite the deterioration of the trade balance deficit of the chemical sub-sectors, four chemical sub-sectors, namely (i) Basic chemicals, (ii) Fertilizers and nitrogen compounds, (iii) Soap; cleaning & cosmetic preparations, (iv) Paints; varnishes; printing ink and mastics show increasing terms of trade in the period of 2013-2016. This heterogeneity can be studied further by examining the components from which the changes in the terms of trade are calculated.

The four chemical sub-sectors with improving terms of trade largely benefited from increasing weighted export price, with the exception of the soap; cleaning & cosmetic preparations sub-sector, which experienced a decreasing weighted import price.

The terms of trade of other chemical sub-sectors regressed sharply after 2012, mainly due to the increase in weighted import price. Increasing terms of trade could signal the latency potential of the chemical sub-sectors in the international market due to the increasing quality of exports. Nonetheless, the trade balance deficit of on average USD 400 million suggests a substantial shortfall in supplying domestic demand.

It is evident that there is much untapped potential for Ethiopia's chemical sub-sectors to further upscale and upgrade production, considering its abundant and competitive labour resources. A higher technological content of exports runs alongside the gains in the barter terms of trade in manufacturing; failure to upgrade the quality of exports is accompanied by a deterioration of the barter terms of trade in manufacturing[19].

- Upscaling and upgrading of chemical sub-sectors should go hand-in-hand to ensure not only that the volume of production increases but also that the quality of production improves. The quality of production translates into value added and technological content in products and the adoption of best practices.
- Countries should consider quality differences within specific product categories or industries (vertical differentiation), and that developing countries can increase their economic performance by improving the quality of their manufacturing exports.

To reiterate the terms of trade and associated requirements to upscale and upgrade, the experience of two major exporters of chemicals, namely Malaysia and the Republic of Korea, highlights that the increase in the terms of trade is often the outcome of technological change and upgrading (see Annex). Sound export structures are crucial for growth and development, with high-tech products generating the greatest benefits for exporters in terms of spillover effects, dynamically increasing returns (learning curve effects) and dynamism in world trade[20].

- The terms of trade of Malaysia and of the Republic of Korea underwent different developments. A sectoral analysis allows us to understand the determinants of these differences.
- It is worthwhile to reiterate that Malaysia experienced an appreciation of its terms of trade in other chemical product sub-sectors due to the strong foreign demand for specific chemical products. The five products listed below have the highest export value in the chemical industry, and make up an important share (80 per cent) of Malaysia's chemical exports.
    - Chemical elements for use in electronics in the form of discs
    - Reaction initiators, reaction accelerators and catalytic preparations
    - Prepared glues and adhesives
    - Activated carbon

19 UNIDO (2018).
20 Lall (2011).

- Mixtures of odoriferous substances.

- The Republic of Korea experienced an appreciation of its terms of trade in the soap, cleaning and cosmetic preparations sub-sector due to strong foreign demand for skin care products. Beauty, make up and skincare products alone account for 66.5 per cent of the country's chemical exports.

Thus, the quality of exports is a key determinant of economic growth. Developing countries should therefore strive to produce the goods that industrialized economies make[21]. At a later stage of development, diversification towards dynamic products is extremely important, as it limits the risk that the export market will become rapidly saturated and that prices will decrease, while increasing the chances of exploiting the potential of long-term productivity growth associated with export-oriented industrialization. To be able to produce such products competitively, however, firms need to meet minimum productivity thresholds. Their capacity to do so depends on economic and social framework conditions and government policy (UNIDO, 2018). As discussed in the first section, infrastructure and logistics are also key determinants of industrial development as reflected in cost competitiveness. Therefore, Ethiopia should strive not only to upscale its existing product portfolio, but also to generate quality, higher value-added products as other low-income countries enter these markets.

4. Dynamism and Revealed Comparative Advantage Analysis

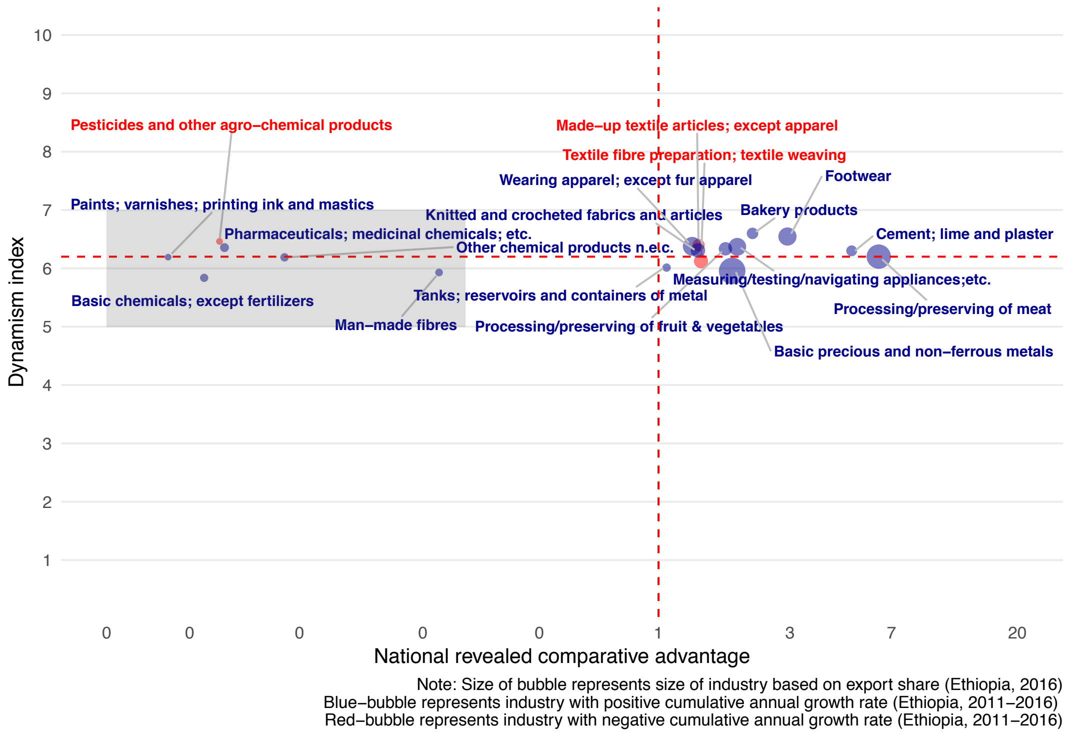
Comparative advantage is an economic term that refers to an economy's ability to produce goods and services at a lower opportunity cost than its trading partners. A comparative advantage gives a company the ability to sell goods and services at a lower price than its competitors and realize stronger sales margins. The law of comparative advantage is popularly attributed to English political economist David Ricardo and his book "Principles of Political Economy and Taxation".

The concept of comparative advantage analysis pertains to the relative trade performance of individual countries in particular commodities. Under the assumption that the commodity pattern of trade reflects inter-country differences in relative costs as well as in non-price factors, the comparative advantage of the trading countries is "revealed". The factors that contribute to shifts in RCA are economic: structural change, improved world demand and trade specialization.

- It is of particular interest to learn about the export performance of sub-sectors in which Ethiopia has relative comparative advantages (RCAs) compared to other world economies. This allows identification of sub-sectors that could enter the world market as highly competitive participants. Identifying and unlocking the full growth potential of highly competitive sub-sectors could result in an extensive growth boost to Ethiopian manufacturing growth.

[21] Hausmann, Hwang & Ridrik (2007)

Figure 11 Dynamism and revealed comparative advantage (RCA) in 2016



Source: UN Comtrade (2018)

- This assessment presented in Figure 11 not only allows identification of industries with a comparative advantage based on export performance relative to world performance, but also illustrates how dynamic these sub-sectors are:
  - The y-axis of Figure 11 presents the dynamism index. It indicates the dynamism of a sub-sector (based on a group of comparators). The dynamism index denotes the normalized average export growth rate of each sub-sector (2011-2016) of the group of comparator countries (large countries with an income per capita higher than Ethiopia).
  - The x-axis of Figure 11 represents the revealed comparative advantage measures (RCAs) of Ethiopia in 2016. The concept of comparative advantage based on Balassa (1965) is derived by calculating the export share of product x_{ij}^k relative to all exports X_{ij} from country to the rest of the world in proportion to the global export share or exports of the respective good x^k:
    - $B_{ij} = \frac{x_{ij}^k / X_{ij}}{x^k / X}$
    - A country is said to have a comparative advantage if the relative export share for country exceeds the aggregated export share, in other words, if ($B_{ij} > 1$)

    - The bubble size represents the export share of the sub-sector in Ethiopia's total exports in 2016.
    - The blue (red) bubbles represent sub-sectors with positive (negative) cumulative annual growth rates in Ethiopia between 2011 and 2016.

- This basic tool allows us to group sub-sectors based on their position in the two-dimensional layout.

    - There are several sub-sectors in Ethiopia that have a comparative advantage and are attractive from a trade perspective (shown in the upper right panel), such as processing/preserving meat, cement, footwear, textile fibre and made-up textile articles and wearing apparel.

        - It is not surprising that these are labour-intensive sub-sectors in which countries at a similar level of income as Ethiopia's (low- to lower middle-income countries) manifest their comparative advantage. These countries benefit from the abundant labour with relative low factor costs to develop such labour-intensive industries (UNIDO, 2013). Due to these sub-sector's labour-intensive production processes, they employ much more labour (and female employment) as they develop than other industries, contributing to the generation of formal manufacturing jobs with decent wages.
        - It is promising that Ethiopia has comparative advantages in these fast-growing sub-sectors and that they have become the country's major exports as indicated by their bubble sizes.

- Most of the chemical sub-sectors (upper left panel of Figure 11) display high dynamism, but Ethiopia has yet to reveal its comparative advantage in the sub-sectors.

    - The trade balance deficit as presented in Table 14 also confirmed the underperformance of these chemical sub-sectors.
    - Although the chemical industry belongs to the high-tech group, on a positive note, certain chemical sub-sectors often emerge at an earlier stage of a country's development as discussed in an earlier section (see Figure 8).
    - It is still important to analyse the feasibility of developing such domestic-oriented chemical sub-sectors within the country to fully exploit Ethiopia's comparative advantage at the current and future stages of development.
    - The development of these chemical sub-sectors is crucial to generate forward linkages from the supply chain and increase domestic value added.

Figure 11 shows the success of exports in certain dynamic sub-sectors such as bakery products, footwear, knitted and crocheted fabrics, which is encouraging. In the face of declines in textile and wearing apparel exports, the growth of basic chemical exports is in line with the type of structural transformation that Ethiopia has to follow in the future.

5. Assessment of Production Capacity and Export Competitiveness: Chemical Sub-Sectors of Ethiopia

As discussed earlier, the chemical industry is the only candidate among the high-tech industries that can sustain value-added growth as countries develop from the early stage of industrial development. This section provides an in-depth analysis of key chemical sub-sectors identified by the Ethiopia Tech Roadmap and which have particularly noteworthy performance patterns. These sub-sectors are analysed based on a set of parameters with the purpose of assessing their performance at different stages of complexity.

The comparative advantage of a country is often represented by its ability to generate value added and transform goods in the production process at lower factor costs than other players. In a rapidly globalized economy, capital, goods and services move increasingly freely around the world. Production is more often than not carried out along international value chains, with components of finished goods being produced wherever this can be done most efficiently[22]. For this, an international orientation is essential. From this perspective, we focus on the following assessment of the production capacity of two chemical sub-sectors (i) Basic chemicals except fertilizers (ii) Soap, cleaning and cosmetic preparations:

- Value added generation
- Employment creation
- Export performance
- Unit labour costs, labour produvtivity and wages.

The assessment results indicate that well-performing comparators whose chemical sub-sectors have been extremely successful are typically characterized by above-average labour productivity and directly associated with an equally exceeding relative value-added generation.

5.1 Assessment of Basic Chemicals, Except Fertilizers

The following section discusses the various aspects of competitiveness in basic chemicals except fertilizers in Ethiopia in comparison with the comparator countries and the rest of the world.

As Figure 12 illustrates, the chemical sub-sector basic chemicals except fertilizers in Ethiopia in comparison to the Republic of Korea and Malaysia's, performs notably below average in terms of manufacturing value added generation. However, there are significant signs of improvement in the performance of Ethiopia overtime.

In Figure 12 and 13, the coherent shift of value added creation and employment in the period 1991-2013 reflects the fact that the main contribution to the expansion of the basic chemicals sub-sector draws on an expanding scale of production without much improvement in labour

[22] UNIDO (2015)

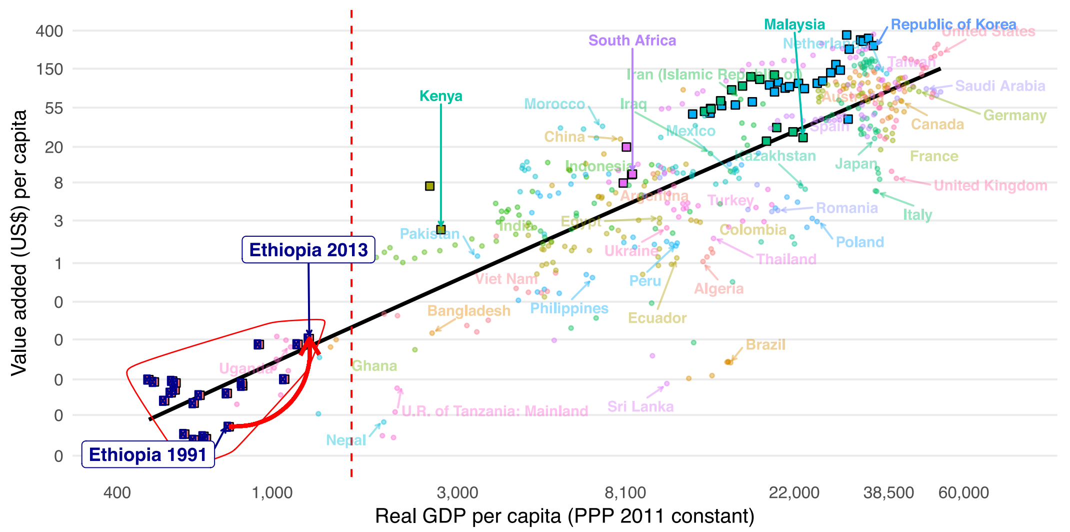


Figure 12 Capability of generating value added

productivity as the unit labour costs remains one of the highest among countries a with similar level of income as Ethiopia's. In Figure 13, it is evident that an increase in employment is important, considering the social aspect of bringing more people into formal employment, but without increasing labour productivity, their wages are likely to remain low. Moreover, the relative export unit price of the basic chemicals sub-sector has declined in the past five years due to losing international cost competitiveness in exports from this sub-sector. In other words, it is relatively costly to innovate and upgrade in Ethiopia.

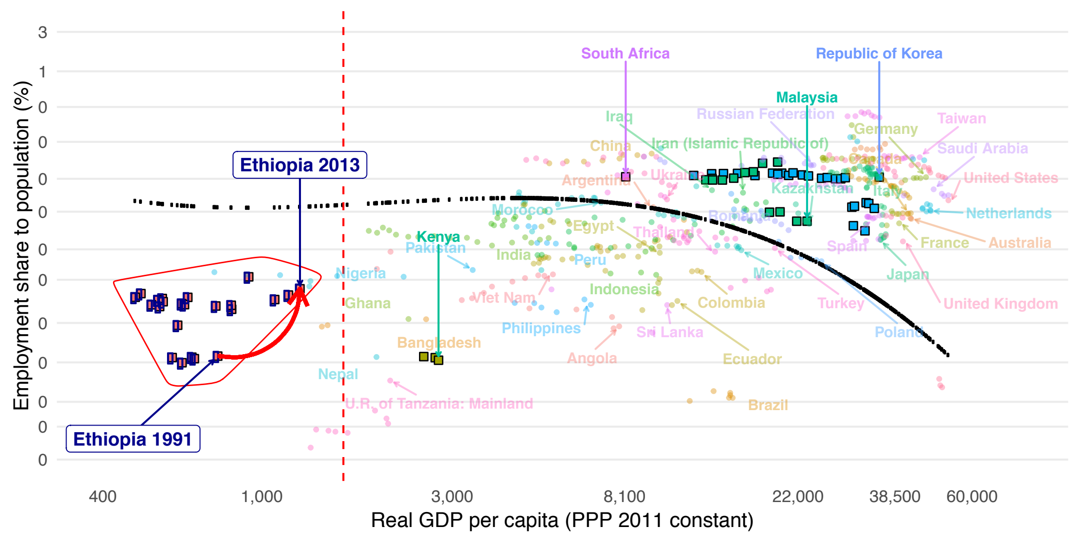
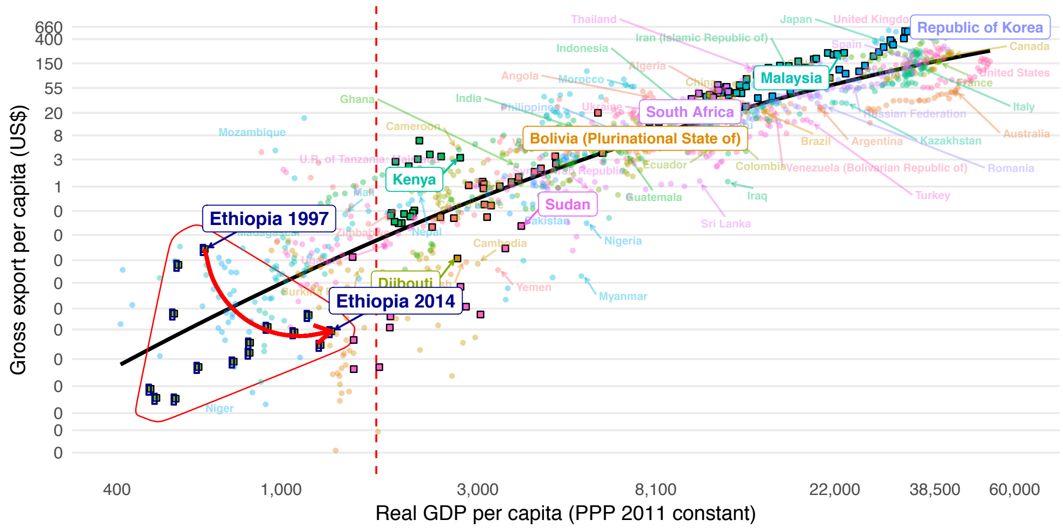


Figure 13 Capability of generating manufacturing employment

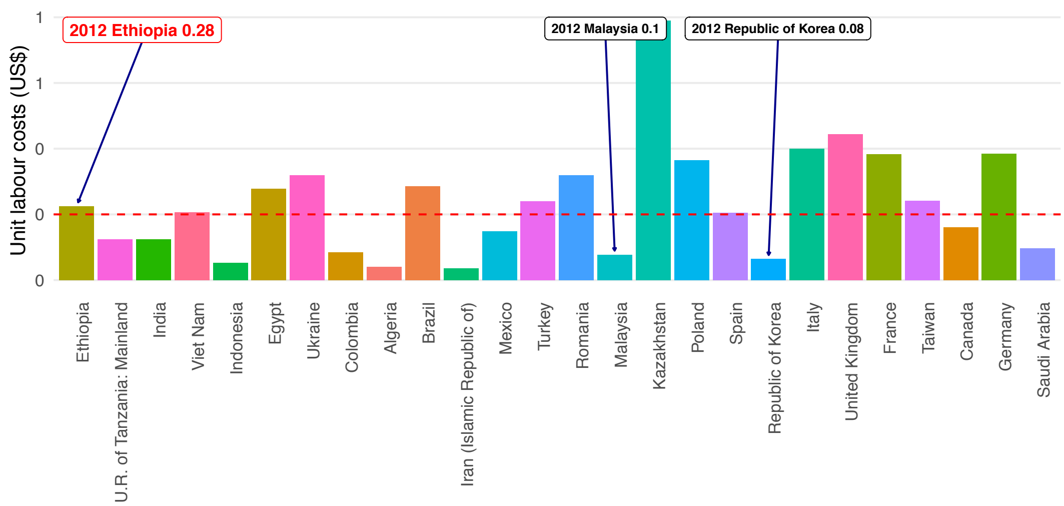
Figure 14 Capability of manufacturing export



As Figure 14 illustrates, Ethiopia's chemical sub-sector basic chemicals except fertilizers performs notably below average in terms of export performance in comparison to Malaysia and the Republic of Korea. In other words, the export performance of the chemical sub-sector failed to follow the trajectory of value added and employment performance. It is not surprising that the sub-sector's export competitiveness is beset by low productivity.

Figure 15 shows that Ethiopia's unit labour costs are higher than the average unit labour costs.

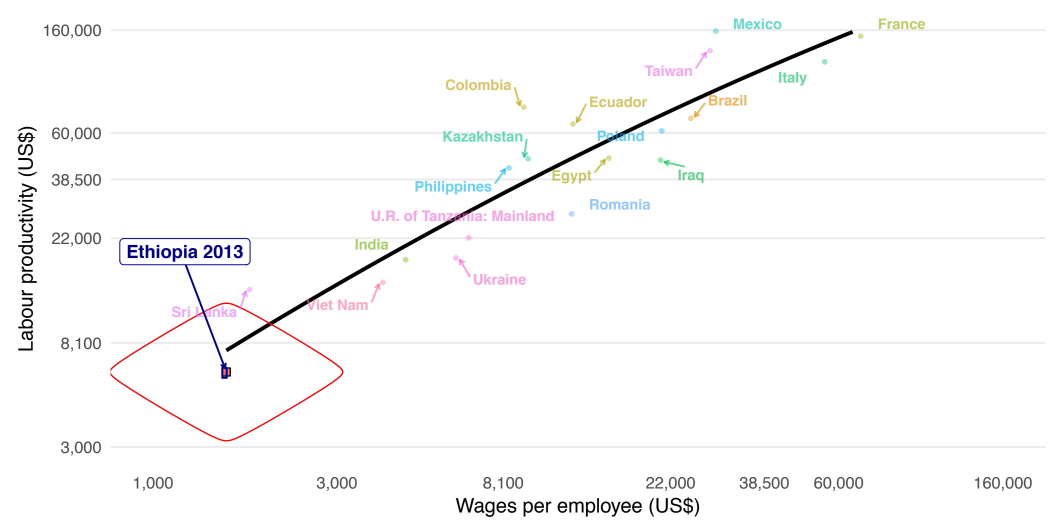
Figure 15 Unit Labour Costs (ULC)



To some extent, Ethiopia's unit labour costs are as high as those in some industrialized countries like Spain and Taiwan ROC, which makes Ethiopian firms less cost competitive, especially considering that their production focus is on basic chemical products, except fertilizers. On the contrary, the unit labour costs of both Malaysia and the Republic of Korea are almost less than half of Ethiopia's, demonstrating their competitive prowess in basic chemicals except fertilizers.

The export volume of the respective sub-sector is closely related to the degree of competitiveness of factor costs. As Figure 15 highlights, the basic chemicals sub-sector is a counter-image of the sectoral characteristics found for the more successful soap, cleaning & cosmetic preparations chemical sub-sector in Ethiopia, whose unit labour costs are notably less competitive (i.e. higher unit labour costs) compared to its market competitors in the region, i.e. Tanzania. In other words, at the given wage level in Ethiopia, the labour productivity of the basic chemi-

Figure 16 Labour productivity, wages and competitiveness



Source: UNIDO elaboration based on UNIDO INDSTAT (2018)

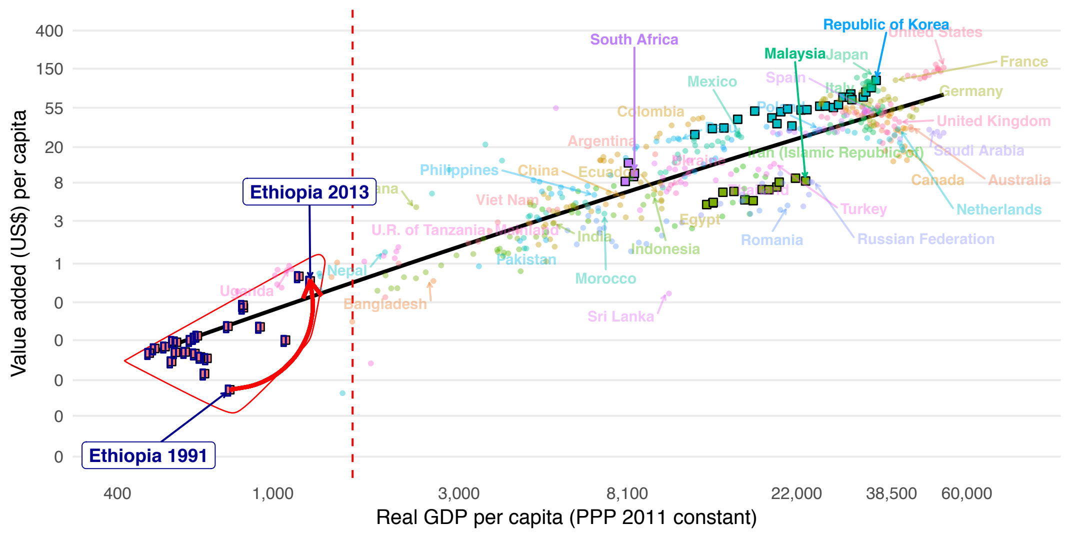
cals sub-sector should be much higher in order to keep unit labour costs at competitive levels. The Figure 16 elaborates Ethiopia's labour productivity in 2013 was USD 6,300. Sri Lanka as one of competitors of Ethiopia, of which it attained one-fold higher in labour productivity (USD 13,460) than Ethiopia at the given similar wage level (USD 1,780). Based on the relationship between wages and labour productivity in low- to lower middle-income countries, Ethiopia's labour productivity should be in the proximity of USD 8,000 to be considered competitive at the same given wage rate.

Ethiopia's labour productivity is lower than in comparator countries and its wages are too high. Given the conditions in Ethiopia, the country should build capabilities for processing rather than for product innovation to improve labour productivity by ensuring workers receive the necessary amount of training, including vocational training.

5.2 Assessment of the soap, cleaning and cosmetic preparations sub-sector

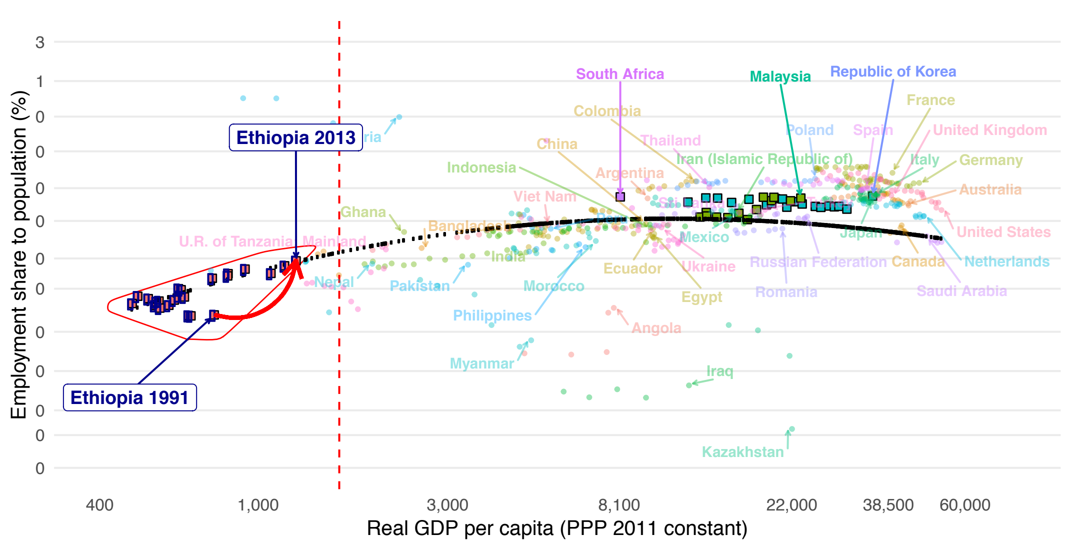
The following section examines various aspects of competitiveness in Ethiopia's soap, cleaning and cosmetic preparations sub-sector in comparison with comparator countries and the rest of the world. The soap, cleaning and cosmetic preparations sub-sector is an interesting case, with the performance of Ethiopia's sub-sector being on par with the average in terms of manufacturing value added per capita, employment generation and even export performance.

Figure 17 Capability of generating value added



As Figure 17 and 18 show, unlike in the basic chemicals sub-sector, the value-added increase of the soap, cleaning and cosmetic preparations sub-sector derives from above expected performance in both employment and labour productivity. The unit labour cost of the sub-sector is one of the most competitive ones in the income range of Ethiopia.

Figure 18 Capability of generating manufacturing employment



The coherence between satisfactory performance in exports and competitive unit labour costs is highlighted in Figure 19 and 20, which indicates that Ethiopia has the potential to penetrate international markets. Moreover, it indicates the capability of firms to upgrade the quality and increase the value added content of the products in the export basket. This is also evident when discussing the sub-sector's increasing terms of trade (see Figure 10).

Figure 19 Capability of manufacturing export

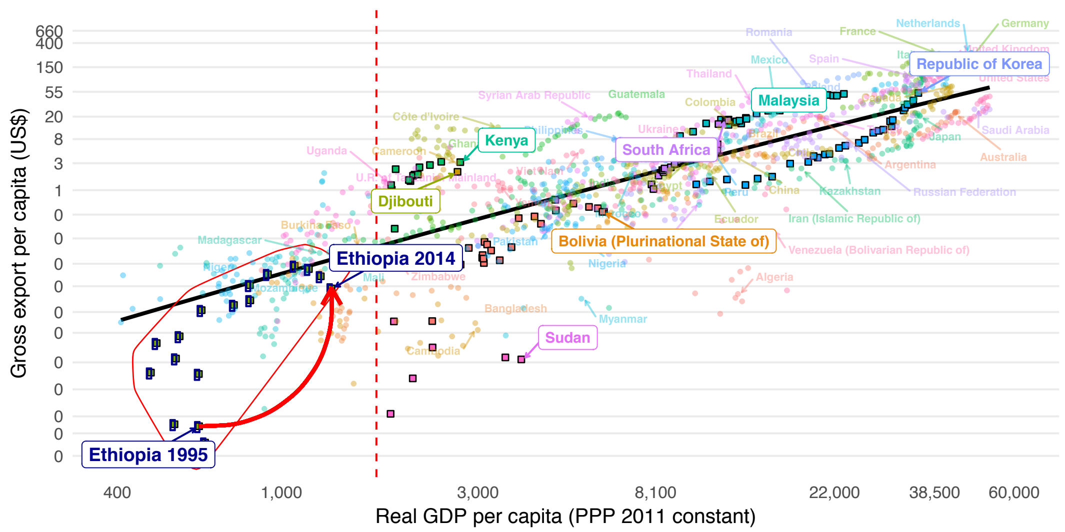
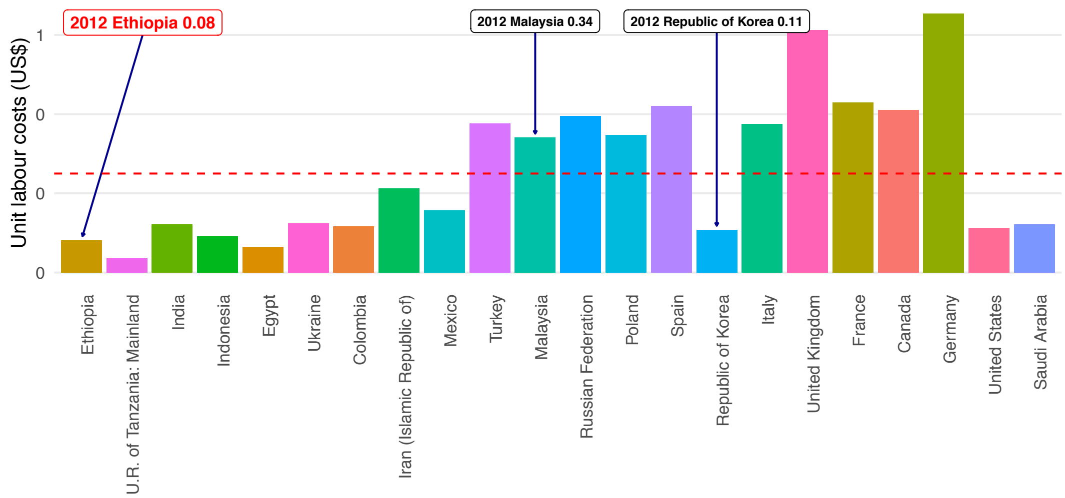


Figure 20 Unit Labour Costs (ULC)



In Figure 21, Ethiopia lies on the black curve, the labour productivity of Ethiopia's sub-sector (USD9,800) is in line with the level expected for the given wage level (USD 1,240).

Figure 21 Labour productivity, wages an competitiveness

Source: UNIDO elaboration based on UNIDO INDSTAT (2018)

For products produced in the same sub-sector which have strong market demand but are less price competitive, appropriate trade facilitation and intervention by the government (i.e. through infrastructure services in certain locations or incentives for first movers in certain industries) could help firms survive and gain a competitive edge in international markets.

6. General Assessment of the Potential of the Chemical Sub-Sector: Logical Matrix

Table 16 provides an assessment of the results for the set of key sub-sectors of the chemical industry based on the previously described comparators. It summarizes the results of the general assessment of the chemical industry based on the previously described assessment tool. The results indicate that successful chemical sub-sectors in countries with an above average performance of value added generation and competitive unit labour costs tend to do very well in the global market and report gross export rates that are well above average. The opposite can be observed for the set of underperforming chemical sub-sectors.

6.1 Soaps, Cleaning & Cosmetics Preparations

The unit labour costs indicator put the overall output of economic activity, labour productivity and wages connected with the workforce into context. It provides a general picture of the competitiveness of the soaps, cleaning and cosmetics preparation sub-sector. The unit labour costs indicator is expressed as the rate of involvement of labour production factors (compensations per worker) in the value of output created in the current period (value added created by each worker).

Table 16 The logical matrix

	Ethiopia	Malaysia	Republic of Korea	Ethiopia	Malaysia	Republic of Korea
Industry	Basic chemicals except fertilizers	Basic chemicals except fertilizers	Basic chemicals except fertilizers	Soap; cleaning & cosmetic preparations	Soap; cleaning & cosmetic preparations	Soap; cleaning & cosmetic preparations
Value added performance	Below expected performance	Above expected performance	Above expected performance	Above expected performance	Below expected performance	Above expected performance
Gross export performance	Below expected performance	Above expected performance	Above expected performance	Above expected performance	Below expected performance	Above expected performance
Labour productivity to wages ratio Unit labour costs	Below expected performance	Above expected performance	Above expected performance	Above expected performance	Below expected performance	Above expected performance

As the subsequent analysis shows, the increase in labour productivity and the reduction of unit labour costs can be translated into a stronger international cost competitiveness of Ethiopia's chemical sub-sectors and increased demand for their manufactured products. These have positive spillovers for the terms of trade. Hence, the soap, cleaning and cosmetic preparations sub-sector hasa high potential for value-added performance and export.

6.2 Basic Chemicals (except fertilizers)

Basic chemicals except fertilizers serve the local manufacturing sector before being transformed into finished products. Formic acid, hydrochloric acid, nitric acid, sulphuric acid, etc., for example, are used as primary inputs for virtually all industrial and manufacturing processes. Therefore, the ripple effect of this sub-sector for the Ethiopian economy is far broader than that of any other sub-sector. Past experiences of imports of basic chemicals have experienced an increasing trend over time because of the growing manufacturing sector in Ethiopia (Table 17).

Table 17 Status of Imports of Basic Chemicals

Major Chemical Imports in Ethiopia							
	Net Weight (Tonnes)				CIF Value (Birr)		
Sn	Chemicals	2009	2010	2011	2009	2010	2011
1	Formic acid	81,490.76	471,197.31	290,733.02	908,916.42	5,587,002.51	6,777,327.45
2	Hydrochloric acid	649,571.91	1,243,592.22	1,344,964.97	2,618,803.46	6,634,421.91	7,842,102.25
3	Nitric acid	329,424.34	992,374.69	372,887.21	1,981,856.01	7,515,818.86	3,555,752.32
4	Potassium chloride	15,962.87	26,217.00	18,479.33	237,916.21	358,757.62	3,287,740.76
5	Potassium nitrate	175,549.63	28,478.00	576,792.44	1,985,808.24	469,121.34	7,807 ,292.14
6	Magnesium chloride	14.45	19.10	238.50	429,532.48	429,532.48	1,933,220.36
7	Polyethylene	4608.00	9750.00	8063.00	67,619.199	123,049.939	154,846.036
8	Calcium carbide	665,921.12	759,692.22	551,374.85	4,565,907.00	5,840,218.73	6,472,688.01
9	PET	5226.00	7271.00	5283.00	76,258.405	98,207.153	103,783.582
10	Talc	647,045.00	1,072,166.00	648,015.90	2,516,612.64	5,903,168.66	4,532,621.21
11	Titanium oxide	1002.878	838.03	1065.7	17,065,291.04	15,984,718.18	19,122,912.60

Source: Ethiopian Customs Authority

This sub-sector underperformed in terms of value addition and labour productivity according to the analysis, thus revealing relatively little scope for exports. However, the development of the last three years has shown that imports of basic chemicals have experienced a downward trend and that their export performance in diverse international markets has improved considerably (see Tables 14 and 15). During this period, the share of the manufacturing sector in Ethiopia's national economy has grown. It can thereby be concluded that the local production of basic chemicals has compensated the dwindling imports. This sub-sector has considerable potential for import substitution because of its wide variety of industrial applications.

Table 18 presents the availability of respective raw materials for basic chemicals in Ethiopia and there is thus high potential for growth in basic chemicals production. Ethiopia is endowed with natural resources but considerably lacks critical factor endowments, such as skills and technology. The current analysis also reveals that basic chemicals is an underperforming sub-sector in terms of competitiveness and export potential. The main reason for this according to the analysis is the poor labour productivity in this sub-sector. A concerted policy approach for this sub-sector could transform it into a major industrial activity in the entire region by inducting modern technology and operational process know-how. This would secure its competitiveness and turn it into a potential export performer. Since this sub-sector has relatively higher ripple effects on the overall manufacturing sector due to its wide industrial application, its better performance and enhanced competitiveness will also certainly boost the overall domestic manufacturing sector considerably.

Table 18 Basic Chemicals: Availability of Raw Materials & Application (2015)

S.No.	Basic Chemicals	Raw Material Availability	Application
1	Potassium chloride	Danakil Depression near Dallol	Agriculture, Food Processing, Fertilizers, Pesticides, Medicines, Substitute for Table Salt, etc.
2	Potassium nitrate	Danakil Depression near Dallol	Agriculture, Solar Power Plants, Fertilizers, Pesticides, Medicines and Food Processing
3	Magnesium chloride	Afdera Lake, Afar region and the Adola area, in Oromia region	Basic Chemicals, Textile, Paper
4	Calcium carbide	Calcium deposits in Ambo, Addis Ababa region, Tigray region and abundant deposits in southern Ethiopia. There are more than 10 identified sites for coal deposits across Ethiopia	Chemicals, Iron and Steel, Fertilizers and Power
5	Talc	Tigray region, Western Wollega, Sidamo and Moyale greenstone belts	Paper, Plastics, Pharmaceuticals, Cosmetics, Paint, Rubber and Ceramics
6	Titanium dioxide	Northern Ethiopian Plateau egion in Lalibela, north-western and south-eastern regions	Paints, Cosmetics, Food Processing, and wide application as white powder pigment

6.3 Fertilizers & Agro-chemicals

Fertilizers and agro-chemicals are the two basic ingredients for improving agricultural productivity. Ethiopia is an agriculture-based economy. The agriculture sector is of great economic importance for Ethiopia. With approximately 51.3 million ha of arable land, Ethiopia has tremendous potential for agricultural development; however, not all of this land is suited for cultivation[23]. Ethiopia has the potential to irrigate about 4.3 million ha of land, of which only an estimated 6 per cent is currently being utilized. Ethiopia's agriculture sector is characterized by low productivity and prevalence of the highest nutrition depletion in the region.

Since the early 1990s, Ethiopia has achieved significant improvements in agricultural output. Irrigation and improved seed coverage of areas under crop have nearly doubled, growing 6-7 per cent per annum. Fertilizer application has grown at 3 per cent per annum, which has led to considerable yield improvements. A number of independent studies highlights the significantly increased crop yield potential due to interactions between combined inputs and practices. However, additional cultivable land in the highlands has become scarce, therefore, Ethiopia must increase future output by improving crop yields.

Table 19 Fertilizers & Agro-chemicals Application in Agriculture in Ethiopia

Input use on cereal crops 1997-8 to 2007-8 (NA - Data not available)			
	2007/8	2001/2	1997/8
Fertilizer applied area (% total area cultivated)	39.0	42.8	32.3
Fertilizer application (kg/ha, total cultivated area)	45.0	30.0	37.0
Fertilizer application (kg/ha, feritilizer applied area)	116	100	115
Improved seed coverage (% of crop area)	4.7	3.5	2.4
Pesticide coverage (% of crop area)	20.8	10.8	12.0
Irrigated crop area (% of crop area)	1.1	1.3	0.6
Extension package coverage (% of crop area)	14.5	NA	NA

Source: Dercon and Hill (2009)

Ethiopia's agriculture involves a variety of crops, with grains representing 78 per cent of total agricultural production. Among grains, cereal production is at the core of Ethiopia's agriculture sector. Other important grain crops include pulses (horse beans, chickpeas, haricot beans, field peas, lentils, soybeans and vetch) and oilseeds (linseed, neug, fenugreek, noug, rapeseed, sesame, sunflower, castor bean, groundnuts, etc.). The nutrient requirements corresponding to the GTP-1 targets were 612,000 MT, which translates into approximately 1.22 million MT, including urea, DAP and MOP, but for all crops, this Figure increases to around 1.48 million MT/annum.

[23] Taffesse et al. (2011).

Table 20 Total Consumption (2013-2011) (in MT/annum)										
	2003	2004	2005	2006	2007	2008	2009	2010	2011	Average
DAP	157995	210837	224819	251156	259020	265768	278239	352309	350209	261146
Urea	106394	112105	121735	124561	120121	131998	148437	201576	200321	142582

Source: Ministry of Agriculture (2012)

Studies show that the use of chemical fertilizers and agro-chemicals in Ethiopia has made significant contributions to crop yield growth. However, Ethiopia remains a net importer of fertilizers and agro-chemicals. Over the last decade, total fertilizer imports have increased by more than 50 per cent, from less than 370,000 MT in 2002 to nearly 570,000 MT in 2011. In 2016, Ethiopia imported fertilizers and agro-chemicals worth USD 546 million. This Figure has exponentially grown over time (see Table 15). High agro-chemical demand and local availability of nitrogenous and phosphates inputs make agro-chemical production in Ethiopia an attractive investment destination in the region.

With the discovery of natural gas in Ethiopia, the development of these two sectors is imminent not only for import substitution but also to strengthen the agriculture sector in Ethiopia. The rough estimates of gas reserves in the Ethiopia-Somali region are approximately 6-8 trillion cubic feet. Likewise, it is estimated that Ethiopia has oil reserves of around 2.7 billion barrels. Both resources will boost the hydrocarbon industry. In addition, the abundant deposits of potassium chloride and potassium nitrate will be an additional advantage for the development of the fertilizer and agro-chemicals manufacturing base in Ethiopia. These two sub-sectors will remain critical to Ethiopia's overall economic development strategy.

6.4 Cement

Ethiopia earned USD 17.3 million from cement exports of 0.2 MT in 2017. According to the Chemical and Construction Input Industry Development Institute, the country's cement industry is planning to reach a production capacity of 27MT/yr by the end of the Second Growth and Transformation Plan (GTP-II) in 2019-20. Ethiopia currently has 16 integrated cement plants and three grinding plants, which cater to local demand and export. With nearly 16.5 million tonnes of cement capacity and almost 10 per cent average growth in annual consumption, Ethiopia is among the top cement producers in sub-Saharan Africa, behind Nigeria and South Africa. This sub-sector's growth is attributed to the increase in public investments in infrastructure projects, the transportation sector and rural housing projects.

This sub-sector is the core sub-sector for transforming Ethiopia's economy. However, it is dealing with a wide variety of policy-related issues. Safety and security were major concerns for the cement sub-sector in the Oromia region. Fiscal issues have long troubled Ethiopia's cement manufacturers. For instance, major foreign collaborations in cement production are confronted with taxation issues when dealing with complex regulatory regimes in Ethiopia because of their different types of international operations. Sometimes unfairly, sometimes not, large companies are also accused of tax evasion. Likewise, the foreign exchange shortages and excessive government controls over the sub-sector have pushed the manufacturing capacities to underperform in the last fiscal year.

Table 21 Cement Production, Imports and Consumption in Ethiopia (in million tonnes)

Year	Domestic production (Mta)	Change (%)	Import (Mta)	Change (%)	Total consumption (Mta)	Change (%)
2003/04	1.42		0.00		1.42	
2004/05	1.25	-12.0	0.06	6000.0	1.31	-7.7
2005/06	2.75	120	0.89	1365.6	3.64	178.0
2006/07	1.72	-37.5	0.85	-4.7	2.57	-29.4
2007/08	1.66	-3.5	1.24	45.1	2.90	12.6
2008/09	1.69	1.8	0.10	-91.7	1.79	-38.1
2009/10	1.62	-4.1	0.49	379.4	2.11	17.7
2010/11	2.72	67.8	0.29	-41.1	3.01	42.6
2011/12	3.77	38.5	0.01	-98.3	3.77	24.4
2012/EYE	4.73	25.6	0.00	-60.0	4.73	25.5
2013/14 F	5.47	15.7	0.00	-50.0	5.48	15.7

This sub-sector holds a lot of promise in the future on account of the GSTP-II. However, the sub-sector requires serious and concerted policy initiatives to implement structural reforms in the overall regulatory environment.

6.5 Bio-Mass

Fossil fuels are finite resource and unevenly distributed with high price and negative impact on environment. Alternatively, biomass has emerged as a potential source for thermal energy for Ethiopia. Currently, traditional fuels contribute 99.9 per cent of the rural energy consumption, with fuel wood being by far the most important source (81.8%), followed by dung (9.4%), crop residues (8.4%) and small amount of charcoal wood. Agricultural residues, animal waste and human wastes are considered as major biomass resources. The total energy that can be derived annually from these resources is estimated to be about 101,656.77 Tcal. Out of this, the share of the woody biomass is estimated to be 79 per cent, followed by animal waste 11 per cent, crop residue 8 per cent and human waste 2 per cent.

Agro-industry in recent years have expanded considerably in the last decade in Ethiopia, which has magnified economic significance of this sector and shifted the focus on biomass as a potential source of energy. There are encouraging initiatives at Messabo to use sesame husk as alternative energy source. Likewise, coffee husk, cotton, saw dust, khat, bamboo, Jatropha, castor, molasses and floriculture also provide remarkable option for developing alternative energy source in Ethiopia.

Table 22 Biomass Potential and Reserve in Ethiopia

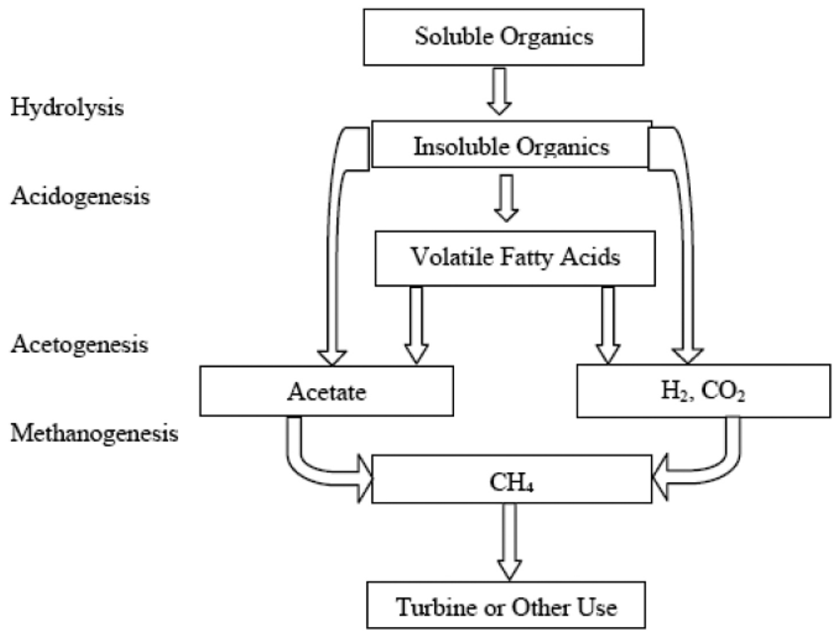
No	Biomass residue	Area (province)	Name of Deposits	Biomass residue (Ton/year)
1	Dry processed Coffee	SNNPR	Coffee Residue[24]	49,496
		Oromiya	Coffee Residue	132,911
		Gambela	Coffee Residue	1,458
		Other	Coffee Residue	158
2	Wet processed Coffee	SNNPR	Coffee Residue	16533
		Oromiya	Coffee Residue	6959
		Gambela	Coffee Residue	1519
		Other	Coffee Residue	9
3	Cotton	Tigray	Cotton Residue[25]	42,822
		Afar	Cotton Residue5	46,100
		Others	Cotton Residue	150,000
4	Saw dust	SNNPR & Oromia	Sawmill residues	25,0006[26]
5	Khat	Addis Ababa	Chat residue	7,094
		Harrage &Dire Dawa	Chat residue	105,000
6	Bamboo Tree	All Regions		1,000,000
7	JATROPHA	All Regions	Jatropha Husk	0.4/1[27]
8	Castor	SNNPR, Oromiya and others	Castor Husk	
9	Molasses	Currently 8 factories are producing molasses, and other 5 factories under construction		202,856.28 tone/annum
10	Floriculture residue	Amhara, oromiya and SNNP	Floriculture residue	300,000 tone/annum, estimation

Source: UNIDO, Ministry of Mining, and EREDPC

[24] 90 % of the residue is coffee husk
[25] Residue to product ratio is 2.755 at 12 % moisture content
[26] Estimation from Ethiopian Rural Energy Development and Promotion Center (EREDPC)
[27] The Jatropha fruit is 40 % pulp, 30 % kernel and 30 oil. About 0.4 tonnes of pulp will be available from 1 tonne of seed processed

Ethiopia has 122 billion cubic meter surface water, 2.6 billion cubic meter ground water, 12 river basins, 18 natural lakes including the rift valley lakes and a potential of 3.7 million hectares irrigable land, which is favourable for agriculture, horticulture and floriculture development. Already, government initiatives have given impetus to foreign investments in the agriculture, horticulture and floriculture sectors. Most agricultural, horticulture and floriculture wastes and residues are ideal candidates for anaerobic digestion because they contain high levels of easily biodegradable materials, which can be easily converted into energy.

Figure 22 Chemical Process for Biomass Energy



As an output of growing agro-industry, solid biomass, such as wood and agriculture waste, can be burned directly to produce heat. Biomass can also be converted into a gas called biogas or into liquid biofuels such as ethanol and biodiesel. Such fuels can then be burned for fulfilling energy needs. Biogas forms when agriculture residue and waste decompose in landfills, which can be produced by processing sewage and animal manure in special vessels called digesters. Likewise, Ethanol is made from crops such as corn and sugar cane that are fermented to produce fuel ethanol for use in vehicles. Biodiesel is produced from vegetable oils and animal fats and can be used in vehicles and as heating oil. A large-scale expansion of the use of biomass for energy is likely to have a substantial positive impact on socio-economic conditions in rural Ethiopia. It will assist in employment generation, increased energy security, improved living standards and health conditions. Thus, biomass potential needs to be exploited in order to fulfil the growing energy needs of Ethiopian economy.

CHAPTER III

R&D AND NATIONAL INNOVATION SYSTEM IN ETHIOPIA

1. Introduction
2. International Experience: National Innovation System
3. The Republic of Korea 'Miracle': Helix of Industry-University-Research Institution
4. Ethiopia: Science Technology and Innovation (STI) Policy (2012)
5. National Innovation System for Ethiopia and the Chemical Industry
6. Conclusion

1. Introduction

Innovation has been considered a key driver of economic growth, enhancing competitive advantage and stimulating productivity in both developed and developing countries alike. Therefore, technological innovation is the key to turning scientific and technological knowledge into goods and services that boost economic development. A vast body of literature shows that the application of scientific and technological knowledge has led to growing disparities between the developed and developing world. The impact, structure and outcomes of science, technology and innovation differ across countries and within regions. However, the overall consequence is that knowledge has become increasingly recognized as a powerful driver of economic competitiveness, growth and sustainable development[28]. There is thus growing recognition in developing countries of the role innovation and research plays in overall economic and human development. Innovation and R&D are essential for upgrading technologies, moving up the development ladder and catching up with developed countries. The experience of newly industrialized countries and their emergence as manufacturing giants can be solely attributed to their technological and innovative prowess.

The chemical industry is science-based on account of the central role played by research and development[29].Technology and innovation have been considered a cornerstone of the chemical industry's growth and profitability, and a prerequisite for its long-term sustainable performance. Ethiopia has abundant deposits of primary input resources for the chemical industry and recently discovered large deposits of natural gas, which in itself is a competitive advantage for chemical production. Presently, technology in the chemical industry is quite complex. One way to differentiate within the industry is to distinguish a more traditional industrial sector, linking basic chemical 'commodities' to products directly dependent upon them and to a second sector that relies upon the finished products with high value added, and to satisfy demand for differentiated products. The chemical sciences and engineering are undergoing far-reaching changes to address future challenges: (a) new synthesis techniques for combining molecules; (b) new catalysers and reactive systems that allow for shorter lifecycle products, more efficient and environmentally friendly processes; (c) alternative uses of traditional raw materials; (d) new materials with better performances and shorter production routes, or routes that allow new combinations of materials in the process; (e) introduction of bioprocesses in traditional chemical sub-sectors. However, global chemical manufacturing seems to be experiencing a paradigm shift in terms of (a) increased market globalization; (b) growing importance of 'clean' products or environmentally friendly products and processes; and (c) innovative and specialty chemical products. This implies strong pressure towards efficient quality programmes and efficient production as a competitive advantage for chemical producers. Thus, extensive R&D in production processing is essential, along with continuous upgrading of product knowledge.

[28] OECD (199); World Bank (2007).
[29] Patel & Pavitt (1994).

Ethiopia is exposed to a wide range of technological opportunities to address its overall development challenges. Technologies can be harnessed and applied to increase food production, attain manufacturing prowess, fight diseases and increase economic competitiveness. However, Ethiopia's ability to tap such opportunities is undermined by relatively weak national innovation systems. This not only adversely affects its chemical manufacturing prowess but its manufacturing sector as a whole. In fact, most African countries lack the requisite scientific and technological capabilities to effectively engage in the application of science, technology and innovation for sustainable development. While commendable efforts are being made, more needs to be done to enable Ethiopia in general to seize the tremendous opportunities that currently exist. There are a number of regional institutions with programmes that focus on helping Ethiopia advance in the areas of science, technology and innovation, such as the African Union (AU), East African Community (EAC), the New Partnership for Africa's Development (NEPAD), the African Development Bank (AfDB). However, these institutions are not well coordinated as to add value to the building of national and regional systems of innovation.

Table 23 General Characteristics of the Chemical Industry in industrialized Countries and Ethiopia

Characteristics	Industrialized Countries	Ethiopia
Firms	Large firms dominate the market; Large number of SMEs specialized in specific products in high-tech 'niche' markets	Small firms with only few large state-owned companies
Production	High scale of production; High diversification of products; Multiproduct companies; High costs of inputs, mainly petrochemicals; Vertical integration from basic petrochemicals to final finished consumer market and semi-finished products (industrial markets)	Low scale of production, single-product enterprises;
Strategies	Continuous introduction of innovative products; Technological alliances through mergers and JVs; Concentration on core activities; Efficient and flexible production process; Strong incentive for pollution prevention and environmentally safe processing	No specific strategy of firms to meet future production and marketing challenge manufacturing sector

Characteristics	Industrialized Countries	Ethiopia
R&D	Development of environmentally safe technology dominates R&D; High basic research intensity in firms; Strong links with academic science and numerous independent R&D institutions and consulting firm	Non-existent
Innovation	Highly intensive innovation process in both products and processes	Low innovation, mainly oriented towards adaptation of products to local market needs
Markets	Large commodities markets, strong competition in 'global' markets; Well-diversified markets for a large variety of specific types of products with high value-added performance specialty products	Small domestic market; Extremely small markets for specialities due to small size of manufacturing sector

Currently, chemical manufacturing has only shifted its base from the developed region to developing countries for the purpose of global competitiveness. The leadership in the manufacturing of chemicals has shifted from developed countries like the U.S. and Europe to the developing regions of Asia. There are examples of resource-poor countries and inadequately sized markets that have emerged as major chemical manufacturing hubs such as Japan, Singapore and the Republic of Korea because of their reliance on science, technology and innovation. Resource-poor countries with large domestic markets, like China and India, have attained leadership positions in chemical manufacturing mainly because of their diversified manufacturing sector and strong science and technological base. Late starters, like oil-rich Malaysia, also attained chemical manufacturing prowess in speciality chemicals by attracting foreign investments in the chemical industry. It is thus evident from past experiences that economically less developed nations have adopted different approaches to emerge as global chemical manufacturing giants. Perhaps some of their developmental experiences can be emulated by Ethiopia in terms policymaking and suitable policy interventions for setting up a robust R&D infrastructure to harness its potential and transform it into a major chemicals manufacturing and exporting nation.

2. International Experience: National Innovation System

The experience of the Asian Tigers in the 1990s reveals their key to success which stemmed primarily from their respective national innovation systems. The collaboration between universities, institutions and dynamic firms led to an enhancement of skills able to commercialize new forms of knowledge. New knowledge and new skills are an essential prerequisite for integrating the local value chain in the global value chain. The new paradigm of production points towards information, R&D and innovation-intensive production technologies, with operating models and organizational structures based on flexible specialization and inter-firm networking. Organizations are becoming increasingly dependent on the complementary resources of other companies, with a view to strengthening collective response to competitive pressures. The effectiveness of the new paradigm of production depends on how quickly companies, the basic structures and institutions of society adapt.

Experience of the Republic of Korea

In the 1960s, the Republic of Korea was no more than barren land. There were only two public institutions for scientific research and technological development with less than 5,000 research scientists and engineers. In 1963, R&D expenditures remained stagnant at USD 9.5 million. However, the country had a well-educated workforce which played a key role in harnessing its potential. As the Republic of Korea lacked technological capability, it had to almost entirely rely on foreign sources for technology. The Republic of Korea's science and technology (S&T) policy strategy was geared towards promoting the inward transfer of foreign technologies, while at the same time developing domestic absorptive capacity to digest, assimilate and improve upon the transferred technologies. The government established a sound National Innovation System which enhanced the absorptive capacity of the local industry capabilities. The Government of the Republic of Korea allowed massive importation of foreign capital goods and turn-key plants in selected areas. Local industry later reverse-engineered imported capital goods for the purpose of acquiring necessary technologies. It started with 'imitation' and later transformed into 'innovation'.

The concept of national innovation systems rests on the premise that understanding the linkages among the actors involved in innovation is key to improving technology performance. Innovation and technological progress are the result of a complex set of relationships among actors producing, distributing and applying various kinds of knowledge. The innovative performance of a country depends to a large extent on how these actors relate to each other as elements of a collective system of knowledge creation and use as well as the technologies they use. These actors are primarily private enterprises, universities and public research institutes and the people within them. The linkages can take the form of joint research, personnel exchanges, cross-patenting, purchase of equipment and a variety of other channels.

The national systems for technology development and innovation demonstrate that innovation and technology development stem from a complex set of relationships among actors in the system, where knowledge and skills constitute factors of production. The actors include universities, research institutions and enterprises. Technology diffusion and skill-formation go hand-in-hand with industrial transitions. The technology diffusion process depends on the skill formation level and capability; as an enterprise moves up the production capabilities spectrum, the workforce's and community's skills progressively advance. The diffusion of technological knowledge takes place in multi-fold ways as individuals tackle common problems, share new methods, advance their skills and move from firm to firm. For policymaking and decision-makers, understanding the national innovation system can help identify leverage points for enhancing the innovative performance of local firms and competitiveness of local products.

OECD Interactive Framework for Technology Development

Industry Alliances
- Inter-firm research cooperation

Industry/University Interactions
- Cooperative industry/university R&D
- Industry/university co-patents
- Industry/university co-publications
- Industry use of university patents
- Industry/university information-sharing

Industry/Research Institutions Interactions
- Cooperative industry/institute R&D
- Industry/institute co-patents
- Industry/institute co-publications
- Industry use of institute patents
- Industry/institute information-sharing

Technology Diffusion
- Technology use by industry
- Embodied technology diffusion

Personnel Mobility
- Movement of technical personnel among industry, universities and research institutes

2.1 Industry Alliances

Industry alliance is a 'strategy' dominated by companies from the world's most developed economies. Companies from developed economies participate in 99 per cent of R&D partnerships, of which 93 per cent consist between companies from North America, Europe, Japan and the Republic of Korea. In this context, the dominance of North America, particularly the U.S., also reflects the leading role in R&D and production in major high-tech industries such as the information technology and chemical industries.

Taiwan ROC's R&D Consortia

When IBM introduced a new PC based on its PowerPC microprocessor in June 1995, firms in Taiwan ROC exhibited a range of computing products based on the same processor only one day later. This achievement rested on a carefully nurtured R&D consortium involving both IBM and Motorola, joint developers of the PowerPC, as external parties. These successes were followed by many more such R&D alliances in digital communications and multimedia. Taiwan ROC emerged as a strong player in the automotive industry, particularly in the expansion of China's market, driven by its development of a 1.2 litre 4-valve engine; again, this was the product of a public-private collaborative research endeavour involving three companies, which jointly created the Taiwan Engine Company to produce the product. Thus, the R&D consortium is an inter-organizational form that Taiwan ROC adapted for its own purposes as a vehicle to catch up in terms of industry creation and technological upgradation.

Source: UNIDO (2003)

Taiwan ROC's success in climbing the ladder of technology upgrading rests on a capacity to leverage resources and pursue a strategy of rapid catch up. Its firms tapped into advanced markets through various forms of contract manufacturing and were able to leverage new degrees of technological capability from these arrangements. This was an advanced form of "technological learning", in which the most significant players were not the giant firms (as in the case of Japan or the Republic of Korea), but small- and medium-sized enterprises whose entrepreneurial flexibility and adaptability were the key to their success in reducing the distance to technological frontiers.

The 'alliance' strategy has so far been relatively successful in high- and medium-technology areas, namely aerospace, information technology, chemicals-pharmaceuticals, automobiles, etc. Even though some alliances have not been so successful, all partners seem to have learned organizational lessons from the early cases when the government contributed all the funds and research tasks were formulated in generic and overly ambitious terms for the companies to take advantage of them. More recent R&D alliances have been more focused, more tightly organized and managed, and have involved participant firms much more directly in co-developing a core technology or new technological standard which can be easily incorporated by local companies through adoption and adaptation in their respective product categories.

[30] OECD (1996).
[31] Kline & Rosenberg (1986).

2.2 Industry-University/Research Institution Interactions

The "linear model of innovation" has been very influential in shaping national research and development policy. In this model, innovation is recognized as a fixed, sequential process starting with scientific discovery in academia and passing it on to industry through stages of product development and marketing, ending with the successful sale of a new product in the market[30]. This model has paved the way for the establishment of basic infrastructure for research and development. The well-known "chain-linked model of innovation" illustrates innovation as a non-linear, problem-solving activity within an organization[31]. In other words, modern innovation theory focuses on including other activities in addition to basic research.

The innovation system approach is based on the interactive learning model of innovation, but takes this model one step further by emphasizing the institutional framework as a factor influencing innovation. Public and private universities/research institutions are recognized as "the knowledge infrastructure" in national systems of innovation[32]. The nature and intensity of the interactions between this knowledge infrastructure and industry is considered one of the factors influencing industry's ability to innovate and sustain competition. Such interactions involve both formal and informal forms of collaboration as well as student and researcher mobility and other types of interactions. Technology is viewed as something more than the mere application of basic research. Scientific and technological developments are perceived as intertwined processes. University research or basic science is thought to contribute to technological innovation in more indirect ways, e.g. through instrumentation, methodologies and skilled scientists. Moreover, the relationship between science and technology is not seen as a process of one-way knowledge transfer, but rather as a two-way exchange of knowledge with potential for mutual learning.

As the knowledge economy underscores the critical role in technological innovation, collaboration between universities/public research institutes and enterprises has become increasingly important in the globalized world. As entrepreneurs are often not scientists, likewise scientists often are not dynamic entrepreneurs. To promote technology and the commercialization of new knowledge, one cannot overlook this fact. It is therefore important to establish effective interfaces between scientists and entrepreneurs to commercialize research findings. For example, the Medicinal and Aromatic Plant Research Centre in Khartoum, Sudan, has collected a wealth of information on the medicinal uses of rare plants from isolated villages in Sudan that are worthy of patent rights. But related research findings of the Centre turned out to be a dead investment due to the complete absence of commercialization of those findings. Such examples are far too many, especially in developing and less developed countries. Most of the traditional knowledge in developing countries that is available in communities of practice is likely to be lost if the national innovation system fails to convert them into patents and commercialize existing research findings.

If the respective national innovation system fails to convert traditional knowledge and the use of bio-products into intellectual property, the country will be deprived of many potential

[32] OECD (1997).

opportunities. What is therefore needed is an interactive institutional framework in which research laboratories, firms and universities network with the aim of commercializing traditional knowledge and uses of products. A long-term vision is needed to achieve such an endeavour. It is crucial for developing countries to identify promising resource-based products, benchmark best practices in the processing, design and marketing of those products, and to identify viable avenues of replicating best practices to make optimal use of natural resource endowments.

A mere increase in R&D expenditure over the years may not have a significant impact on per capita GDP. In fact, there is evidence of a negative correlation between R&D expenditure and industrial productivity in a number of countries. However, when the source of R&D finance is gradually shifted from the public to the private sector, industrial productivity is significantly enhanced. The U.S., Republic of Korea and Finland are some of the successful examples of such transformations.

USA: Technological Leadership

The emergence of the U.S. as a global leader in technology is mostly attributed to the strong interface between academia and industry. Academia not only provided scientific solutions but also an adequately skilled workforce. On the other hand, industry readily converted these into marketable products. When it comes to university-industry linkage, American universities have been involved in entrepreneurship dating back to the Bayh-Dole Act of 1980, which allowed ownership of patents generated by the use of Federal Research Funds[33]. The goal of the Bayh-Dole Act was to facilitate the commercialization of university technology[34]. It is quite evident that a policy instrument like the Bayh-Dole Act spurred American universities to pursue more collaborative research projects with industry and to push for more commercialization. This development allowed universities to directly earn revenues using their own resources, such as patents, technology licensing and facilities as well as research and development collaborations.

In fact, such examples are the tenets and contours of proven best practices on the design of research grant programmes to help public and private research institutions forge partnerships in collaborative research and the commercialization of technologies. Without doubt, the U.S. is the most important source of technology for all OECD countries. With an investment of USD 91 billion (2016) in R&D, the chemical industry is one of the largest manufacturing industries in the U.S. Strong enforcement of intellectual property rights has resulted in the highest number of patents in the U.S.' chemical industry. It serves both the sizable domestic market and the expanding global market. It is also one of the top chemical exporters in the world, accounting for nearly 15 per cent of global chemical shipments. The U.S. is a world leader in overall chemical production and exports. This is the result of a highly educated workforce, world class research, protection of intellectual property and a robust regulatory system.

[33] Rothaermal, Agung and Jiang (2007).
[34] Shane (2004).
[35] Papaconstantinou, Sakurai and Wyckoff (1996).

2.3 Technology Diffusion

Technology diffusion is the process of adoption, adaptation, absorption and diffusion of procured technologies. An empirical analysis of embodied technology diffusion revealed that the flow of technology across industries and nations is achieved through the purchase of intermediate and capital goods. Though innovations were mainly developed in clusters of high-technology manufacturing industries, different clusters of industries were acquirers of technologically sophisticated machinery and equipment[35]. These findings also bear testimony to the fact that less than 50 per cent of the total acquired technology for every OECD country is channelled through capital investment. Imports of capital equipment were also an important method of technology acquisition.

The U.S. is the most important source of process technologies in the chemical industry. It has been persistently proven that the embodied technological prowess of R&D is a major source of productivity growth in the chemical industry. Therefore, an open trade and investment regime are important elements in technology catch up, reducing the distance to technological frontiers.

3. The Republic of Korea 'Miracle': Helix of Industry-University-Research Institution

The 'Korean Miracle' built on the Republic of Korea's innovation capabilities. The role of the government was as facilitator in implementing a competent national innovation system comparable to that of the most advanced countries. In the 1960s, the government focused its resources on promoting selected industries, namely automobile production, ship building, mechanical engineering and electronics. To realize its policy effectively, an institutional science and technology framework was established by setting up the Korean Institute of Science and Technology (KIST), which carried out R&D activities, particularly in the areas identified. Academia focused solely on producing scientists and engineers. This was a decade of absorption and imitation of imported technologies. By the next decade, the government placed emphasis on the establishment and expansion of chemical, heavy industries and export-oriented industries. To expand the scope of R&D, the government established 13 major public research institutions in key technological areas. The role of academia remained limited to producing engineers and scientists. Throughout this period, there were strong industry-public research institution interactions as part of the national innovation system.

During the next two decades, the government recognized the significance of science, technology and innovation and increased its national R&D expenditure by 2 per cent of GDP. This move by the government pushed industry to carry out R&D activities which had previously been carried out by public research institutions. The government also strongly promoted the R&D and innovation capabilities of universities. In the late 1990s, a new policy direction evolved in the national innovation policy, with the government initiating a regional innovation policy.

During this period, the central government played the leading role in innovation policy. The R&D budget of all regional governments represented less than 7 per cent of the national science and technology budget. By 2000, eight of the 16 regional governments had established independent organizations to promote technological innovation capabilities in their respective regional administrations.

In the 1970s, national R&D expenditure was predominantly financed by the public sector. But by the 1980's, the role of the public sector diminished considerably, with around 50 per cent of national R&D expenditure still being financed by the government. In the next decade, the ratio of public to private financing was about 16 to 84, thus implying that industry gave more importance to technological innovation and in-house R&D.

By the next decade, the Brain Korea-21 (BK-21) and the New University for Regional Innovation (NURI) Programme spurred R&D collaborations and interactions between academia and industry. Due to continuous efforts to develop technological and innovation capabilities, major industries (Chaebols) were transformed into globally competitive world class producers of frontier products. This cannot be attributed solely to their strategic decisions, but also to the active support provided by the government to enhance technological innovation capabilities and build effective collaboration between academia, public and private research institutions. The Chaebols have become globally competitive in several key industrial sectors, such as chemicals, semiconductors, electronics, steel and bio-technology.

The strong university system complemented the growing need of the expanding economy of the Republic of Korea in all stages of development. The annual turnout of scientists and engineers formed the integral part of the national innovation system. Before the early 1980s, the national innovation system was equipped with only 18,434 researchers. However, this number rapidly increased to 70,503 by the end of the decade. The strong university infrastructure played a predominant role in this development and academia rather than industry emerged as the largest employer of researchers.

The decade of the 1990s was the watershed moment in the rapid industrialization of the Republic of Korea. It represented the decade of transforming the economy from imitation into innovation. The number of researchers more than doubled during this decade. The national innovation system began to play a dominant role in domestic manufacturing. By the early 21st century, private industry became the largest employer of researchers. In other words, domestic industry had come to recognize the importance of science, technology and innovation in overcoming recession and enhancing competitiveness. With the increase in R&D investments, private firms boosted their number of well-qualified researchers.

It is imperative to establish a legal framework for R&D activities and collaboration conducive to the development of enterprises' technological capabilities as well as those of the nation as a whole. As S&T and R&D have the characteristics of common goods, the government needs to assume a proactive role in policymaking and implement various policy instruments, including legislation. With a legal framework and a set of financial incentives, the government can set directions for technological and economic development, mobilize resources and motivate innovation actors to pursue their R&D and innovation activities efficiently. Based on these lines, the government established relevant research institutions, initiated national R&D programmes and motivated technology transfers from academia to industrial enterprises. These efforts were complemented by policy instruments and appropriate legislation. The Patent Law (1946) was enacted to establish a comprehensive industrial property legal regime. The government initiated a series of national R&D programmes over the next three decades. The Ministry of Science and Technology activated industry-university-public research collaborations within the scope of their own national R&D programmes. The aim was to mobilize all R&D resources during that period.

Republic of Korea: Industry-University Collaboration Law (2003)

Promoting industry-university collaboration is a major policy priority in the Republic of Korea. The motivation behind such a policy initiative is to make the nation's system of innovation as well as the financial reward conditions for the universities more dynamic. The industry-university collaboration has various facets, namely product knowledge, technology innovation and financial rewards. Most universities in the Republic of Korea have set up Industry-University Cooperation Foundations (IUCFs) since the introduction of the Industry-University Collaboration (IUC) law of 2003. Subsequently, promoting industry-university collaboration activities has become a major public policy in the Republic of Korea, as demonstrated by a series of legislative actions. The revised IUC law in 2008 permits universities to establish a holding company. The IUC law dramatically changed the incentive system for universities. Prior to the promulgation of the IUC law, universities in the Republic of Korea were not only inactive in the pursuit of own revenues but also did not have the status of legal persons in charge of those revenues and could therefore not claim direct income. Under the IUC law, universities have thus been able to generate financial revenues. The IUC law is similar to the Bayh-Dole Act in the United States. The conducive environment for industry-university collaboration in the Republic of Korea has allowed the POSCO steel company to set up the Pohang University of Science and Technology, which is currently a top-ranked university in the Republic of Korea. Likewise, Sungkyunkwan University has developed a close relationship with Samsung. Universities in the Republic of Korea publishing in collaboration with Samsung dominate a separate group of universities publishing the highest share of their total research outputs in collaboration with a single industrial partner. Such collaborations represent seven of the top-14 universities in terms of links with individual companies, responsible for nearly 5 per cent of those universities' total research outputs. The fact that the Republic of Korea was a poor, agriculture-based economy until the early 1960s and has since experienced an industrial miracle may be one of the explanations for its strength in university-industry collaboration.

Prior to industrialization, there were no laws addressing R&D activities and collaborations in the Republic of Korea. After the initial industrial base was set up, the government decided to establish an operational legal framework for R&D and technological development, thereby establishing the national innovation system. Since the beginning of the 21st century, the government has shifted its focus to promote innovation at the regional level. However, it had to deal with unequal economic and technological development between different regions, which represented a major bottleneck. To overcome this problem, the government enacted the Special Law for Balanced National Development in 2004. This law created an environment for regional innovation systems composed of industrial enterprises, universities and research institutions.

Most legislation governing R&D cane classified into two categories, namely comprehensive laws for R&D collaboration and non-comprehensive laws. The comprehensive laws aim at promoting R&D collaboration only and spell out the procedural matters and stipulate various aspects of R&D collaboration, e.g. the Law for the Acceleration of Collaborative R&D. The non-comprehensive laws deal with different issues, but only few provisions relate to S&T and R&D collaboration, e.g. the Patent Law.

Table 24 Comprehensive laws for R&D collaboration and non-comprehensive laws

Enacted year	Law	Characteritics	Responsible ministry
1946	Patent Law	Non-comprehensive	KIPO
1972	Law for the Activation of Technology Department	Non-comprehensive	MOST
1986	Law for the Promotion of Industrial Technology Research Consortia	Comprehensive	MOST
1994	Law for the Acceleration of Collaborative R&D	Comprehensive	MOCIE
1995	Law for the Establishment of an Industrial Technology Infrastructure	Non-comprehensive	MOCIE
2000	Law for the Acceleration of Technology Transfer	Comprehensive	MOST
2001	Science and Technology Basic Law	Non-comprehensive	MOST
2003	Law for the Promotion of Industrial Education and Industry-Academy Collaboration	Comprehensive	MOE-HRD
2004	Special Law for Balanced National Development	Non-comprehensive	MOCIE

Source: Chung S. (2011)

While the government gradually established alegal framework for collaboration between academia and industry, it launched several programmes to promote R&D capabilities and collaboration between innovation actors. Some of these programmes include the Excellent Research Centre, the Regional Research Centre, the Technology Innovation Centre, the Technology Business Incubator, etc.

Table 25 Major R&D Collaboration Programs & Main Characteristics

Programme	Ministry	Major targets	Programme scope	Major characteristics	Evaluation
ERC	MOST	Research universities	Nation-wide	Joint research	▲▲▲
RRC	MOST	Research universities	Region	Joint research	▲▲▲
TIC	MOCIE	Cluster	Region	Comprehensive ellabboration	▲▲
TBI	MOCIE	Start-ups	Nation-wide	Incubation	▲▲
BI	SMBA	Start-ups	Nation-wide	Incubation	▲▲▲
Techopark	MOCIE	Cluster	Region	Comprehensive ellabboration	▲▲
I-I-I Consortium	SMBA	SME-s	Nation-wide	Joint research	▲▲▲

▲▲: Successful, ▲▲▲: Very Successful
ERC: Excellent Research Center; RRC: Regional Research Center; TIC: Technology Innovation Center;
TBI: Technology Business Incubator; BI: Business Incubator; I-U-I: Industry-University-Institutes.

Source: Chung S. (2011)

To date, the government has established around 30 ERCs at the major research-intensive universities and 112 RRCs in 15 regions to conduct research in strategic technology areas. These programmes have significantly contributed to the development of academic research and innovation in the Republic of Korea. The TIC programme aims to develop region-specific technologies by aggregating the technological resources of regional universities, enterprises and research institutions. By the end of 2003, 39 TICs operated in region-specific technology areas. Under this programme, the government provided KRW 1 billion per year for five years to establish and support the centres. Operating costs and space were supplied by the regional government and participating industrial firms. This programme was merged with RRC and renamed Regional Innovation Centre in July 2005.

The TBI programme aimed to encourage the creation of business start-ups by providing a series of services from start-up to the commercialization of research results. Participants received about KRW 100 million to commercialize their R&D results. If the start-up became successful, the participant would reimburse half of the funding initially received within five years. Likewise, the BI programme supported SME start-ups. The BI supplied a series of incubation services, such as management, technology, finance and marketing to potential or new entrepreneurs that lacked knowledge in commercialization. So far, 166 TBIs and 283 BIs have become part of the national innovation system of the Republic of Korea.

The Republic of Korea's efforts to enhance its innovation capabilities are characterized by very close cooperation between major actors, namely industry, universities and research institutions. The government undoubtedly played an important role in this transformation. Its innovation policy made significant contributions to the development and expansion of the national economy. The Republic of Korea adopted the concept of the national innovation system and developed both suitable policy programmes and a legal framework conducive to providing mechanisms for implementation. The resultant impact of the national innovation system on various industry segments has been far-reaching.

Presently, the Republic of Korea has emerged as a brand name at the global level for quality excellence and innovation. It has become a global leader in diverse manufacturing industries, ranging from high-tech industries like electronics to process industries like chemicals and steel. Currently, it is the fifth largest producer of petrochemicals in the world. The 25 largest global chemical manufacturers have at least one manufacturing base in the Republic of Korea. Global leaders, such as Dow and BASF have relocated their regional HQ for their respective electronics businesses to the Republic of Korea, and both companies operate substantial research facilities in Seoul. The Belgian specialty chemical producer Solvay has recently opened a state-of-the-art research centre in collaboration with Seoul's Ewha Women's University. The Republic of Korea's experience is a true success story for developing economies to strengthen their national innovation systems.

4. Ethiopia: Science Technology and Innovation (STI) Policy (2012)

Recent developments and initiatives in the education and development policy landscape suggest a clear trajectory towards greater emphasis on knowledge-based development as opposed to the traditional preoccupation with higher education for manpower development. This new development dispensation is firmly anchored in knowledge produced through research and innovation activities and constructed broadly as Science Technology and Innovation (STI). The launch of Africa's Science Technology Innovation Consolidated Action Plan (2006–2010) envisions capacity building for knowledge-based development and policymaking in African countries. The Consolidated Action Plan articulates Africa's overall vision for harnessing and applying science and technology to eradicate poverty, promote sustainable growth and development and to strengthen Africa's fuller integration into the global knowledge and economic system. The plan demonstrates the increasing focus on building capacity and mainstreaming of knowledge (science-technology-innovation) into Africa's development. In this context, the Ethiopian government announced its Science, Technology and Innovation Policy (STI) in 2012.

[36] OECD (1997)

The STI Policy (2012) attempts to adopt the national vision of '**alleviating poverty and joining mid-level income earning countries**' as expressed in the GTP. It envisages the creation of a national framework that defines and supports how Ethiopia will search for, select, adapt and utilize appropriate and effective foreign technologies in the future and addresses the establishment of a national innovation system. A national innovation system is a network of institutions organized through linkages "to relate to each other as elements of a collective system of knowledge creation and use as well as the technologies they use".[36]

Objectives of STI Policy (2012)
- Establish and implement a coordinated and integrated general governance framework for building STI capacity;
- Establish and implement an appropriate national Technology Capability Accumulation and Transfer (TeCAT) system;
- Promote research that is geared towards technology learning and adaptation;
- Develop, promote and commercialize useful local knowledge and technologies;
- Define the national science and technology landscape and strengthen linkages among the different actors in the national innovation system;
- Ensure implementation of STI activities in coordination with other economic and social development programmes and actions;
- Create an environment conducive to strengthening the role of the private sector in technology transfer activities sustainably.

The STI Policy (2012) is an enabling framework for the establishment of a national innovation system in Ethiopia by promoting interactive activities between and among institutions to generate and use new products, processes and organizational practices. It identifies 11 critical policy issues, namely technology transfer, human resource development, manufacturing and service, providing enterprises, research, financing and incentive schemes, national quality infrastructure development, universities, research institutes, TVET institutions and industry linkages, intellectual property systems, science and technology information, environmental development and protection and international cooperation.

Technology Transfer

The issue of technology transfer is considered a critical policy issue. The STI (2012) focuses on devising a system of learning, adapting and utilizing as well as disposing of imported technologies to meet national demand. However, most technology transfer activities currently being carried out in Ethiopia are not in line with the envisaged technology demands of the development programmes. In general, the national capability to learn, adapt and utilize foreign technology is still at a very low stage. The STI (2012) attempts to channel the transfer of technology into Ethiopia by setting up a system to search, select, adapt, utilize as well as dispose of imported technologies.

Human Resource Development

Lack of adequate manpower is a major shortcoming for the implementation of the STI Plan (2012). The level of qualified manpower capable of transferring foreign technology is low, and certainly inadequate to facilitate an effective transfer of technology. Thus, the Plan places emphasis on producing engineers and scientists qualified in understanding and utilizing appropriate technologies. The Plan envisages the development of science and technology institutions for producing highly qualified technicians, engineers and scientists to meet future demands of the economy. The TVET institutions are a priority area along with adequate female representation in science and engineering courses.

Manufacturing & Service Enterprises

The SIT Plan (2012) emphasizes the development of a well-diversified SME sector by supporting them to play a pivotal role in technology transfer. However, such enterprises have no clear value-adding linkages between them and their role in advancing the STI is not well-defined in Ethiopia. The strategy outlines the building of linkages between medium-sized and large firms, especially as focal points for researching, learning, transferring and adapting foreign technologies. It also places emphasis on strengthening TVETs' contribution to building capacities for the SME sector.

Research

An effective national research system is of significant strategic importance for successful learning, transfer, adaptation and utilization of technology. In Ethiopia, research is needed to address the resolution of major social and economic problems; contribute to the achievement of national development objectives and to meet technology demand. However, there is a gap between the research activities and focus of higher education and research institutions and national development needs. Hence, the national research system should be strengthened and orientated towards focusing on national technological demands to search for, learn about, adapt and utilize effective foreign technologies.

Finance and Incentives Schemes

An effective transfer of foreign technologies requires availability of sufficient financing. Ethiopia does not yet have a well-developed and systematized finance and incentive mechanism to support technology transfers in manufacturing and service-providing enterprises. Therefore, financing and incentives schemes need to be established to support activities to search for, learn about, adapt and utilize effective foreign technologies in line with national development needs.

National Quality Infrastructure

A national quality infrastructure landscape significantly contributes to the delivery of quality and standardized products and services to local and international markets. Failure to meet quality standards is one of the major problems that prevail in most of local manufacturing and service-providing enterprises in Ethiopia. This is mainly due to a lack of implementing standards at the national level. To resolve problems related to productivity and quality, creating competitive manufacturing and service-providing enterprises, enabling standardization, metrology, conformity assessment service providers and accreditation bodies is of paramount importance.

Universities, Research Institutes, TVET Institutions and Industry Linkage

Universities, research institutes, TVET institutions and industry are key actors in the national innovation system. The strength as well as effectiveness of the established linkages among these institutions largely depends on their inclination and capability to be involved in activities related to technology transfer. As far as technology learning is concerned, the current situation in Ethiopia confirms that universities are not taking the lead and are lagging behind industry. The linkages that exist between these actors should therefore focus on contributing to capacitating the productivity of manufacturing and service-providing enterprises. The shared effort should also focus on identifying appropriate technologies and their sources, understanding the technologies through learning-by-doing and adaptation as well as effective utilization. Thus, joint cooperation and support systems among the actors should be established with the aim of supporting and facilitating the search, selection, importation, adaptation and utilization of effective foreign technologies.

Intellectual Property System

The intellectual property system is said to play a valuable role if it contributes to technology transfer as well as technology capability building through FDI and technology licensing. Ethiopia’s intellectual property system as a whole does not play a substantial role in accelerating technology transfers and the expansion of local innovation activities. Hence, the Ethiopian IP system needs to be designed in such a way as to support the endeavour of technology learning and adaptation as well as to protect the rights of inventors and innovators and support the augmentation and application of local knowledge.

Science & Technology Information

Information related to science and technology is of significant importance for successful technology transfer. There is no well-organized science and technology information source or system in Ethiopia as required by manufacturing and service-providing enterprises, higher education, research institutes and other entities. Despite the fact that there are certain types of information that are prepared and kept in the form of statistics, databases, indicators and literature, there are no mechanisms to publish and update them regularly. Therefore, it is imperative to develop and establish a national science and technology information system to fill the gaps and publish expected results as well as accelerate technology transfer.

Establishing and strengthening such a system will create a capacity to accelerate technology transfer by identifying, gathering, organizing, analysing, disseminating and properly utilizing science and technology information.

Environmental Protection & Development

Environmental protection and development are crucial to maintaining continual and sustainable economic growth. The major environmental issues in Ethiopia are desertification, deforestation and soil erosion. Large cities lack solid waste disposal and sewerage systems, which are critical environmental challenges. To address these and other environmental problems that prevail in the country, appropriate technologies need to be applied in the course of natural resource utilization and implementation of various development activities.

International Cooperation

International cooperation in the areas of science and technology is crucial for information sourcing, manpower training, expert assistance, scientific visits, collaborative research, joint ventures in technology transfer and funding of scientific and technological projects. However, the current cooperation practice in Ethiopia lacks focus, particularly on STI information sourcing and exchange of scientists and engineers, thereby highlighting specific needs for cooperation to strengthen national technological capabilities. Therefore, the primary focus of international relations should be encouraging cooperation with developed and developing countries as well as with various international and regional organizations, the objective being to build national technological capabilities.

5. National Innovation System for Ethiopia and the Chemical Industry

The National Science Technology and Innovation Policy (2012) is an exhaustive statement on the status and strategy for development of the science and technology base and the promotion of innovation in Ethiopia. The national innovation system is an open system. It is characterized by seamless inflows and outflows of information, skills and technology. The main activity in the system is learning. This entails interactions between people and institutions. The learning is interactive, characterized by feedback. The feedback takes place between economic firms and consumers, between R&D institutions and industry, between R&D institutions and financial bodies, between policymaking bodies and R&D institutions, between policymaking institutions and private firms, and between education and training institutions and industrial firms. In the light of this, the policy document falls short of a few critical issues, namely identification of priority sectors, interface of the main actors and integration of strategies for an overall impact on innovation and on industrial development.

Identification of priority industries has been exhaustively dealt with in GTP-II. GTP-II acknowledges the lack of physical infrastructure as one of the major shortcomings for Ethiopia's economic development. The physical infrastructure at present includes surface transport, electricity, telecommunications and internet connectivity. However, other aspects of physical infrastructure for innovation systems include institutional actors like universities, public R&D institutions, private enterprises, financial institutions, technology supporting agencies, etc. These are also critical infrastructure for industrial firms to be able to design and develop new products and processes, or even to use existing technologies. The state of this type of physical infrastructure impacts institutions' ability to produce and apply knowledge. The World Economic Forum has identified this type of physical infrastructure as one of the pillars of eco-

[37] World Economic Forum (2008).
[38] SARUA (2008), UNESCO (2005).

nomic competitiveness of a country[37].

Some of the literature on national innovation systems emphasizes physical infrastructure as a major weakness of most African countries[38]. Some of the important findings in the literature, which are also common to Ethiopia, are:

a) Science and technology is too narrowly defined to actually represent R&D;
b) There is little emphasis on innovation aspects, such as technology prospecting, procurement and diffusion;
c) No explicit innovation policy;
d) Few but very weak institutional linkages and collaboration;
e) Weak engineering and entrepreneurship capabilities;
f) Limited financial resources for technological innovation;
g) Low levels of technological readiness and innovation capacities, and
h) R&D infrastructure is generally poor and neglected.

While commendable efforts are being made, more needs to be done to enable Ethiopia to seize the opportunities that currently exist. The government must also recognize other determinants of innovation systems, namely research and innovation priorities; policies for R&D and innovation; quality of scientific research institutions; public and private sector investment in R&D; protection of intellectual property rights; institutional linkages, particularly university-industry collaborations; availability and utilization of skills in science, engineering and entrepreneurship; existence and use of technology standards and regulatory agencies and the participation of Ethiopia in regional and international programmes.

5.1 Setting Up R&D Priorities and Capacities

Various policy statements and news reports indicate that Ethiopia applies many approaches to set up R&D priorities. There are no organized national R&D priority setting processes. R&D priorities seem to emerge from political statements. It is common in most African countries for R&D priorities to be determined by individual research institutions based on available funds from national governments or international donors. R&D priorities are also determined within sectors such as agriculture and health, and at the level of individual departments or ministries. As a result, the direction of research and funding decisions remains unclear.

Indubitably, Ethiopia has identified multiple priorities in the GTP-II, but limited resources are available. The chemical industry is one of the many areas identified in the GTP-II with the potential to influence economic growth and strengthen the domestic manufacturing base. Therefore, there is a need for clear priority setting and allocation of funds for R&D in the chemical industry. The assessment identifies four potential areas in the chemical industry, namely (a) soaps, cleaning and cosmetics preparation, (b) basic chemicals (except fertilizers), (c) fertilizers and agrochemicals, and (d) cement. The government must select these sub-sectors of the chemical industry as priorities for R&D activities.

5.2 Public Expenditure on R&D Activities

Statistics or data on public expenditure on R&D in Ethiopia is scanty. Absence of such information makes this task more difficult for policymakers. The national statistics office does not seem to survey or collect statistics on R&D expenditure. The STI Policy (2012) spells out the importance of information on S&T for successful transfers of technology. This once again highlights the weakness of the national innovation system mentioned earlier. R&D needs must be understood and defined more broadly than merely S&T for technology transfer. Lack of information makes it impossible to estimate Ethiopia's R&D intensity. Therefore, we have to depend on regional databases published by multilateral agencies. According to UNESCO (2004), Africa as a whole accounted for less than 1 per cent of the world's expenditure on R&D. Asia accounted for 30.5 per cent, North America for 37.2 per cent, Europe for 27.2 per cent and Latin America and the Caribbean for 2.9 per cent of total world expenditure on R&D. Sub-Saharan Africa's public R&D expenditure has been estimated at 0.3 per cent. It is important to note that for most African countries, data on public expenditure on R&D is too aggregated to determine how resources are allocated across R&D areas and there is little information about their relevance, quality and effectiveness of the research projects and activities that get funded. What is clear, however, is that the limited expenditure on R&D is to a great extent spent on small research projects and salaries of staff in institutions. Therefore, the government will need to establish institutions and programmes that undertake R&D surveys and collect data on R&D expenditure. Once a priority sector has been identified, the Ethiopian government needs to commit at least 1 per cent of GDP on public expenditure on R&D in the beginning and raise it to 2 per cent over the next five years. The role of public expenditure on R&D was one of the most important factors in the 'Korean Miracle'.

Once the government commits public funds for R&D, the main actors of innovation in the chemical industry will need to identify the technological gaps in the four sub-sectors with potential and commit their resources to filling those gaps. In fact, public expenditure on R&D will act as a prime mover for them to innovate and commercialize their R&D efforts.

5.3 Institutional Arrangements for Public Research & Development

Ethiopia has a broad network of universities and institutions of higher learning. However, only a small number of its population are engaged in this network. Some of these institutions also conduct R&D in addition to their core business of education and training. By 2012, the number of public universities was 34. In addition, there were 64 accredited non-government universities/colleges awarding degrees. In the absence of government statistics on R&D infrastructure, the UNESCO Report (2004) paints a bleak picture of the state of R&D infrastructure in African institutions of science and technology training. The report states that only a few universities in Africa are in a position to have quality scientific journals in their libraries; few university staff have access to computers in their offices (even in computer science departments); and many of the libraries in African universities do not have computers and are not computerized. The report finds that engineering schools or university institutes lack equipment more than those for basic sciences. The report concludes that the reported average age of laboratory equipment is too high (11.6 years for basic sciences and 15.8 years for engineering sciences). Hence, African institutions are clearly lagging behind in the areas of experimental science.

Chemical engineering is the nucleus of R&D of chemical process industries. R&D in chemical engineering encompasses product and process development of various chemicals, petrochemicals, plastics, pharmaceuticals and other medicines, agrochemicals, processed foods, energy (fuels, nuclear energy, others), pulp and paper, beverages, cement, ceramics and many others. There have been significant technological changes in the processing industry over time. New molecular compounds, chemical reagents, manufacturing processes, testing methods and equipment, etc., are the hallmark of the modern chemical industry. Technology is evolving rapidly in this industry, primarily to reduce costs and improve quality. New speciality materials are fast emerging and replacing old materials. To deal with modern chemical manufacturing processes, adequately trained, high-skilled manpower is necessary. Of the 34 public universities and 64 unaccredited colleges and universities, there are only a few universities that offer chemical engineering-related courses. Likewise, the graduate and post graduate course curriculums, laboratories and training equipment require immediate review and upgrading to boost R&D in the chemical industry.

5.4 Policy Instruments for Research & Development

The experience of the Republic of Korea is an example of how government can use policy instruments to motivate universities and industry to pursue R&D and innovation activities in priority industries. A growing number of countries have taken the lead by emulating the Republic of Korea's experience and use specific policy and legal frameworks to govern R&D activities.

Currently, Ethiopia does not have a science and technology-specific policy framework but has explicit policies scattered in sectoral policy documents such as national plans for agriculture, a national health policy, energy plans and strategies, ICT plans, etc. However, the Ethiopian government needs to prepare a 10-year Innovation Plan as part of its STI Policy (2012), in addition to a white paper reviewing the status of the priority industries. The Innovation Plan must emphasize the strengthening of national public R&D institutions by improving infrastructure, improving the coordination of institutions, building and strengthening collaboration between public R&D institutions with private companies, increasing investments in R&D, promoting science and technology education and raising public awareness as well as increasing and retaining scientists and engineers. The Plan should be integrated into the trade and industrial policy, annual national budget statements, investment policies and legislation and intellectual property protection legislation. The government should also adopt appropriate fiscal measures to promote R&D, including tax regulations, customs and excise duties, immigration laws, fiscal policies, foreign affairs policies, industrial policies, health regulations, environmental impact regulations and import and export regulations.

Lack of information is a major constraint. There has thus far not been a systematic review or

[39] WEF (2008).

assessment of how well Ethiopia uses implicit policies to promote R&D. It is therefore imperative that the government carries out a review of the use of implicit policies in the chemical industry, which may be useful to inform efforts aimed at integrating science and technology considerations into national economic policy frameworks. It may also be helpful in informing the reform or development of innovation-related policies and the legal framework for the chemical industry.

5.5 Technological Readiness and Innovation Capacity

Several indices have been developed to measure and provide some assessment of countries' technological status and performance. These include the Technology Achievement Index (TAI) used in the United Nations Development Program's (UNDP) Human Development Report, the Industrial-Cum-Technological Advance Index (ITA) used by UNIDO's Industrial Development Report and the Technological Readiness (TR) used by the World Economic Forum in the Global Competitiveness Report. The TAI focuses on countries' innovative capacity. It is used to measure a country's ability to create new products and processes through R&D, and use new and old technologies to increase productivity. In fact, it is a well-researched conclusion that OECD countries account for 86 per cent of patent applications and 85 per cent of scientific and technical journal articles published worldwide. African countries are not significant sources of technological innovations. They are not really engaged in the creation of technology but are merely adopters. Except for a few countries, all are technologically marginalized.

TR "measures the ability with which an economy adopts existing technologies to enhance the productivity of its industries."[39] It is an assessment of a country's preparedness to procure, absorb and use technology. Technological readiness is determined based on factors such as firm-level technology absorption, laws relating to information and communication technologies, FDI and technology transfer, personal computers per 100 inhabitants, and internet users and mobile phone subscribers. It is separate from innovation capacity, which entails a country's ability to expand the frontiers of knowledge and create new technology. Technological innovation is important for countries with diminishing possibilities of adopting and using existing technologies. Under these circumstances, firms cannot increase their productivity by relying on or using existing technologies or by merely undertaking incremental innovations. They must push the frontiers of knowledge and create cutting edge products and processes in order to be competitive. This will require a proactive role of the government.

Ethiopian firms are exposed to a wide range of foreign technologies in the chemical industry. These technologies are embedded in foreign products available in the domestic market. Malaysia followed a definitive path to adopt, adapt and successfully apply chemical sector technologies in its economy and emerged as a major chemical manufacturing hub. Ethiopia could use this strategy to improve its technological readiness and innovative capabilities in the chemical industry. The major constraints to adopting this strategy are low levels of education, lack of policies that deliberately promote technology diffusion and adaptation, and above all, poor S&T infrastructure.

5.6 Technology Support and Regulatory Agencies

Standards, quality and metrology institutions are an important part of national systems of innovation. They are part of the technological infrastructure. These institutions support R&D and technological innovation. It has been observed that most metrology, quality and Ethiopian standards institution is under-resourced. Firms rely on revenue from the sale of services such as calibration and metrology. The STI Policy (2012) identifies this shortcoming and developed multiple strategies to address the issue of technology support mechanisms but silent on how it plans to put these in place. It also falls short on specific regulators and associated legislation. Also, the policy does not outline the role of industry and industry associations/councils in strengthening technology support mechanisms. After all, it is industry that will ultimately be responsible for compliance with standards and quality level.

In addition to technology support institutions, Ethiopia has regulatory agencies that deal with FDI, technology procurement and licensing, environmental impact assessment, registration of new companies, safety and trials, registration of drugs and medicines and export processing zones, among many other aspects of economic activity. Regulatory agencies are an important part of national systems of innovation as many of them to some extent determine the inflow of technology. These agencies can promote or obstruct the procurement and diffusion of new technologies. There is therefore a need to examine the role of regulatory agencies in building a national innovation system. In times of globalization, government regulatory bodies should act as facilitators and enablers. Their mandates should be redefined to explicitly include the promotion of technological innovation.

A clear distinction must be made between technology procurement which is the sole prerogative of the firm while the regulator's sole responsibility is to oversee compliance. The role of the market is therefore crucial when it comes to standards and quality. The chemical industry is a highly regulated industry internationally. It also operates in a highly standardized operational environment. Therefore, standards, quality and metrology institutions become an integral feature of this industry. In such cases, the industry council's role in the identification of standards and quality levels become imperative. There is a need for a strong interface between the major actors of the national innovation system in setting up of the technology support mechanisms and regulatory bodies for the chemical industry.

5.7 Institutional Arrangements for Financing Technological Innovation

Finance is critical in the promotion of technological innovation. It is important in the development of firms, particularly start-ups, which are the locus of innovation. Research and training institutions also require financial resources to be able to test their ideas, work with firms to commercialize research results, and generally turn their ideas into products and services. Finance is one of the main barriers to technological innovation in developing countries, including Ethiopia. The majority of firms in Ethiopia disregard R&D and innovation due to lack of finance, as most businesses are self-financed business.

Funding instruments such as venture capital are either underdeveloped or non-existent. Therefore, commercialization of research findings, technology prospecting and diffusion, or even funding activities aimed at testing technologies are close to non-existent in Ethiopia. Besides, there is no evidence of monetary or fiscal incentives available for innovation or commercialization of technologies developed by universities, small and medium-sized enterprises (SMEs) or R&D institutions. Even formal financing institutions are not engaged in providing financial assistance for technological innovation. A poor balance of payment position is already a major impediment for Ethiopia's industry in accessing foreign exchange. The government must intervene and provide financial assistance to industry to innovate and commercialize research results. Proactive policy should be made in favour of venture capitalists to promote start-ups.

5.8 Science, Technology and Innovation in Regional Economic Treaties

There are over 25 regional agreements on cooperation and economic integration at the subregional and continental level in Africa. These agreements range from promoting limited cooperation among neighbouring countries in specific areas of political and economic development to the creation of African Common Market. A common feature of these agreements is their explicit recognition of the role of STI in regional economic integration and development. Some agreements recognize that regional integration is being driven by advances in transport, ICTs as well as in policy and politics. This is evident in the increasing transboundary movement of information, skills, finance and products across regions.

At the African level, measures for promoting science and technology cooperation can be found in the 2000 Constitutive Act of the AU. Article 13(i) of the Constitutive Act provides, inter alia, that the Executive Council of the African Union (AU) shall coordinate and make decisions on policies in the areas of science and technology that are of common interest to the member states. Article 14(d) establishes a specialized committee (i.e. the Committee on Industry, Science and Technology, Energy, Natural Resources and Environment) to deal with science and technology-related issues, among others. The Committee's functions include preparing AU projects and programmes dedicated to science, technology and innovation.

Similar provisions are found in the treaty creating the Common Market for Eastern and Southern African (COMESA). Article 100(d) calls on member states to cooperate to promote "industrial research and development, the transfer, adaptation and development of technology, training, management and consultancy services through the establishment of joint industrial support institutions and other infrastructural facilities." The treaty also aims at promoting cooperation in the creation of an enabling environment for foreign, cross-border and domestic investment, including the joint promotion of research and adaptation of science, technology and innovation for development.

In summary, African regional economic and trade treaties recognize the importance of STI in promoting regional integration and development. The integration of these considerations

[40] AfDB (2007).

into regional agreements is informed by the understanding that individual African countries' economies are small and unable to marshal scientific and technological resources for development. Many countries, including Ethiopia, are poorly endowed with the human, physical and financial resources necessary to develop and harness knowledge and innovation for economic change and growth. Cooperation in STI is thus necessary to enable countries to pool and share their scarce resources such as R&D infrastructure and skilled human resources.

In light of the above, the Ethiopian government should utilize this opportunity for establishing a strong base for science, technology and innovation with the help of neighbouring countries like Kenya and North Sudan. The chemical industry has tremendous potential for regional cooperation. Kenya and North Sudan are rich in terms of oil and gas reserves. Regional cooperation in this regard will pave the way for establishing a petrochemical complex that will have a positive impact on the entire eastern region. Economic rationality must be given priority over political expediency to share the fruits of joint cooperation. Kenya's education infrastructure is better placed than that of its neighbours, however, R&D and innovation require a strong and well-diversified industrial base. Each country has a comparative advantage over its neighbours in certain chemical product categories. Regional cooperation between the three countries has a lot of potential for attaining technological readiness and technological capabilities in certain areas of the chemical industry by each country.

5.9 African Development Bank (AfDB)

The AfDB is one of the main sources of financial capital for African development. In 2007, the AfDB adopted a strategic plan to invest in higher education, science and technology[40]. The strategy focused on three aspects of institutional capacity building, namely (a) strengthening national and regional centres of excellence in science and technology; (b) building and rehabilitating science and technology infrastructure in tertiary and higher education institutions; and (c) linking higher education and science institutions with the private sector. It also aims at assisting African countries to retain scientists and engineers to stem brain drain and promote the cross-border exchange of expertise.

The AfDB has collaborated with regional centres of excellence and national governments to identify and develop projects or programmes to be funded through loans or non-loan arrangements. It established a Division of Tertiary Education, Science and Technical Implementation of the strategy. The AfDB is already working with a number of African countries to design projects based on its strategy. For example, in 2008, it approved funding for Rwanda to develop the Kigali Institute of Science and Technology (KIST) into a centre of excellence in science and technology.

[41] FAO, UNDP, UNICEF, UNESCO, WHO, UNIDO, UNCTAD, UNEP, etc., among many others.
[42] Council of European Union (2007).

5.10 Multilateral Agencies

At the multilateral level, the United Nations (UN) has a number of initiatives aimed at promoting science, technology and innovation in Africa. UN agencies[41] have launched a number of programmes to promote STI activities in Africa. These activities and programmes range from agricultural research to promotion of space technologies. The main activities of UN agencies can be grouped as: (a) spreading or promoting the diffusion of existing agricultural, health and energy technologies; (b) provision of policy information and statistics on science, technology and innovation to decision-makers; (c) strengthening national quality standards and metrology institutions; (d) support to countries to strengthen intellectual property protection legislation and offices; (e) environmental technology assessments and generation of scientific information on climate change, trends in biological diversity, land degradation and depletion of the ozone layer; and (f) strengthening educational and training institutions.

Likewise, the Council of the European Union adopted "The Africa-EU Strategic Partnership: A Joint Africa-EU Strategy", which identifies STI as a priority in EU-Africa cooperation. Paragraph 84 of the joint strategy states: "Africa and the EU will strengthen their cooperation in building knowledge-based societies and economies. Both sides recognise that the development of STI is one of the essential engines of socio-economic growth and sustainable development in Africa; that competitiveness in the global economy is increasingly dependent on knowledge and innovative ways of applying modern technology, especially ICT; and that meeting the MDGs requires a special global effort to build scientific and technological capacities in Africa. Thus, partnerships and investments advancing access to ICT infrastructure, access to quality education, and the development of STI systems in Africa are crucial for attaining all other development goals." [42]

Undoubtedly, most development bodies have shown commitment in improving science, technology and innovation infrastructure in Africa. The impact of these efforts on Ethiopia is still evolving. It requires close engagement with multilateral agencies to exploit these opportunities to strengthen their national innovation system.

6. Conclusion

Ethiopia has already made commendable progress in recent years. However, to sharpen the national focus on innovation, Ethiopia needs a policy regime that will guide it to make strategic choices for R&D; take a long-term anticipatory approach to technology development; invest in technology foresights, prospecting and procurement; and create appropriate incentives for private sector in-house R&D. Good national innovation policy also entails specific measures to promote long-term capacity building in industrial firms and larger parts of society. It should encompass "a wide range of policies including social policy, labour market policy, educational

[43] Lundval et al. (2002).

policy, industrial policy, energy policy, environmental policy and science and technology."[43] A policy regime must be developed for the chemical industry as a priority industry, which would enable the government to make strategic choices for R&D and innovation. This industry not only has the capabilities of broadening the manufacturing sector, but can also substitute imports and improve export competitiveness.

The coordination of science, technology and innovation regime, its design and implementation require high-level executive authority. It cannot be left to ministries or departments of science and technology. For innovation policies to be effective, leadership for their coordination and implementation should be vested with the Presidents' office. For instance, the President of the Republic of Korea appointed the Science and Technology Minister as the Deputy Prime Minister to ensure effective leadership and monitoring of the national innovation system. Likewise, the Science and Technology Ministry also needs to develop and use clear multi-year (e.g. 10 years) rolling implementation strategies to ensure that national innovation policy is implemented. The strategies for the chemical industry should be formulated by all major actors of innovation with clear benchmarks and articulation of institutional responsibilities.

Ethiopia's education and training institutions do not produce sufficiently skilled manpower to meet market demands for skills in science and engineering. The situation of chemical engineering is even worse. There is a shortage of adequately skilled chemists and chemical engineers. This is a major barrier to improving the chemical industry's technological performance and to enhancing the national innovation system. It should undertake immediate reforms in its education and training systems in the chemical industry. It should improve the curriculum of chemical sciences and engineering, double the number of academics and trainers and equip the chemistry laboratories in schools and colleges. It must also create a fund dedicated to training at PhD level in chemical engineering. This can also be achieved by creating research chairs at universities. Chemical firms should be provided with fiscal incentives to create chairs and departments in promising universities. In fact, increasing enrolment in chemistry and chemical engineering courses requires a wide range of measures, including increasing universities' capacities by building more and better laboratories, increasing lecturers and technicians and encouraging private universities to develop and offer such courses.

It is necessary to take a holistic approach to building chemistry and chemical engineering skills. Single, short-term interventions will be inadequate. For example, placing emphasis on increasing student enrolment without an adequate focus on creating employment opportunities in businesses is unlikely to succeed, at least in the long run. Increasing investments in chemical sciences training should go hand-in-hand with concerted efforts to develop the private sector, improve physical infrastructure, create more jobs and grow the economy as a whole. Thus, Ethiopia should avoid single isolated interventions in its efforts to improve chemical sciences and engineering skills.

After field visits and industry interactions, we observed that there is a weak entrepreneurial culture among graduates as one of the barriers to increased business development and job creation in Ethiopia. Many graduates enter the labour market unprepared and ill-equipped to manage businesses and take risks. Universities, polytechnics and other institutions of higher learning need to introduce courses in entrepreneurship in their curricula. Technical colleges could team up with businesses and business schools to design and offer entrepreneurial courses as part of their standard teaching curriculum.

Despite commendable efforts, Ethiopia's national innovation system is still relatively weak. The innovation system in the chemical industry is even weaker. The industry cannot, therefore, adequately take advantage of new opportunities that are arising with the rapid scientific and technological development, intensifying regionalization and globalization, increased FDI flows, political stability and better macroeconomic conditions. If taken on and effectively implemented, the strategic interventions proposed for the national innovation system and specifically for the chemical industry, Ethiopia can go a long way in fostering STI in the economic transformation of its economy.

CHAPTER IV

DEVELOPMENT STRATEGY FOR TECHNOLOGY-BASED CHEMICAL INDUSTRY IN ETHIOPIA

Ethiopia has the potential to develop a technology-based large-scale chemical and petrochemical industry. The Ethiopian Industrial Development Strategic Plan (2013-2025) envisions "building an industrial sector with the highest manufacturing capability in Africa which is diversified, globally competitive, environmentally-friendly, and capable of significantly improving the living standards of the Ethiopian people by the year 2025." The 2nd GTP set an ambitious plan for developing a technology-based chemical industry in Ethiopia. The IDSP also identified seven strategic issues that need to be addressed in order to achieve the desired objectives. Those strategic issues are:

1. Inadequately developed business-enabling environment
2. Poor human resource development system and shortage of highly qualified human re sources
3. Insufficient industrial inputs and infrastructure development
4. Lack of well-established investment and technology development
5. Inadequate market diversification and development
6. Inadequately developed institutional support and enterprise cultivation
7. Weak strategic sector development and diversification.

Therefore, the development strategy for a technology-based chemical industry must address these issues. However, these are issues that are common to all sectors of the economy. Moreover, the chemical industry in Ethiopia is seriously constrained by numerous structural obstacles. For instance, the government failed to boost infrastructural capacities against the set targets of GTP-I. Likewise, the investment policy for this industry is still quite restrictive, especially with respect to petroleum and natural gas, the primary feedstock of the chemical industry. As a result, foreign investments in this sector are not forthcoming. The chemical industry is heavily dependent on imports, but severe restrictions on imports have adversely affected the chemical production facilities. Disrupting chemicals supply lines wreaks havoc in the related downstream industries. For instance, the garment and leather industry requires dyes, ink and bleaching chemicals, the food processing industry needs chemical preservatives, and fertilizers and agro-chemicals are essential inputs for the agriculture sector. There are thus scores of cross-sectoral policy issues along with chemical industry-specific issues, which act as an impediment to the overall industrial development efforts.

1. Key Challenges

All good plans fail because of poor implementation, but even bad plans sometimes provide better than expected results because of effective and efficient implementation. Existing processing enterprises are engaged in small-scale operations. Even public sector firms operating in the chemical industry operate at sub-optimal levels of capacity utilization. A large part of current industrial production is comprised of limited but simple variants of the chemical industry. Productivity is low and quality standards are poor. The chemical industry exhibits a strange paradox, i.e. the upstream supply chain is largely untapped. The mid-stream is dominated by the inefficient public sector. The downstream linkages are nearly non-existent. Domestic chemical producers remain perennially dependent on raw material imports. The chemical industry is still in its infancy in Ethiopia. Therefore, the key challenges for the development of a technology-based chemical industry lie at two levels.

1.1 Chemical Industry

The key challenge for the chemical industry is to become competitive in the marketplace. Domestic players must focus on specializing in their areas of expertise in line with the global trend. Innovation is gaining importance as it enables firms to focus on core competencies and to lead in specialty products. The idea is to focus on one's core competency and select business segments that have a competitive advantage. Likewise, a chemical producing organization that wants to successfully compete in the marketplace must focus on customer demand. These demands can be numerous, even for a narrow customer segment. Domestic chemical producers must translate customer demands into objectives for operations known as competitive priorities, such as low cost, consistent quality and on-time delivery. The industry must focus on improving its product and production processes by investing in technology development and building R&D capabilities. Such steps will enable the industry to not only build its expertise in chosen fields, but will also lead to reductions in production costs. Adherence to environmental and public safety norms and the promotion of safe management of substances are also pivotal areas that need to be focused on from design, end use, to the final disposal (hazardous waste) of products.

a) The chemical industry must ensure full competitiveness, i.e. the competitiveness of firms at the upstream to the downstream level through backward and forward linkages. If the upstream units produce quality products at competitive prices, the output of mid-stream are good quality products at competitive prices. This output is input for downstream units, which in turn produce quality outputs at competitive prices. Thus, attaining economies of scale at each level is currently a major challenge for the chemical industry.

b) Import substitution represents another challenge for this industry. The government will not be able to adopt a regressive policy of mandating local content requirements. The chemical industry must position itself for value addition instead of importing finished goods. For instance, rather than buying finished goods to represent a part of the assembly line, the industry may adopt a combination of made to order and assemble to order products. In other words, the challenge for the chemical industry is to ensure reduction of excessive import dependency.

c) Innovation is the key to success in a highly competitive business environment. Enterprises must invest in technology to improve their products and production processes. With the current state of R&D infrastructure, technology transfer is the only way to meet the requirements of a technology-based chemical industry. However, the scope of technology transfer should not be limited to merely import technology, but the enterprises need to make a concerted effort to adapt and absorb the newly acquired technologies and thereafter undertake efforts to develop technologies. This requires a strong interface with universities and research institutions.

d) The industry chambers' role in times of globalization has changed. Instead of acting as a lobbying group with the government seeking concessions, industry chambers are required to network with their members to create a strong information base on producers, products and markets. For instance, protection against excessive imports in the form of anti-dumping, countervailing duties and safeguard measures requires a proactive role of industry chambers. Thus, industry chambers are necessary to continuously educate their members about the changing international business environment and potential emerging markets.

e) Chemicals companies largely operate on the basis of a business-to-business model, selling products that are used by their customers as inputs to create another set of products. The rapid introduction of IT in the chemical industry is strongly influencing the way companies operate by digitally integrating physical assets across different stages of their value chain. The challenge lies in the digital integration of the chemical industry across the entire value chain in the light of an existing weak info-communication infrastructure.

f) The chemical industry is one of the most regulated industries globally. Therefore, the chemical industry must comply with the international safety norms, good manufacturing practices and international standards. Initially, this represents a challenge for the chemical industry, but in the long run, it is advantageous for chemical manufacturing units to integrate with global production networks. In other words, the industry must ensure the integration of vertical value chains.

1.2 Government

The domestic chemical industry is endowed with availability of low-cost labour. Agriculture along with associated industries such as leather, plastics, food processing, rubber and textiles offer tremendous growth opportunities for the chemical industry in the long term. However, weak infrastructure continues to plague the development of the chemical industry despite the availability of abundant natural resources. Porous borders and weak regulatory mechanisms have allowed excessive imports of cheap and low-quality chemicals. Thus, logistical bottlenecks, cheap unchecked imports and poor regulatory mechanisms pose a threat to the chemical industry as a whole. Therefore, attracting technology transfer and technology upgrading, access to skilled manpower and the availability of funds at a reasonable cost, adequate infrastructure support and economical input costs are essential for the sustained growth and development of the chemical industry in Ethiopia. The major challenge for the government is to develop basic infrastructure to foster the growth of the domestic industry. Thus, the key challenges for the government are:

(a) The infrastructure industry has gained significant importance in the transformation of Ethiopia. It is one of the government's priority focus points. The chemical industry is energy intensive. However, the industrial policy and energy policy have no common denominator in thought and expression. Likewise, Ethiopia is a landlocked country and requires multimodal transport linkages to gain access to international markets. Thus, the key policy challenge is to synthesize the industrial policy with various policies that are relevant for infrastructure development, like energy policy, multi-modal transport policy, etc.

(b) Public sector enterprises are inefficient and under-utilized. How to improve the performance of such enterprises remains a major challenge for the government. The public sector suffers from acute low productivity, outdated technology, weak R&D and sub-optimal operations. The challenge is to turn around these public sector enterprises by immediate infusion of new technology and capital for additional capacities.

(c) The challenge for the government is to attract large-scale foreign direct investment in the chemical industry. Unfortunately, the extracting industries have not been able to attract the attention of big players in the petroleum business. Even the gas discovery has not been able to attract the attention of petrochemical majors in Ethiopia. FDI brings in technology, access to international markets and productivity along with a strong impact on economic activity. A review of the current FDI policy and FDI policies of Ethiopia's neighbours is urgently required. The objective of Ethiopia's FDI policy should be made more attractive in order to draw attention of international giants in the chemical industry.

(d) Cheap and low-quality imports from neighbouring countries is one of the reasons for the narrow manufacturing capabilities in the chemical industry. Porous borders and poor regulatory mechanisms have adversely affected Ethiopia's industrialization prospects. It is a challenge for the government to ensure that the trade policy is not protectionist in its approach but must also safeguard the interests of local manufacturing. The chemical industry experiences an inverted tariff structure in certain categories of goods, for instance, tariffs are higher on raw materials/intermediate goods (petrochemical variants) as compared to tariffs on imports of finished goods (packaging material).

(e) There is a shortage of trained technical workforce, qualified chemical engineers, researchers and managers. Expatriates comprise a large majority of the technical workforce employed in Ethiopia. In general, the government faces the challenge of preparing an adequately trained workforce to become an integral part of the transformation from an agriculture to an industrial economy. Human resource development at all levels is a major challenge.

(f) Absence of market extension support systems for the chemical industry. This is an integral feature of any manufacturing sector, but plays a vital role in the chemical industry. Market extension systems usually comprise testing laboratories, quality certification agencies, pre-shipment inspection agencies, technical standards bureaus, tool rooms and technology generators. It is a challenge for the government to ascertain a nationwide network of market extension and support services for the chemical industry.

2. Recommendations for a Development Strategy for Ethiopia's Chemical Industry

It is clear that Ethiopia's chemical industry has thus far not even attained a critical mass to influence supply side or demand side linkages. Almost 90 per cent of domestic demand for chemicals, such as raw materials, intermediate or finished goods, is serviced by imports. The balance of 10 per cent domestic demand for chemicals is serviced by local manufacturing. Local manufacturing of chemicals is plagued by low productivity and operational mismanagement, resulting in the non-competitiveness both in terms of quality and price against imports. The one-third rule of economic growth is often used to denote the critical mass on a variety of economic issues. To make any significant impact on the chemical industry's manufacturing capabilities, local production must attain a critical mass of 33 per cent. Once the domestic producers have successfully met 33 per cent of the local market requirements, it is believed that the industry has attained a critical mass at which it can successfully compete against imports and influence the local market as well. In other words, the upstream supply side producers like refineries, cracker plants and petrochemical plants, must be in a position to provide raw material and feedstock at competitive prices to service 33 per cent of downstream demand in order to influence the domestic market. The chemical industry's development target should be to become cost competitive in the short term, emerge as a strategic substitute for chemical imports in the medium term and finally, become a net exporter of chemicals in the long run.

Therefore, the development strategy for the technology-based chemical sector should be a double-pronged strategy comprising of substantive measures for the chemical industry and policy recommendations for the government.

2.1 Substantive Measures for a Technology-based Chemical Industry

a) **Changing mindset from 'Look Local, Think Local' to 'Think Global, Act Local'**

At the global level, the presence of Ethiopia's chemical industry is nearly non-existent. The production capacities and product mix are designed for the domestic market. The mindset of local producers is inward looking, which results in a lack of interest in quality consciousness, innovation and achieving economies of scale. Chemical producers are limited in number and production capacity, but domestic demand for chemicals has increased over time, which has resulted in largely skewed competition in favour of cheap imports.

Ethiopia is awaiting accession to the WTO. After becoming part of the multi-trading regime, fierce competition in the domestic market is expected, which will also be visible in the chemical industry. Excessive cheap imports have already begun to hurt local producers financially. Increased competition will force local producers to change their mindset and review their operations. They must realize that a protectionist regime is a thing of the past and they will have to become globally competitive to remain competitive domestically. Therefore, the mindset of local producers must undergo a change from inward looking to 'think global, act local'. Competition will shift their focus from small domestic markets to large global markets to achieve economies of scale. Price competitiveness will force them to become quality conscious, innovative and technology-driven. As a result, the changed mindset will force local chemical producers to review and realign their production operations, product offerings, etc.

b) Change in the product mix

Domestic chemical producers have a sizeable presence in downstream industries. However, the upstream and mid-stream production of chemicals is almost non-existent in the private sector. To a limited extent, the public sector is present in the mid-stream chemical industry. However, the product mix in chemical production is limited at all levels. The analysis identified potential areas of chemical production in Ethiopia, namely soap, cleaning and cosmetics, basic chemicals (except fertilizers), fertilizers and agro-chemicals and cement. Each sub-sector depends on the variants of hydro-carbons and the output of upstream and mid-stream industries. For instance, gas is cracked in the upstream petrochemical plant and fertilizer plant to provide outputs for multifarious usage in mid-stream industries like agro-chemicals and downstream industries like paints, cosmetics, etc. To achieve economies of scale, chemical manufacturers will not only have to add capacities but also broaden product offerings. The basic chemical sub-sector (except fertilizers) has a wide range of product offerings which include acids, alkalis and other chemicals in different concentrations for downstream industries.

Likewise, chemical products are also experiencing a change in the preferences of buyers. Demand for special chemicals is growing at the global level. Environmental concerns are also putting pressure on chemical producers to innovate and produce products that have minimal impacts on the environment. For example, the chemical industry has been pushed into producing alternative refrigerants to air conditioning and refrigeration. Thus, domestic producers will have to now work on different variants of chemicals to address global market issues. As income levels rise, demand for better and environmentally friendly products increases. Therefore, domestic demand will also shift to higher quality and environment-friendly chemical products. This, however, will require R&D investments. Chemical producers who seek to participate in the global market will tend to develop an appropriate product mix to cater to different markets and market segments. Such producers will consider R&D investments as an integral part of their operational costs.

c) Compliance with the international quality regime

The chemical industry follows a very stringent quality standards regime at the international level due to its hazardous impact on animal and plant life. Despite the existing quality regulatory mechanism, domestic producers and consumers have little interest in complying with international quality standards. Their knowledge on subjects like ISO 9001:2015, ISO 14001, ISO 18001 (OHSAS) and ISO 27001:2013 is quite low or absent altogether. International quality norms for the chemical industry as catalogues in the ISO standards catalogue 71.100 are relatively high, both in terms of quality standards and compliance requirements. Domestic chemical producers, both in the public and private sectors, have limited capabilities to comply with these standards. However, the changing business environment will force local chemical producers to recalibrate their production lines and upgrade their quality standards. This will be a major challenge for all stakeholders in the chemical industry.

d) Backward integration

The mid-stream and downstream chemical industries in Ethiopia face a major challenge in the form of continuous supply of inputs. Existing capabilities to exploit natural resources are poor and force the local chemical industry to import primary chemical inputs, which makes the production process perennially dependent on imports. Frequent disruption in primary input supply lines results in under-capacity plant utilization and diseconomies of scale. To overcome this shortcoming, chemical producers at mid-stream and downstream level should try to integrate their production with the source of primary inputs. Backward integration is a well-tested strategy adopted by most resource-based industries. For instance, a large capacity hydrochloric acid plant can make investment in magnesium chloride brine fields in the Afar region for continuous supply of primary inputs. Such types of backward integration are most common for resource-based industries. Another strategy often used by resource-based industries is to enter into alliances with primary input suppliers. For example, a petrochemical plant or fertilizer plant entering into an alliance with a gas exploration company to ensure continuous supply of gas. Backward integration allows a firm to exercise control over the supply of raw materials.

e) Upgrading of skills and training

Human resources are an important resource for the chemical industry. High-skilled workers are required by the industry, hence it must continuously invest in human resource development. There is a short supply of technically competent and skilled workers in Ethiopia. Most technology-intensive industries, including the chemical industry, thus depend on expatriates. The chemical industry should improve its interface with the local universities to enable them to understand their current and future requirements. Close interfaces can be achieved by instituting fellowships and scholarships at the tertiary level of education to popularize chemical sciences and chemical engineering among students. The chemical industry can institute a Chair at the university for technology development and promote research in chemical sciences. In times of globalization, it is imperative for the chemical industry to improve its interaction with universities and research institutions for continuous upgrading of skills and training of locally available human resources.

f) Attaining competitiveness through lean management

To be competitive in chemical production, the 'lean' philosophy supports all kinds of waste minimization through value stream mapping. Lean management cuts off non-value adding activities and overall operations cost by 35 per cent in processing activities. Undoubtedly, there are challenges of implementation in an already established industrial set-up. However, the Ethiopian chemical industry is in its infancy and it will be easier to establish lean management norms at the initial stages of the industry's development. The chemical industry should follow Standardized Work Instructions (SWIs) that allow processes to be completed in a consistent, timely and repeatable manner. The SWIs will increase production, improve quality and provide for a safer, predictable working environment. Value Stream Mapping (VSM) is also used to illustrate the flow and relationships between work processes. Reducing or eliminating non-value adding activities is of paramount importance and a principle goal of lean manufacturing.

"Poka Yoke" is one of the powerful tools used for ensuring error free processing or zero-defect operations. Frequent voluntary customer-vendor interactions improve area effectiveness in chemical processing industries. "Heijunka," provides a system for advanced scheduling of production activities. This lean tool allows for a reduction in inventories, decreased lead times, and the production of variants to suit market requirements. The establishment of Single Minute Exchange of Die (SMED) to create swift changeovers and set-ups to reduce machine downtime and increase throughput should be considered. Inventory and lead time reduction lower excess inventory, spoilage and pilferage, storage requirements, tied-in funds for inventories, etc. The "KanBan" system indicates to the workforce what tasks need to be completed and when through signal boards and colour codes. Such tools control wastages of resources in chemical enterprises and make the processing operation efficient and cost effective.

2.2 Policy Recommendations

To achieve the objective of developing a technology-based chemical industry in Ethiopia, the government will have to adopt a multi-pronged strategy based on (1) Consolidation of the public sector on the supply side and attracting foreign investment, (2) Set up a chemical industry agglomeration as a pilot project, and (3) Incentivize the demand side for import substitution. This multi-pronged strategy will enable the local chemical industry to attain a critical mass to influence the overall chemical industry in Ethiopia. However, this strategy must be complemented by (a) improvement of infrastructure, (b) strengthening of public institutions, (c) human resource development, (d) Improving access to finance, and (e) promoting entrepreneurship development.

Recommendation-1: Consolidation of Upstream Public Sector Enterprises

The role of public sector enterprises in Ethiopia is manifested in the quantum of capital they control and the magnitude of the economy's dependence on such enterprises. The upstream chemical industry is dominated by public sector enterprises and suffers from operational inefficiencies. Consolidation is a business strategy to enhance competitiveness by way of drawing strategic alliances. Strategic alliances essentially are non-equity and equity based. Non-equity-based strategic alliances are licensing and franchising, while equity-based alliances are essentially joint ventures and other strategic means of consolidation including mergers, acquisitions and takeovers.

[44] Selvan (2008).

To improve the performance of public sector enterprises, the government carried out two phases of privatization, the first wave occurred from 1991 to 1994 and the second wave lasted from 1999 to 2004. During these two periods, a total of 224 public sector enterprises existed in Ethiopia. Industry had the highest number of PSEs (113) followed by the agriculture sector (37). Around 40 loss-making PSEs in industry were privatized, of which 13 were in the chemical industry. However, the production levels declined by nearly 14.21 per cent after privatization due to depleted machinery and a shortage of raw materials[44].

Upstream operational PSEs, for example, the Calub Gas Share Co., control the entire supply of gas for domestic consumption. Slow development of gas fields has hampered mid-stream and downstream industrial production. Likewise, domestic production of fertilizers and petrochemicals has also decelerated. The government recently announced that it would privatize its 95 per cent stake in public sector companies, but the actual privatization of PSEs has not yet occurred. Internationally, major public oil and gas companies have been seeking to sell off their downstream operations and focus on potentially more lucrative upstream operations. Market demographics are encouraging downstream investment, thus highlighting the range of strategic options available in just one area of the value chain. The impact of technologies has so far been greatest on downstream enterprises like petrochemicals and petroleum products. This secures a competitive advantage by introducing new technologies. The use of technology becomes more widespread to broaden the product mix in the chemical industry.

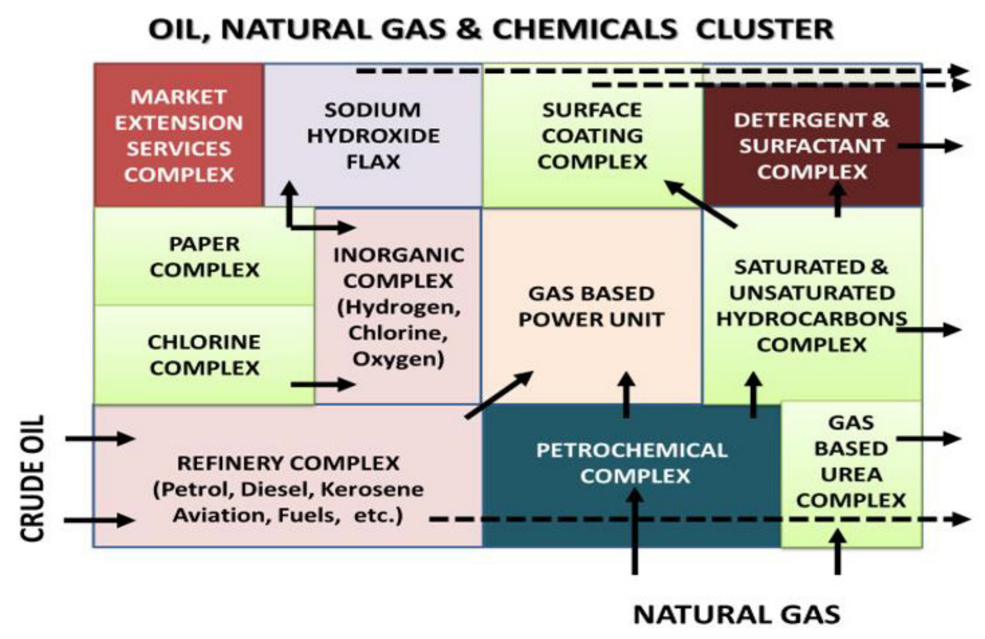
Major players in the chemical industry, like China, the Republic of Korea, Japan and India are looking for new opportunities. The prospects of strategic alliances with PSEs should be beneficial for developing capacities of manufacturing specialty chemicals in Ethiopia. These chemicals are usually at the higher end of the chemical value chain, which have a wide utility in a variety of downstream industries, including waste water treatment, textiles, agriculture, oil and gas, electronics and consumer goods. In general, demand from end-user industries will result in increased growth prospects for several manufacturing segments, most notably for mining chemicals, specialty polymers and electronic chemicals.

Recommendation 2: Set-up of a Chemical Industry Agglomeration

Involving the private sector for value addition and exploring export markets is crucial. The strategy for development of a technology-based chemical industry centres on cluster formation on a pilot basis (with reference to the homogeneity of a chemical industrial complex or chemical cluster/agglomeration). A cluster approach accelerates the transition of an infant manufacturing sector into a mature competitive one by synergizing strengths and adopting state of the art technologies. Clusterization results in total factor productivity and comparative advantage through continuous innovation. Rather than distributing scarce resources to multiple regions, the government benefits from concentrating on a particular region to build infrastructure and develop market extension services. Focused development attracts private investment and technology in the cluster. Lessons learnt from such focused initial efforts could then be transferred and replicated across other producing regions of the country by spreading investments sequentially.

To set up a cluster, the government needs to enact a Special Purpose Vehicle (SPV) to establish the basic operational framework for developing a chemical cluster zone. The SPV is not a new subject. Existing chemical producing locations are concentrated in Addis Ababa and the Oromia region. However, with the discovery of gas in the south-western region, the strategy would aim to develop a cluster in that region to achieve complementarities and overall competitiveness. In fact, this SPV could be developed as a centre for regional cooperation with neighbouring oil and gas rich Kenya and North Sudan. The cluster approach recognizes that all stakeholders in the chemical value chain are often pushed to be more innovative and successful when they interact with supporting institutions and other actors in the supply chain. By promoting vertical and horizontal linkages between feedstock suppliers at the upstream level to supply inputs at the downstream level, as well as supporting relationships between them and facilitating organizations (e.g. local governments, research institutes and universities), cluster policies promote the diffusion of innovation, as well as the use and generation of important local externalities. Chemical clusters enhance access to markets and information.

Figure 23 Oil, Natural gas & Chemicals Cluster



Cluster policies are crucial for MSMEs and market linkages, as they enable them to engage in higher productivity and more market-oriented and higher value-added production. Therefore, the SPV for the chemical cluster must elaborate the role and responsibility, expression of interest, identification of land, eligibility criteria, etc. The most common SPV mode of cluster development are Public Private Partnerships (PPPs).

[45] Goldin and Reinert (2007).

The global experience of the chemical industry shows the advantages of clustering and agglomeration as it enhances supply chain responsiveness and provides easier access to markets, talent and substantially lowers logistics costs. Although the government has been implementing schemes to promote industrial zones in Ethiopia, their full benefits of agglomeration have yet to be realized. A chemical cluster will catalyse the growth of the processing industry and will emerge as a first chemical industrial agglomeration in East Africa, benchmarked with the best manufacturing practices in the chemical industry. A chemical cluster will help meet the increasing demand for creating a world class chemical production hub, while it will also absorb surplus labour by providing gainful employment opportunities in the entire region. The chemical industrial agglomeration will address the infrastructural bottleneck which has been cited as a constraining factor for the growth of industrial development.

Recommendation 3: Review of the Foreign Direct Investment Policy

FDI plays a critical role in enhancing the manufacturing sector's efficiencies and competitiveness. Under appropriate conditions, FDI can generate direct and indirect employment, promote competition, improve efficiency and provide access to newer and appropriate technologies[45]. FDI is usually associated with new job opportunities and enhancement of technology transfers, and it boosts overall economic growth through exports. Investment, without doubt, is one of the primary engines of growth in all economies. However, its effectiveness rests on strong complementarities with other elements in the growth process, most notably technological progress, skills acquisition and the development of innovative capability. These elements make investment a natural point of departure for governments seeking to formulate a robust development strategy. The link between investment and these other determinants of growth, however, is not an automatic process. It requires, among other things, a favourable macro-policy environment and specific policies and institutions aimed at encouraging savings and attracting and directing investment to key sectors in the economy, thereby enhancing the contributions of investment to skills formation, technological change, competitiveness and economic growth.

FDI policy is undoubtedly a cross-sectoral policy, but the chemical industry also has a considerable impact on multiple sub-sectors of the economy. It was observed that the current provisions in Ethiopia's FDI policy include certain provisions for the oil and gas industry, which look relatively restrictive and discretionary from an international point of view. Oil and gas are the primary feedstock of the chemical industry and it is therefore recommended for the FDI policy to be reviewed in order to accommodate the concerns of the chemical industry. World leaders in the chemical industry are some of the most welcomed entities in all nations because of their technological prowess, market dominance and commitment to sustainable development. Chemical MNCs prefer a liberal policy and transparent regime. Therefore, the domestic FDI policy must be made more attractive than that of other countries, especially of those in the region, to attract foreign inflows in the chemical industry.

Singapore is an example of pursuing a proactive FDI policy for the chemical industry. The available FDI incentives include tax and other fiscal inducements, financial subsidies and deroga-

[46] Tamrat W. (2018).

tions from regulations offered to foreign-owned enterprises with the purpose of making them invest. The incentives may include duty-free privileges; concessionary tax rates, breaks and exemptions; preferential fees for land or facility use; favourable arrangements on project duration, size, sector invested in, location and type of ownership; flexible treatment regarding business management, employment and wage schemes; etc. The aim of policies to attract FDI must necessarily be to provide investors with an environment in which they can conduct their business profitably and without incurring unnecessary risks. A sound foreign investment law addresses foreign investment in the context of general investment laws, basically granting foreign investors "national treatment", which is a global best practice.

Recommendation-4: Human Resource Development Policy

The global economy is increasingly becoming 'knowledge based'. As technological change occurs at unprecedented speeds, it becomes increasingly important for developing countries to create institutional mechanisms that can foster skills formation at both the national and firm level to become globally competitive and to promote economic development. One development observed on a global basis is a growth in demand for products with a high level of skill content, flexibility and multi-tasking. This calls for a high level of skills, which in turn push the national government to expand allocation of finance for tertiary education. Besides, the quality of a country's national education system is increasingly being compared internationally, placing high premium in mathematics, science, English and communication skills. Digital mediums are being introduced in education systems, partly to expand the quality of education at lower costs through distance learning, and partly to deliver higher quality education (at a higher cost) through computer-assisted instructions and the use of the internet. These issues are the fundamental guiding force to developing any human resource development policy.

Ethiopia has major shortcomings in nearly all levels of education, i.e. primary, secondary and tertiary education. Given resource constraints, the government's priority is primary education. Therefore, government funds for tertiary education have decreases considerably. It is evident that public universities in Ethiopia are exercising new forms of privatization within their realms of operation. Strenuous efforts are being undertaken to increase former sources of revenue through different income generation schemes and to outsource non-academic activities. The failure of Higher Education Relevance and Quality Agency (HERQA) in monitoring quality levels has resulted in poor infrastructural facilities for imparting university education. University education in Ethiopia, especially technical education, is suffering the most[46]. As discussed earlier, laboratories and workshops in technical colleges in Ethiopia are poorly equipped with a lack of journals and laboratory and workshop equipment and machinery. The government's R&D investment is miniscule. Thus, there is a severe shortage of technically competent skilled manpower in Ethiopia. However, university graduates are mostly unemployable due to a lack of updated skills as required by industry. Ethiopia's human resource development policy is undoubtedly a cross-sectoral policy, but high-technology industries such as the chemical industry are affected most. The majority of high-technology industries rely on expatriates. Therefore, the following recommendations are chemical industry-centric.

1) The government should increase allocation for tertiary education. This recommendation may be sector neutral, but the government will have to conduct a mapping exercise of the existing turnout and the requirements of chemical engineers, chemists, pharmacists and technicians with a focus on the expansion of the chemical industry. The mapping exercise will channel financial allocation for interfaces between research and training institutes, such as chambers of commerce and industry, universities, colleges and vocational schools, and disseminate information on available training courses on business and management as well as chemical technology and chemical engineering to develop local managerial and technical skills.

2) Often, higher education needs are related to employment opportunities. Chemical engineering is not popular among the technical disciplines offered in Ethiopia because of lack of employment opportunities. For instance, there are a total of 60 students in the undergraduate chemical engineering programme at Addis Ababa University. This number of chemical engineers cannot even support MSMEs in the chemical industry. Therefore, the government needs to establish public-private partnerships to incentivize students to pursue chemical engineering courses through scholarships, fellowships, waiver of fees, etc.

3) Labour Proclamation No. 377/2003 provides provisions on apprenticeship contracts. The government should make apprenticeship training mandatory for all students pursuing technical courses. They should spend at least 45 working days in a factory as part of the curriculum requirements. This is a sector neutral policy recommendation. However, high-tech industries require hands-on experience to complete their educational training. The chemical industry is one such industry where education is incomplete without gaining hands-on experience in the industry. For instance, to teach chemistry, a fully equipped chemistry laboratory is necessary. This will strengthen and improve the interface between industry and technical universities.

4) Technical and Vocational Education and Training (TVET) are an integral part of education systems across the world, contributing to the competitiveness of SMEs. The Ministry of Labour is the nodal ministry to implement technical and vocational training on a nationwide basis. The chemical industry requires large numbers of trained chemists, pharmacists and lab technicians. At present, the Ministry of Labour has not yet identified chemical trade for developing the training and education module. The ministry must first identify it as a priority and expedite preparation and training modules on chemical trade.

Recommendation-5: S&T Policy and Strengthening of the IPR Regime

It has been established that firm-, industry- and national competitiveness are closely integrated with one another. This outlines the need for an appropriate Science & Technology policy that boosts the innovative edge of smaller firms as they improve their own nation's capacity to compete in global markets. However, small firms find it more difficult than larger ones to secure sufficient knowledge, human resources and funds to develop and protect their innovation, particularly through intellectual property rights (IPRs). Moreover, Ethiopia is lagging behind its neighbouring countries in terms of R&D spending and technology capacity building. In order to help domestic MSMEs create new businesses with the potential to generate innovations, active support will continue to be provided for initiatives undertaken by MSMEs, such as the development of new products and services. There is an urgent need for a holistic policy approach that facilitates the development of human resources, business incubators, science parks and ICT applications. The following policy actions are proposed:

1) The Ministry of Science & Technology (MOST) needs to design a simplified and streamlined institutional framework for the development of science and technology at both the national and the sub-national levels and develop national and sub-national innovation systems through institutional networking and coordination, capacity building and infrastructure development (e.g. science and technology parks);

2) The government should launch an initiative for the promotion of innovation by developing a legal framework to allow public-private partnerships in tertiary education to adapt technical education to the requirements of industry. For instance, it could provide fiscal incentives for joint R&D, technology transfers and technology commercialization in the chemical industry through various financial and non-financial measures, including special tax schemes; development of the patent office and its portal site; and subsidize patent, design and trademark applications made by manufacturers.

3) The government must foster business and technology incubators in priority industries, i.e. the chemical industry, and develop tools for technology-based MSME development. The industry chambers, in association with MOST, need to conduct studies on patent application trends and selected technological themes, assist in the development of R&D and intellectual property (IP) strategies and make the results available to the public. The number of patented technologies in the chemical industry shall soon be in the public domain for usage. The MOST and industry chambers must keep close track of these technologies to be used by the chemical industry, especially MSMEs.

4) Raise awareness on IPRs among MSMEs by organizing information sessions and training courses on innovation and IP systems; ICT applications for business management, productivity improvement and new product/service development; subsidize MSME investment in ICTs in cooperation with financial institutions; and provide a regulatory and policy framework to reduce the cost of communications for business.

Recommendation-6: Incentivizing Local Value Addition & Import Substitution

Start-ups in chemical industry range from billion dollar refining facilities to small packaging units in MSMEs. Industrial policy must therefore be coherent and flexible. The monetary and fiscal incentives for start-ups in the chemical industry shall include:

(i) 100 per cent exemption from stamp duty and registration fees during the pre-production phase for chemical start-ups;

(ii) Capital subsidy for industrial units and incentives to the existing units for captive power generation/diesel generating sets;
(iii) Subsidy on the use of renewable sources of energy;
(iv) Reimbursement of expenses incurred on project reports, technical know-how fees; quality certification, ISO certification; and
(vi) Customs duty relief on machinery, tools, parts and spare parts.

The government may also grant fiscal incentives like reimbursement of tax for import substitution. This type of reimbursement will be valid for a fixed period so that the chemical industry attains a critical mass.

An import substitution strategy is an attempt to replace commodities that are being imported—usually manufactured goods—with domestic sources of production and supply. Typically, tariff barriers or quotas on certain imported commodities are first introduced by the strategy. Subsequently, a local industry to produce these goods is set up. Although the initial costs of production may be higher than the former costs for imports, the government should create a tariff wall to eliminate the price differential. The economic rationale put forward for the establishment of import substituting manufacturing operations is either that the industry will eventually be able to reap the benefits of large-scale production and lower costs or that the balance of payments will improve due to imports of fewer consumer goods. Eventually, the infant industry will hopefully grow and be able to compete in world markets. It will then be able to generate net foreign exchange earnings once it has lowered its average cost of production. Besides, import substitution is often considered a regressive policy. Alternatively, instead of enforcing local content requirement, any manufacturing unit sourcing chemicals from domestic producers can be induced with an employment incentive by the government for generating direct employment in the chemical industry. This incentive can come in the form of partial sharing of the EPF amount paid by such manufacturing units.

The chemical industry has a wide variety of import substitution applications. For example, despite the supply side constraints, it is useful to import LDPE and HDPE granules (an output of petrochemical plants) and convert them into polythene films for packaging material. This form of import substitution will allow domestic value addition. Likewise, inorganic chemicals and gases can be produced as by-products for various industries like pulp and paper, petrochemicals, fertilizers, etc.

Recommendation-7: Compliance with International Quality Standards, GMP and Safety Norms for the Chemical Industry

The chemical industry is highly regulated internationally. The erstwhile American Society for Testing and Materials, currently known as ASTM international, is the sole agency to issue standards for the chemical industry. The industrial chemical standards are instrumental in the testing and evaluation of the physical and chemical properties of substances used or produced primarily in industrial applications. These chemicals, both organic and inorganic, are manufactured and employed for a variety of consumer goods including engine coolants, rubbers and plastics and petroleum. These industrial chemical standards allow chemical industrial plants, material processing companies, product manufacturers, and other producers and users of such chemicals in their proper fabrication and treatment processes to ensure quality in safe production and utilization.

In the absence of any mandatory or voluntary compliance of national standards for the domestic chemical industry, the manufacturing sector has yet to inculcate a robust culture of quality standards, adequate safety norms and good manufacturing practices. The U.S. experience of setting industry level standardization serves to integrate company standards and unify them in the interest of the industry as a whole. Industry level standards also serve as a basis for overall integration at the national level. When the manufacturing sector is at infancy level, it has the potential to adopt international standards on a voluntary basis. Even though the chemical industry is poised to serve local demand, it should voluntarily comply with international standards. In this regard, the chemical industry association has a greater role to play in setting industry standards. The government may also incentivize voluntary compliance with international quality standards.

The government's role is more important in setting the safety norms for the chemical industry. The Bhopal gas tragedy is an example of poor regulatory norms for safety standards in the chemical industry. The government should adopt international norms of safety. It should also enact stringent regulation for adopting good manufacturing practices and compliance with international norms on safety. This is possible by way of levying heavy penalties and vicarious liability on defaulters.

Thus, voluntary compliance with international quality standards and the regulatory framework for the adoption of good manufacturing practices and stringent safety norms shall enable the local chemical manufacturing industry to explore export markets after attaining a critical mass. Besides, there are other benefits of standardization:

Manufacturers: (a) Rationalize the manufacturing process, (b) Eliminate or reduce wasteful material or labour, (c) Reduce inventories of both raw material and finished products and reduce the cost of manufacture.

Customers: (a) Assurance of the quality of goods purchased and services received, (b) Provide better value for money, and (c) Convenience of settling disputes, if any, with suppliers.

Traders & exporters: (a) Provide a workable basis for acceptance or rejection of goods or consequential disputes, (b) Minimize delays from inaccurate or incomplete specification of materials or products, (c) Provide starting points for research and development for further improvement of goods and services.

Recommendation-8: Review the Tariff Policy to Eliminate Any Inverted Tariff Structure in the Chemical Industry

1) Review the chemical industry's trade policy and tariff structures, especially at the 8-digit level for chemicals. The government needs to raise tariffs selectively on basic chemicals, agrochemicals and industrial chemicals to remove any price advantage enjoyed by imported chemicals. There are too many instances where the tariff structure is currently inverted, i.e. the tariff on finished products is lower than on the raw material. For instance, the tariff on LDPE and HDPE is higher or equal to the tariffs on polythene films used as packaging material.
2) It has been observed that porous borders allow large quantities of illegal imports. The Ministry of Commerce should ensure proper border control measures to check the inflow of illegal imports. Weak border control measures not only distort the domestic market, but also hurt the national budget through the evasion of duties.

3) As a pilot project, the government should wave custom duties on inputs, machines and other equipment imported inside the chemical cluster. This will foster the development of local manufacturing capabilities into mature and competitive production facilities.

4) Import substitution will spur innovation and quality consciousness in the chemical industry.

CHAPTER V

RECOMMENDATION FOR THE FEDERAL DEMOCRATIC REPUBLIC OF ETHIOPIA'S CHEMICAL TECHNOLOGY ROADMAP

1. Background of Chemical National Technology Roadmap (NTRM)
2. Introduction
3. Overall Review and Recommendations
4. Review and Recommendation of NTRM Deployment of Strategic Produts
5. Annex

1. Background of Chemical National Technology Roadmap (NTRM)

To realize Ethiopia's vision of becoming a lower middle-income country by 2025, the Government of Ethiopia has been actively promoting the transition of its nation from an agriculture-led economy into an industry-led economy.

For decades, Ethiopia has faced difficulties and has often been portrayed through images of famine and conflict. Ethiopia is now emerging from troubled times, and the latest International Monetary Fund (IMF) forecast states that Ethiopia is, in fact, the fastest-growing economy in sub-Saharan Africa in 2018. How was the government able to change the country around so drastically? The Government of Ethiopia is trying to transform the country from an agriculture-dominated economy to an industry-dominated one. From 2004 onwards, the Ethiopian economy has grown at 11 per cent annually. This growth has primarily been attributable to favourable agro-climate conditions, high coffee prices, inflows of aid, and a boom in construction. Not only does it not reflect an increase in competitiveness, but significant change in the economic structure has also not yet been prompted by this growth. The share of manufacturing in GDP has stagnated at 5 per cent for a long time.

The first Growth and Transformation Plan (GTP I, 2010/11~2014/15) entailed four objectives: (i) maintaining an average real GDP growth rate of at least 11 per cent per annum; (ii) expanding access and ensuring the quality of education and health services in the social sectors; (iii) creating a stable democratic and developed state; (iv) ensuring sustainability of growth by maintaining macroeconomic stability.

During this period, the share of agriculture, service and industry in GDP averaged 41.5 per cent, 45.6 per cent and 12.9 per cent, respectively, in 2009/2010, and 38.5 percent, 46.3 per cent and 15.1 per cent, respectively, by 2014/15. Within industry, the share of the manufacturing sector in total GDP remained below 5 per cent in 2014/15. The share of the construction industry in GDP increased from 4 per cent in 2009/10 to 8.5 per cent by 2014/15. This indicates that during 2010/11-2014/15, the construction industry has been the major driver of industry both in terms of growth and structural change.

In general, a structural transformation from the agriculture sector to the service sector has been observed. During the Plan's period, priority was given to the manufacturing sector. However, the manufacturing sector fell short of the GTP I target both in terms of growth performance and structural change. The share of the manufacturing sector's value added in GDP remained low compared to the average for sub Saharan African (SSA) countries (see Table 26).

There has been a significant degree of economic development in Ethiopia; however, the development of industry, particularly the manufacturing sector, did not meet the expectations. Accordingly, the key strategy of GTP II became the promotion of the development of the manufacturing sector, while also maintaining the successful policies that brought about the country's economic development.

Table 26 Composition of Ethiopia's GDP (% value added)

	1999	2000	2014
GDP	USD 12.6 billion	USD 8.2 billion	USD 54.8 billion
Agriculture	52.4 %	47.8 %	42.3 %
Industry	4.9 %	6.2 %	11.3 %
Manufacturing	4.9 %	6.0 %	4.2 %
Service	38.2 %	40.0 %	42.3 %

Source: World Bank, 2015

After the success of GTPI, GTPII followed. The major objective of GTP II was (like that of GTPI) to serve as a milestone towards realizing the national vision of becoming a low middle-income country by 2025.

To this end, GTP II set out the following specific objectives:

1) Achieving a real average annual GDP growth rate of 11 per cent.
2) Developing the domestic engineering and fabrication capacity and improve productivity, quality and competitiveness of the productive sectors (agriculture and manufacturing industries) to speed up structural transformation;

Based on the major objectives and following pillar strategies, the main strategies of the manufacturing sector were:

- Improving productivity
- Improving quality and competitiveness of products
- Building labour-intensive light industry
- Expanding metal and engineering and chemical and pharmaceutical industries
- Substituting strategic imported items with locally produced goods.

Consequently, the following strategic industries were established to develop the country's industry: textile and garment industry, leather and leather products industry, sugar and sugar-related industries, cement industry, metal and engineering industry, chemical industry, pharmaceutical industry and agro-processing industry.

Among these strategic industries, the chemical industry has been found to play an important role in supplying input materials to other industries. Focusing on the selection and promotion of strategic chemicals and chemical products is considered a priority in order to develop the chemical industry. Therefore, a roadmap was developed, the reviews and recommendations of which are included here.

2. Introduction

2.1 Chemicals as a milestone of the manufacturing sector

Chemistry has contributed significantly to the advancement of human civilization and our daily life. Chemical technologies transfer natural resources to functional chemicals which are key materials for many other industries. The chemical industry produces 70,000 different types of products that are used by individuals as well as other industries. It is of strategic importance to the sustainable development of national economies and plays a vital role in the economic development of any country.

The chemical industry can be classified into basic chemicals, intermediates, specialty chemicals and consumer chemicals. There is no theoretical classification of all these chemicals, so the above classification was also used in Table 27. Industries that use chemical inputs are also presented in Table 27, exemplifying the case of the U.S.' chemical industry. Table 27 shows that many industries are connected to the chemical industry, and its importance for the national economic development cannot be denied.

Table 27 Chemical industry and related industries

Category		
Specialty chemicals Consumer chemicals	**Intra-industry chemistry sales - US$ 409.2 bil*** **Sales to consuming sector - US$ 391.3 bil***	
	Rubber & plastics ($75,6)	Transportation equipment ($13.5)
(Intermediates)	Health care ($68.6)	Fabricated metals ($11.5)
	Other manufacturing ($31.6)	Electrical equipment ($ 9.5)
	Agriculture ($29.6)	Construction ($ 9.0)
	Paper & printing ($26.5)	Oil & gas ($ 7.6)
	Textile & apparel ($23.1)	Machinery ($ 5.1)
	Computer & electronic ($22.2)	Other industry ($42.7)
	Food & beverages ($15.2)	
Basic chemicals	**Inorganic chemicals** Chlor-alkali, sulfuric acid, hydrochloric acid etc.	**Petrochemicals** PE, PP, PVC, PS, PU, PET, BTX, Other organic chemicals

*Total market of U.S. chemical industry: US$ 800.5 billion

Source: ACC analysis based on data from the Bureau of the Census, and the IMPLAN model, and modified reviewer

Historically developed countries like Germany, the UK and the U.S. started from basic chemicals to consumer chemicals, but latecomers like the Republic of Korea and Taiwan ROC started from consumer chemicals to basic chemicals. Usually, developing countries do not have enough money to invest in basic chemical factories and do not have a sufficient local market for basic chemicals.
The chemical industry's development strategy for developing countries is crucial for the national economy.

Recently, over 80 per cent of the chemical industry has been concentrated on producing polymers and plastics. These chemicals are not only used in packaging, but also in numerous other product, like wiring, furniture, clothing, home decoration, prosthesis and electronics. PVC piping, water tanks and huge storage containers are made of plastics. Because of their convenience, easy operation and the relative price of plastics, their applications are expanding rapidly.

2.2 General Information on Ethiopia

Ethiopia, the second most populous country in Africa, is a one-party state with a planned economy. Ethiopia grew at a rate of between 8 per cent and 11 per cent annually over the last 10 years – one of the fastest growing states among the 188 IMF member countries. This growth was driven by government investment in infrastructure, as well as sustained progress in the agriculture and service sectors.

Over 70 per cent of Ethiopia's population is still employed in the agriculture sector, but the service sector has surpassed agriculture as the principal source of GDP. Despite progress towards eliminating extreme poverty, Ethiopia remains one of the poorest countries in the world due both to rapid population growth and a low starting base.

While coffee remains the largest foreign exchange earner, Ethiopia is diversifying its exports and commodities such as gold, sesame, vegetables, livestock and horticulture products, which are becoming increasingly important for its economy.
Manufacturing represented less than 8 per cent of total exports in 2016, but manufacturing exports should increase in future years due to a growing international presence. Ethiopia has attracted roughly USD 8.5 billion in foreign direct investment, mostly from China, Turkey, India and the EU. Investments have focused primarily on infrastructure, construction, agriculture, agricultural processing, textiles, leather and leather products. In the fall of 2015, the government published the current 2016-20 five-year plan, known as GTP II, which emphasizes the development of manufacturing. To support industrialization, Ethiopia plans to increase its installed power generation capacity by 8,320 MW, up from a capacity of 2,000 MW. The government devalued the birr by 15 per cent to increase exports and alleviate a chronic foreign currency shortage in the country.

Table 28 General information on Ethiopia

	2015 (est)	2016 (est)	2017 (est)
Population	96,633,000	99,467,000	105,350,000
GDP purchasing power parity	US$ 167.2 billion	US$ 180.5 billion	US$ 195.8 billion
GDP real growth	10.4%	8%	8.5%
GDP per capita	US$ 1,900	US$ 2,000	US$ 2,100
GDP composition	Agriculture 41.4%	Agriculture 4%	Agriculture 35.8%
	Industry 15.6%	Industry 1%	Industry 22.3%
	Service 43.0%	Service 4%	Service 42.0%
Industrial production growth rate	8.5%	9.0%	10.5%
Major industries	Food processing, beverages, textiles, leather, garments, chemicals, meats processing, cement		
Exports	US$ 3.76 billion	US$ 2.81 billion	US$ 3.08 billion
Exports commodities (value, 2017)	Coffee (27%), oil seeds (17%), vegetables (17%), gold (13%), flowers (7%), live animals (7%), raw leather products (3%), meat products (3%)		
Imports	US$ 10.69 billion	US$ 16.03 billion	US$ 16.76 billion
Imports commodities (value, 2017)	Machinery/aircraft (14%), metals/metal products (14%), electrical materials (13%), petroleum products (12%), motor vehicles (10%), chemicals/fertilizers (4%)		

Source: CIA Factbook, 2018r

Ethiopia's goal is to transform the country into an industrialized economy and increase the per capita income of its citizens to middle-income levels by 2025. To achieve this goal, the government must address the obstacles and challenges to achieve a flourishing manufacturing sector that would expand benefits to more Ethiopians. The NTRM examines the challenges for building a strong chemical industry, which supports a diversified manufacturing sector by supplying raw materials to increase competitiveness of manufacturing products.

2.3 Chemical Industry of Ethiopia

The chemical industry in Ethiopia is still in its infancy and needs to be developed to support the country's rapidly growing economy. Many chemical inputs and chemical products are still imported with a huge sum of foreign currency from abroad for national manufacturing processes and direct consumption.

The Ministry of Industry (MoI) aims to develop the chemical industry with agro-processing, textile, leather and metal. MoI has assigned state ministers to promote the development of the chemical industry (Table 29).

Table 29 Organizational Structure of MoI

The Ministry of Industry	Textile & Leather Sector State Minister
	Metal & Chemical Sector State Minister
	Agro Processing Sector State Minister

The country's demand for chemical products is primarily met through imports. There is an increasing amount of chemicals and chemical products that is being imported every year for which a considerably high amount of foreign exchange is being spent. Basic chemicals represented the largest share of imports, followed by pharmaceuticals (Table 30). Those two industries accounted for the major share of imports, namely 80 per cent of the top-5 importing industries. Chemical consumption will increase considerably as Ethiopia's economy is rapidly growing. Import substitution of basic chemicals and pharmaceuticals should be the top priority in the development of Ethiopia's chemical industry.
Chemical imports of Ethiopia in line with other countries: The share of Ethiopia's chemical

Table 30 Major imported chemicals and chemical products (2005~2011)

No	Types of chemicals imported	Average CIF value in million USD	Average percentage growth
1	Basic chemicals	337.5	20%
2	Pharmaceuticals	203	22%
3	Other chemical products	66	14%
4	Soap, surface active agents	48	15%
5	Tanning and dyeing extracts	23	15%
Total		675	-

imports compared to the world, Africa and COMESA is presented in Table 31. The table reveals that the global import of chemicals and chemical products increased during the period 2004-2011, with an average rate of 10.64 per cent to reach USD 1.65 trillion. During the same period, imports of chemicals and chemical products in Africa rose at an average rate of 16.68 per cent to reach USD 42.51 billion, while imports by COMESA and Ethiopia grew at an average rate of 25.91 per cent and 15.74 per cent, respectively, to reach USD 12.84 billion and USD 0.83 billion, respectively. Compared with the global share of chemicals and chemical products imports, Ethiopia's share of 0.05 per cent is negligible. If the import of chemical and chemical products to Ethiopia continues with the same average rate of 15.74 per cent until 2025, the country will spend USD 3.33 billion and USD 6.99 billion on imported Chemicals and chemical products by 2020 and 2025, respectively. It is therefore important to promote import substitution of these products in Ethiopia's chemical industry. Moreover, the Common Market for Eastern and Southern Africa (COMESA) represents a large market for chemical and chemical products exports. The average import value of COMESA member states during 2004-2011 was USD 7.73 billion, a Figure which is expected to grow at an average growth rate of 25.91 per cent. In other words, the development of Ethiopia's chemical industry comes at the right time as it is presented with a great opportunity for economic growth.

Table 31 Import value of chemicals and chemical products (USD million)

	2004	2005	2006	2007	2008	2009	2010	2011	Aver.	% growth	% share Ethiopia
World	838	940	1044	1232	1429	1243	1432	1649	1226	10.64	0.05%
Africa	15.11	16.85	20.97	25.18	35.06	32.44	37.32	42.51	28.18	16.68	2.3%
COMESA	3.54	3.85	4.41	4.49	10.61	10.60	11.62	12.84	7.73	25.91	8.4%
Ethiopia	0.32	0.40	0.48	0.57	0.80	0.97	0.83	0.83	0.83	15.74	

3. Overall Review and Recommendations

Ethiopia's chemical industry looks very promising. Even though the development of the chemical industry in Ethiopia is in its infancy as industrialization does not yet account for a sizeable share of GDP, the country's large population of about 100 million and its rapid economic growth over the last 10 years will be driving forces in the development of Ethiopia's chemical industry. However, compared to the agriculture and service sector, the development of the chemical industry is very sluggish. The question is why is the development of the chemical industry so slow?

The reason for this is that: 1) the current Ethiopian chemical market is small, 2) the amount of basic chemicals being manufactured in the country does not suffice to supply other industries, 3) outdated technologies are being used, 4) there is a lack of skilled manpower, and 5) the poor quality of raw materials being used for production. To overcome these challenges, government policy plans and their implementation are crucial.
After reviewing the NTRM, the followings recommendations are proposed:

Proposal 1: Full support for the development of small and medium-sized firms in the plastic industry

Develop products that improve the quality of life such as consumer products or housing furniture, and start with exports to Africa and gradually extend to global exportation. This will lead to an increase in exports, while local demand for chemicals and petrochemicals will also increase. With the establishment of petrochemical factories of an economically competitive size, the chemical industry could play a considerable part in achieving Ethiopia's vision of becoming a lower middle-income country by 2025.

▶ Case 1: The Experience of the Republic of Korea's Chemical Industry; Developing downstream industry as an initial strategy

The Republic of Korea's petrochemical industry started as a latecomer, and experienced strong government-led growth and privatization, and is now ranked among the world's best.
Privatization policy: in the early stages of industrialization of the Republic of Korea (1960s and 1970s), only few private companies with the capacity to enter new businesses requiring large amounts of capital, technology and experienced experts existed. NCC (Naphtha Cracking Center), which is a relatively sizeable facility with a large amount of financial investment, was managed by government-owned enterprises, such as the Korea National Petroleum Corporation (KOC) and Chungju Fertilizer. Government-owned enterprises in the new petrochemical industry rapidly expanded in size and capabilities alongside the economy's rapid growth. Once the capacity of private sector firms had sufficiently increased in the following decades, government-owned enterprises were eventually privatized.

In developing countries with weak domestic demand, it is recommended to first develop a downstream industry such as textiles and plastics, rather than build a naphtha cracking industry or ethane cracking industry first, which require a large amount of financing, but is quite risky for commercialization. One example of the development of the Republic of Korea's petrochemical industry is the process of developing the clothing industry → textile industry→ petrochemical industry. The Republic of Korea first earned foreign currency by using cheap labour and exporting clothing, and later expanded local demand for petrochemicals. In a nutshell, after the expansion of clothing exportation, the localization of textiles was promoted. In the second stage, synthetic fibre factories were established to localize yarn, which is an intermediate material of the fabric. In the third stage, petrochemical plants that provide raw materials such as synthetic fibre, synthetic resins and synthetic rubber, which are used in almost all industries, were established.

The Republic of Korea has experienced 'backward industrialization' rather than 'forward in-

Table 32 Value chain of petrochemical and development strategy

Textile & Garment Industry	Korean Development Strategy	Timeline of Development
Petrochemicals: PET, TPA resins & chips	Basic Chemicals	4th
Synthetic Fibres	Intermediate chemicals	3rd
Fabrics	Intermediate products	2nd
Garment, Clothes	Final products & competitiveness to export	1st

dustrialization' as Table 32 indicates. This was inevitable because unlike most developed countries, industrialization in the Republic of Korea was not achieved gradually over a long period of time, but underwent compressed growth within a short period without sufficient capital and technology. This backward industrialization is a unique industrial model, and has not been replicated by any other developed country.

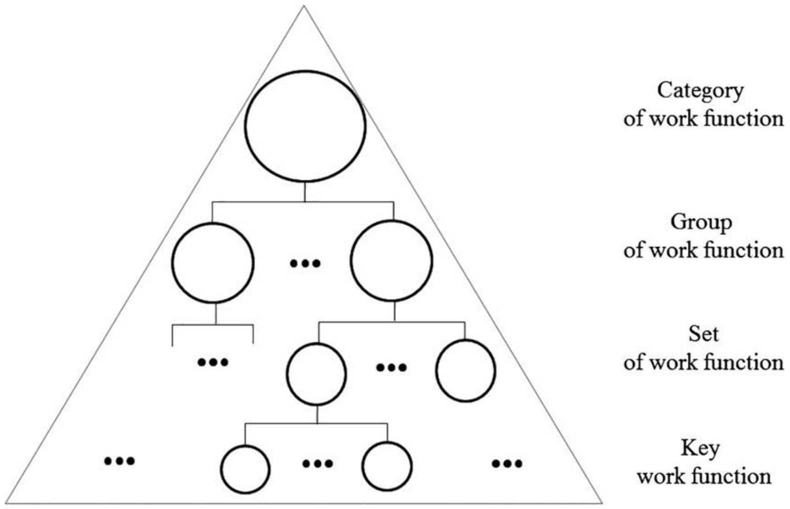
It is crucial to expand local demand. In such a narrow domestic market, business is risky because it is extremely difficult to secure demand. It is therefore necessary to first develop demand for chemicals and chemical products and to then expand domestic demand for products from the petrochemical industry, for example.

Proposal 2: Introduction of standardized technical, vocational education and training (TVET) in all parts of the chemical industry - vocational education with standard processes for operation, material handling and training programmes (referred to as NCS in the Republic of Korea). One of the key issues of Ethiopia's chemical industry is the quality of local chemical products. The quality of chemical products and the consistency of that quality are crucial for the market and for sales. To ensure the quality of products, it is recommended for the government to adopt NCS (national competency standards) and standardized education.

▶ Case 1: Introduction of the Republic of Korea's NCS Programme as a Reference

The Human Resources Development Service of Korea (HRD Korea) was responsible for the establishment of the Republic of Korea's NCS programme. The NCS curricula were partly developed by various NCS committee members who represent individual work areas. Committee members are selected from three categories: highly experienced industry workers, HRD Korea officers, and vocational college or university faculty. Industry representatives were included in the NCS programme to develop the curricula to reflect industry's training needs (Alsheri et al., 2016; Burke, 1989). The structure of the Republic of Korea's NCS system is illustrated in Figure 24.
Four hierarchical classifications are used in the NCS system: category, group, set and key work

Figure 24 Hierarchical diagram of work functions of the NCS programme



functions as illustrated in Figure 8. The top classification represents 24 work categories in the NCS system of the Republic of Korea. There are two categories in the chemical industry: chemistry (17) and environment and energy (23). Each category has several groups of work functions. Sub-units of groups are sets of work functions. Finally, each set has several key work functions.

The hierarchical configuration of the chemistry work category can be found in the Annex. The category chemistry consists of four different groups of work functions: chemicals and chemical process management (1701), petroleum, commodity chemicals production (1702), fine chemical production (1703), and plastic production (1704). Each group is composed of several sets. Finally, each set consists of several key work functions. Each key work function is defined for each competency of the core workforce. Over 890 key work functions (or competencies) out of 24 work categories are generated by HRD Korea. The category chemical industry is extended and updated in accordance with industrial requirements.
One of the benefits of the NCS programme is that trainees can acquire standard skills and the contents of the work.

Proposal 3: Plan for Foreign Expert Resource Pool

Increasing productivity and capacity utilization in the chemical industry is one of the urgent issues that needs to be addressed in Ethiopia. This is possible to some extent without new investments in productive capacity, but requires an improvement in labour skills and management know-how.
There are only few skilled and experienced experts in Ethiopia's chemical industry, and working with foreign experts and technicians in the initial phases of the development of the chemical industry is therefore highly recommended.

▶ **Case 1: China - Initial development strategy of China's pulp industry**

Chinese human resource supporting strategy: at the beginning of China's industrial development, there were not enough skilled and experienced experts in the paper industry. Chinese workers were hired for simple tasks (manual labour) and technicians from the Republic of Korea and Taiwan ROC were hired for management and quality maintenance, resulting in the rapid development of the paper industry in China.

▶ Case 2: Proposal for Ethiopia's Cosmetic Industry Development

By hiring foreign experts who possess in-depth knowledge and practical experience in the latest soap manufacturing technology, the government can thereby provide comprehensive training to all local soap manufacturing companies and provide customized technology advice or guidance for individual companies at their production facilities. The high quality soap produced by domestic soap companies can replace the imported soap products. Soap products can be exported to neighbouring countries, leading to the profitable and sustainable growth of the domestic soap production industry

▶ Case 3: Introduction of Ulsan NCN

To resolve the problem of field technology development and operation, it is essential to have a workforce with field experience. Ulsan was the first location in the Republic of Korea's history at which a petrochemical complex was built, and many types of chemical industries have developed around that region. Many field engineers from this region have recently retired, and Ulsan TP (Techno-Park) has organized a NCN (New Challenge Network) to encourage these engineers to advise SMEs in the Ulsan region and educate students with support from Ulsan City. In cooperation with the Republic of Korea's Ministry of Industry and Ulsan City, it is recommended to identify the pressing technological development problems Ethiopia needs to address and to promote technological development centred on field work.

Proposal 4: Industry R&D and Education R&D should run separately in the field and urgent industrial target-oriented problems related to the R&D system need to be addressed.

National science and technology policy plays a very important role in the initial stages of industrial development. In addition, productivity improvements and the expansion of factory capacity are crucial to resolving any problems related to the field. These issues might not necessarily be major science and technology targets, but a number of technologies and experts will be necessary to resolve the lack of skilled labour in Ethiopia quickly. It is recommended to separate on-site R&D from basic S&T issues. The basic S&T programme needs to be supported by different government organizations, including MoI.

In the case of the Republic of Korea's R&D in industry, research institutions, schools and corporations were formed to resolve the urgent problems of enterprises. Numerous firms are cooperating today to pursue a rapid spread of technology in the private sector.

4. Review and Recommendation of NTRM Deployment of Strategic Produts

Chemical products were evaluated based on the following impact criteria; economic impact, strategic importance, potential for success, availability of raw materials, involvement of high-skilled labour force, as input for a large number of industries and market opportunities/demand. Seven chemical strategic products were selected, with chlor-alkali determined as being the top priority strategic product based on the aforementioned selection criteria.

Seven strategic chemicals and chemical products were reviewed in three separate groups; 4.1 alkali chemicals, 4.2 chemical products, and 4.3 petrochemicals.

Table 33 Grouping of strategic chemicals and chemical products

	Groups for discussion	Chemical products
Strategic Chemical & Chemical Product	Alkali chemicals	Chlor-alkali
		Soda ash
	Chemical products	Soap and detergents
		Pulp and paper
	Petrochemicals	Polyethylene (PE)
		Polypropylene (PP)
		Polyvinyl chloride (PVC)

The key reasons for selecting these strategic chemicals and chemical products have already been discussed in detail. NTRM is a phased action plan that addresses the acquisition, application and dissemination of core technologies. As such, the results of the measures presented and their impact on related infrastructure and industries need to be analysed and quantified. It is furthermore necessary to explore how the phased growth of domestic industries can be achieved in connection with the supply value chain.

As the key technologies for the strategic chemicals and chemical products have already been described, other factors for NTRM development, a gap analysis, R&D strategy, key infrastructure, etc., will be reviewed for the seven strategic chemicals and chemical products.

4.1 Review of Alkali Chemicals Group

Chlor-alkali and soda ash were grouped together under the heading alkali chemicals. In the draft of the roadmap, the process technologies of chlor-alkali were discussed in detail in Section 2.4.2 Process Technology of Chlor-alkali & PVC", including the lime soda process, which is currently being used in Ethiopia in addition to other electrolysis methods. The core technologies of chlor-alkali & PVC were also discussed in detail, and a priority technology selection was carried out, which was further developed for the next stage of the roadmap, MACRO TRMS for STRATEGIC PRODUCTS.

4.1.1 Chlor-alkali Industry

4.1.1.1 Global trends of the chlor-alkali industry

The chlor-alkali industry produces chlorine (Cl_2) and alkali, sodium hydroxide (NaOH). Currently, 95 per cent of world chlorine production is obtained through the chlor-alkali process.

The geographic distribution of chlor-alkali processes worldwide differs considerably (production capacity of chlorine):
- Western Europe, predominance of mercury cell process (June 2000): 55 per cent
- United States, predominance of diaphragm cell process: 75 per cent
- Japan, predominance of membrane cell process: >90 per cent.

The global production capacity of chlorine in 1995 was about 44 million tonnes, the EU accounting for around 24 per cent of that capacity. In June 2000, the chlorine production capacity in western Europe was 11.3 million tonnes. Of world chlor-alkali capacity, 65 per cent is concentrated in three regions: North America, western Europe and Japan. After a decline at the beginning of the 1990s, production in western Europe now seems to have stabilized at around 9 million tonnes per year.

EDC/PVC accounted for over one-third of global chlorine demand. Demand is rapidly growing in the emerging economies of the Middle East, Africa and Asia-Pacific. With the market for packaged and processed foods increasing, demand for soda ash in the food processing industry is also growing at a rapid rate.

The Middle East and Africa have already witnessed heavy investments in downstream chemicals. The low costs of production and the abundant labour make the region a favourable location for the establishment of production facilities. The region is also strategically positioned to export to neighbouring regions.

The inevitable co-production of chlorine and sodium hydroxide in almost equal amounts has always been a problem for the chlor-alkali industry. Both products are used for very different end uses, with differing market dynamics, and only rarely does demand for the two coincide.

4.1.1.2 European Application of the Chlor-alkali industry

Table 34 Europe Chlorine Application

European Chlorine Application		kilotonnes	Share
Polymer	PVC	2,965	32.5 %
	Isocyanates & oxygenates	2,901	31.8 %
	Subtotal	**5,866**	**64.3 %**
Organics	Solvent & ECH	788	8.6 %
	Chloromethane	414	4.5 %
	Other organics	933	10.2 %
	Subtotal	**2,135**	**23.3 %**
Inorganics		**1,134**	**12.4 %**
Total		**9,135**	**100 %**
Production ratio: 1,000 kg chlorine, 1,100 kg Caustic soda, 28 kg hydrogen			

Source: www.eurochlo.org (Euro Chlor)

Chlorine is largely used in the synthesis of chlorinated organic compounds. VCM, which is used for the synthesis of PVC, remains the driver of chlor-alkali production in most European countries. Chlorine is difficult to store and transport economically and it is therefore generally produced close to consumers. Over 85 per cent of the chlorine produced in the EU is used on the same or adjacent sites for other chemical processes.

Table 35 Europe Caustic Soda Application

European Caustic Soda Application	kilotonnes	Share
Organics	3,011	32.1 %
Miscellaneous	1,567	16.7 %
Pulp & Paper Cellulose	1,242	13.2 %
Other Inorganics	1,132	12.1 %
Food Industry	513	5.5 %
Aluminium & Other Metals	408	4.3 %
Water treatment	445	4.7 %
Bleach	356	3.8 %
Soap and detergent	329	3.5 %
Mineral oils	167	1.8 %
Rayon	125	1.3 %
Phosphate	90	1.0 %
Total	**9,385**	**100 %**

Source: www.eurochlo.org (Euro Chlor)

Sodium hydroxide is usually supplied as a 50 per cent aqueous solution and can be stored for long periods and readily transported (rail, road and ship). The main areas of application of sodium hydroxide today vary (see Table 35).

4.1.1.3 Caustic soda industries in Ethiopia

There is only one company in Ethiopia, Caustic Soda Shae Company, which produces caustic soda. It was established by the government in 1987, and uses the chemical process based on soda ash and limestone/lime. The major product is liquid caustic soda (45.5 per cent concentration).
The caustic soda factory in Ziway produces 22,000 tonnes of caustic soda per year (45.5 per cent concentration).
The main raw materials for caustic soda are soda ash and lime. Soda ash is supplied by Abijata Soda Ash S.C. and lime is provided by cement industries such as Dire Dawa, Derba and Muger quarre.

Table 36 Supply Demand Chain of Caustic Soda in Ethiopia

<table>
<tr><th>Strategic Chemical</th><th>Raw Material Supply</th><th>End Product Demand</th></tr>
<tr><td rowspan="5">Caustic Soda</td><td rowspan="3">Lime from cement industries such as Dire Dawa, Derba, Muger quarre</td><td>Awasa Textile</td></tr>
<tr><td>Guele Soap</td></tr>
<tr><td>East Africa Soap</td></tr>
<tr><td rowspan="2">Abijata Soda Ash S.C.</td><td>Moha Soft Drinks</td></tr>
<tr><td>Ambo Mineral Water</td></tr>
</table>

Source: Roadmap

The industry is currently not meeting market demand. For example, 703,525 tonnes of sodium hydroxide (caustic soda) were imported for a total CIF value of ETB 195.1 billion in 2013. This has been the most widely imported inorganic chemical in the last few years.
The quality of Ethiopia's caustic soda is low; its purity level is 48 per cent, well below the standard purity level of 98 per cent. Hence, the new factories should be designed to process caustic soda with the required purity level.

4.1.1.4 Issues of the Caustic Soda Industry: Global Issues of Chlor-alkali

Euro chlor-alkali industry-wide strategy
Key sustainability concerns:
- Include environmental, social and economic factors in all strategic business decisions;
- Optimize energy efficiency in chlorine production;
- Reduce water usage through recycling;
- Continuously reduce polluting emissions to water, air and land;

- Use more hydrogen generated by the industry as a raw material or fuel;
- Give high priority to safe transportation of chlorine.

4.1.1.5 Issues of Chlor-alkali in Ethiopia

Capacity Issue: The local industry does not meet the demand for caustic soda in Ethiopia. The current capacity of caustic soda is 10,000 tonnes per year (Ziway Caustic Soda Share Co.). This capacity is far below the current demand of the local market; therefore, the Ministry of Industry aims to establish a factory that can produce 50,000 tonnes of caustic soda. The capacity expansion was not accomplished under GTP I (2015), and imports of caustic soda are increasing. For example, 703,525 tonnes of caustic soda were imported for a total value of ETB 195.1 billion in 2013, making caustic soda the most widely imported inorganic chemical in the last few years.

Raw Material Issue: One key raw material for producing caustic soda is soda ash, which is in short supply. The Caustic Soda Share Company uses a chemical process to produce caustic soda, using limestone/lime and soda ash. Limestone/lime is supplied by the cement industry, and the available resources and level of production suffice to produce caustic soda. Another raw material required for caustic soda production is soda ash, which is supplied by Abijata-Shalla Soda Ash Share Co. The capacity of soda ash is about 20,000 tonnes per year and for which demand is low.

Quality Issue: The quality of the local caustic soda is not high enough for the requirements of local demand.
Despite the local production of caustic soda, the high demand is met by imports. The low quality of sodium ash, poor facilities and process technology are the main problems that need to be addressed.
The electrolysis process to produce caustic soda and chlorine gas in Ethiopia is not viable, mainly due to the high initial investment and production costs as well as very low local demand for chlorine gas in Ethiopia. The balance of caustic soda and chlorine gas demand in Ethiopia has been difficult to deal with so far.

4.1.2 Soda Ash Industry

Soda ash is the commercial name of sodium carbonate, which is known to occur naturally as carbonate of sodium trona ($Na_2CO_3.NaHCO_3.2H_2O$) and natron ($Na_2CO_3.10H_2O$).
Sodium carbonate is marketed as soda ash or anhydrous soda, (Na_2CO_3) as well as crystal soda or washing soda ($Na_2CO_3.10H_2O$).

4.1.2.1 Global Trends of Soda Ash

The global consumption of soda ash is projected to grow from 56,787 kt in 2014 to 67,120 kt (about USD 22 billion) by 2019, at a CAGR of 3.4 per cent.

The number of producers in the global soda ash industry has declined following the closure of many synthetic soda ash plants in Europe, South America, and Asia, including the Republic of Korea, from the 1990s onwards. Three dominant enterprises have survived to become the world leaders in soda ash – Solvay S.A. of Belgium, ANSAC of the United States, and China's soda ash industry. These three soda ash suppliers produce and export soda ash to many customers around the world. Because the glass container industry is the largest soda ash processing industry, demand for soda ash for glass container production may decline as food and beverages are gradually being packaged in newer PET containers. However, the outlook for soda ash over the next five years is favourable. Asia and South America remain the likeliest areas for increased soda ash consumption in the near future.

ANSAC (American Natural Soda Ash Corporation, www.ansac.com), Green River Basin, Wyoming
The Green River Basin is currently estimated to contain 134 billion tonnes of mineable trona ore, which is exceptionally pure. This is enough to supply the global demand for soda ash for the next several hundred years. ANSAC exports about 4 million tonnes of soda ash, and the enterprise is growing fast due to its profits in mining.

Table 37 Global Application of Soda Ash

Application Industry	Share %
Glass Industry	50 %
Chemical Industry	26 %
Soap & Detergent	10 %
Pulp & Paper	2 %
Water Treatment	1 %
Others	11 %

Source: European alkali association (www,eurochlo.org)

4.1.2.2 Current Status of Ethiopia's Soda Ash Industry (Raw Materials, Soda Ash Production, Demand)

Abijata-Shalla Soda Ash Share Co. (National Mining Corp. (NMiC)) (62 per cent), and the government (38 per cent) produces and distributes approximately 20,000 tonnes of soda ash annually, which is used in the manufacturing of detergents, bottles and glass.
In Ethiopia, soda ash ($Na2CO3$) is found in the sodic lake brine of Lake Abiyata and Lake Shala in the central Ethiopian Rift (Oromia region). Currently, a pilot plant is mining 20,000 tonnes/year of soda ash from Lake Abiyata, which is used as a raw material to manufacture caustic soda in Ziway.

Soda ash has several important uses, chiefly in chemicals, glass, soap and other detergent industries. The processing of soda ash in Ethiopia may differ slightly from its uses at the global level (in terms of share). The majority of soda ash is supplied to the glass industry. There are two glass factories in Ethiopia, Ethiopia Hansom International Glass plc and Addis Ababa Bottle and Glass Share Co (Table 38).

Table 38 Glass Factories in Ethiopia

Industry	Enterprise	Location	Capacity*
Glass	Ethiopia Hansom International Glass plc (CGCOC and China-Africa Development Fund)	Addis Ababa	42,000 tonnes
Glass	Addis Ababa Bottle and Glass Share Co.	Addis Ababa	8,000 tonnes

*Capacity/year

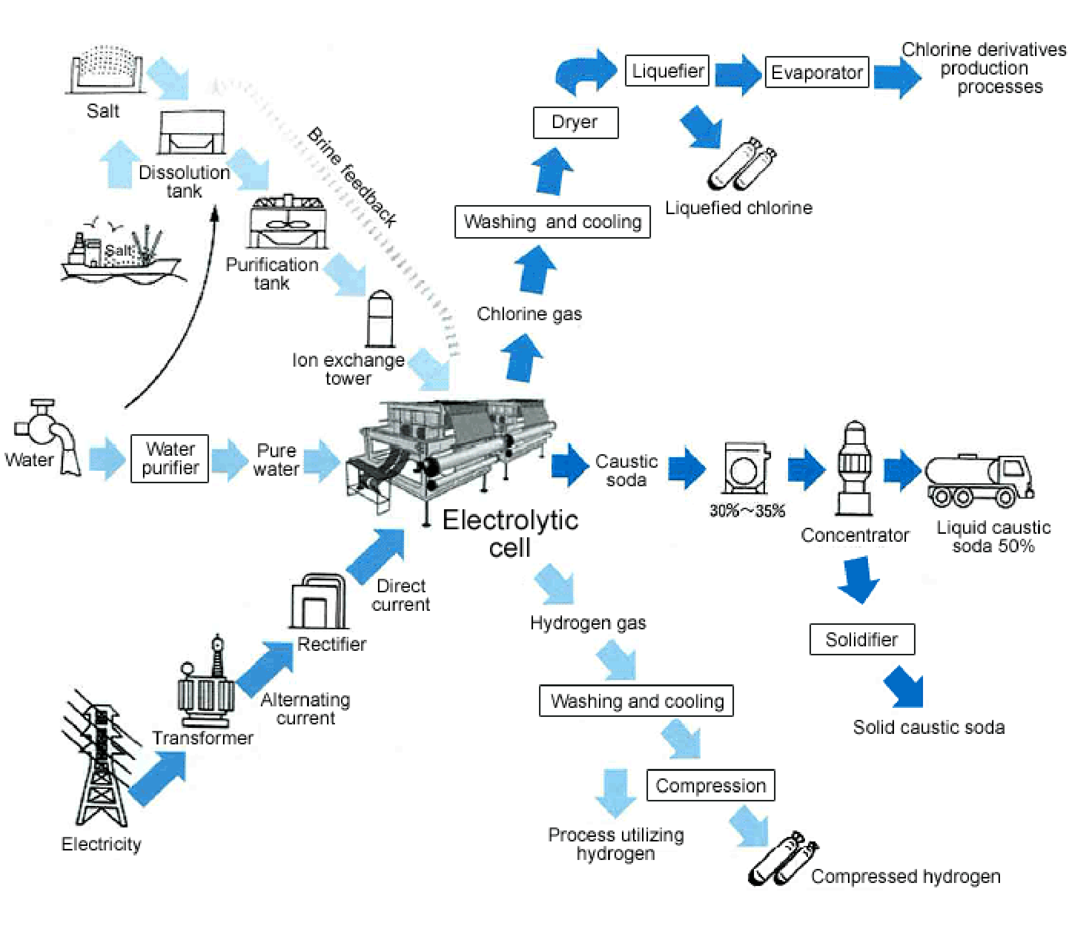
Ethiopia Hansom International Glass was established in 2007, the only manufacturer of glass in East Africa at the time. It produces clear sheet glass products to meet domestic demand, but also exports glass to other neighbouring countries.
The enterprise's annual production capacity is 42,000 tonnes, triple the demand of the domestic market in Ethiopia. The firm exports some of its products to Sudan, Djibouti and Yemen, and there are other potential export markets like Kenya.
Supply and marketing chain: The material requirements are met locally. The main raw materials are silicon sand, limestone, feldspar and dolomite, which are all produced locally. The available soda ash in Ethiopia does not meet the firm's demand and it therefore imports soda ash from China, leaving it with a cost disadvantage.
The case of Ethiopia Hansom International Glass proves that soda ash is important to the competitiveness of the Ethiopia's glass industry. The quality of Ethiopia's soda ash needs to be improved in collaboration with glass producers and soda ash suppliers.

4.1.2.3 Review & GAP analysis

Chlor-alkali products are basic chemicals. Demand for chlor-alkali will increase rapidly as Ethiopia's economy grows. This basic chemical can be locally produced in bulk and at a relatively low price. When such a basic chemical is imported, the transportation costs increase the overall costs of chlor-alkali, which affects the competitiveness of not only the chlor-alkali industry, but also those industries that process it, such as the glass and soap industries.
Import substitution for chlor-alkali is a very urgent issue, because it involves Ethiopia's main manufacturing industry, including soap, paper, leather and textiles.

Key Infrastructure of the Chlori-alkali Industry: The key infrastructure for the chlor-alkali industry are electric power supply, water system, competitive raw material availability, distribution channel of chlorine gas and hydrogen gas (Figure 25).

Figure 25 Production Process of Caustic Soda and Chlorine by Electrolysis



Source: Japan Alkali Association)

4.1.3 Recommendation for Alkali Chemicals

(1) The problems the alkali industry in Ethiopia faces are that the country's factory scale is insufficient and the quality of products and raw materials do not meet local requirements. The factory scale issue can be resolved by adjusting the quality and price to meet local requirements, considering that demand will increase rapidly with economic growth. Two recommendations are proposed to improve the quality of alkali products and the raw materials used.

(i) Application of R&D strategy based on user test
Quality as such is not a straightforward issue. Different types of problems may be associated with the quality of a product and the necessary quality of an input may differ by industry and purpose. In other words, an impurity may be extremely problematic for the glass industry but may not pose a problem for the water treatment industry. Therefore, a user test-involving the supplier and the user needs to be developed by a public institute or university to better understand the areas of application of local alkali products.

(ii) Develop a market sharing strategy with neighbouring countries for caustic soda and chlorine gas.
With the economic development of Ethiopia and social progress such as improvements in the quality of life, introducing an electrolysis processing industry will become necessary. As mentioned above, demand for products from the electrolysis processing industry, such as caustic soda and chlorine gas, are not met. Chlorine gas is a hazardous material that is difficult to store, so it is processed for nearby use. If local demand cannot be met, developing market sharing with neighbouring countries is recommended.

(iii) Ethiopia's construction industry is growing fast. In 2014, the construction industry accounted for 9.4 per cent of nominal GDP (manufacturing share 4.2 per cent). The construction industry grew by 36.5 per cent in 2014, a trend that will continue for some time to come. Due to the rapid growth of the construction industry, local demand for PVC will increase fast. PVC is the driver of the chlorine market.

(2) Polyethylene, chlorine, PVC, caustic soda, etc. are highly interconnected. Polyethylene and chlorine are used to produce PVC, and chlorine and caustic soda are simultaneously produced through electrolysis in nearly similar amounts. Table 39 indicates that a large gap exists between chlorine and PVC availability. The future production of polyethylene, chlorine, caustic soda and PVC should be planned jointly. Local demand should be projected based on Table 39, taking the reasons and interconnections between the chemicals into consideration.

Table 39 Increase in Demand for Alkali Chemicals and Related Chemicals

	2018	2025	GAP
Chlorine	0.45 kt	1.20 kt	0.75 kt
Hydrochloric acid	2.38 kt	6.33 kt	3.95 kt
PVC	24.78 kt	66.19 kt	41.41 kt
Polyethylene	43.65 kt	116 kt	72.35 kt
Soda ash	9.44 kt	25.98 kt	15.64 kt
Caustic soda	13.12 kt	34.86 kt	21.74 kt

Source: Roadmap 1.5.1 Demand/Supply Trend, Present Effective Local Demand, Projected Local Demand

Table 40 Summary of Review of Alkali	
Market	Applications, global trends, Ethiopia status (supply/demand) ∘ Local demand of chlorine needs to be estimated including future PVC demand
Major Player	Initially, development in the public sector, later transfer to private sector ∘ Public enterprises initially, then transfer to private enterprises
Technology	Licensing package and process development ∘ Licensor's package is required for chlor-alkali (electrolysis method) ∘ Local quality of alkali products should be developed to meet local requirements
R&D	Process and manufacturing development, purification technology R&D targets and strategy ∘ Application of R&D strategy based on user test ∘ Market study for chlorine gas in Ethiopia, including PVC
Human Resources	Engineers/technicians
Finance	Facility-oriented, economic scale
Connective Technology	∘ Application companies of chlorine and caustic soda should be balanced ∘ Chlorine-PVC(VCM)-ethylene are connected ∘ Pulp & paper, food processing, soap and detergents and water treatment are connected to all alkali industries

4.2 Chemical Products (Soap & Detergent Industry, Pulp and Paper Industry)

4.2.1 Soap and Detergent Industry

4.2.1.1 Global Trends of the Soap and Detergents Industry

The soap and detergent industry produces household detergents, industrial soaps and detergents, household soaps and other detergents. The size of the global soap and detergent market was estimated at USD 97.26 billion in 2016 and is expected to reach USD 207.56 billion by 2025, with a CAGR of 8.83 per cent for the period 2016-2025.
Rising disposable income, the development of the textile industry and rising penetration of washing machines in developing economies is expected to boost the industry's market growth in the forecast period. Increasing health awareness, coupled with the rise in disposable income, has resulted in soaps and detergents being deemed an essential consumable in the developed as well as in developing countries.

Soaps and detergents are crucial consumer goods and their use is widespread. Vendors are expanding their business by building manufacturing facilities in developing economies such as China and India, which have a high potential in terms of revenue. In addition, the rising penetration of washing machines in developing countries is projected to drive market growth further. The bulk of demand for washing machines is still concentrated in urban areas, however, demand is also rising in rural areas. Thus, the consumption of powder and liquid detergents will continue to grow.

Product innovation and the launching of new products is another major factor expected to drive market growth. Moreover, the steady penetration of powder detergents in both rural and urban areas of developing countries is expected to be the key catalyst for market growth.

The soap and detergents industry is becoming increasingly globalized, with a higher number of global vendors branching out into the market to increase their market share. With rising globalization, vendors will face new challenges in sustaining their growth and compliance with the laws and regulations issued by various government agencies. The potential opportunities opening in developing countries are expected to ensure ample demand for soaps and detergents in the future.

4.2.1.2 Key Market Drivers of the Soap & Detergents Industry

Since soaps and detergents are generally not considered high-technology products, enterprises are always searching for a breakthrough product to increase sales, as new and high value products represent the path to improving profitability. Since most of the largest soap manufacturers in the world have divested much of their chemicals, strengths and capabilities, they are turning to suppliers of raw materials to provide chemical expertise.

Beyond simply searching for efficient suppliers, soap manufacturers and their raw material suppliers are expected to establish closer technology alliances over the next few years. This requires soap manufacturers to develop a new culture in which they share information with their suppliers.

Key market drivers of this industry include:

(1) Product Innovation: Product innovation allows all firms, large and small, to participate in an industry in which customer needs are evolving and in which opportunities are increasing for both the mass market as well as niche markets to satisfy diverse lifestyles and uses. Major developments, innovations and technological breakthroughs can occur at the formulation level, product level, or packaging level.

(2) Sustainable Consumption: Sustainable consumption means modifying people's habits to minimize their impact on the environment. This principle has been applied with the advent of concentrated products. These products did not, however, attain their intended economic and environmental effect, because not all were convinced that a lower dosage of concentrated products was necessary. Consequently, the soap and detergents industry has recently introduced the concept of unit dosing in capsules or tablets for dishwashers and washing machines. Unit dosing is convenient and simple, anticipat-

ing consumer demand for easy to use and safer products. Unit dosing has also had various positive environmental effects, due to a reduction in transport, among others.

(4) New Product Development: Developing and introducing new products to the market spans the complete product lifecycle, which starts from primary identification of a market opportunity, to conception, design and development, production, product launch, support, enhancement ends with retirement. The process entails the conversion of a product concept into an actual reality.

(5) Regulations: The soaps and detergent industry is one of the most regulated industries and is subject to several requirements that aim at reducing the release of chemical substances into the environment during the manufacturing process. Such requirements generally include limitations (through regulations) on the quantity of a substance that can be released into the environment.

4.2.1.3 Soap and Detergents Industry in Ethiopia

General Status of Soap and Detergents in Ethiopia:

Since the number of firms in Ethiopia's soap and detergents industry is low (22-24 firms), they are unable to meet local demand, even though they comprise the highest share in the number of total chemical manufacturing firms in Ethiopia.

Ethiopia imported 705,364 tonnes of soap and detergents at a CIF value of ETB 199.2 billion in 2013.

These industries require less intensive technology and capital. Hence, the capacity utilization of existing establishments is planned to increase from 32 per cent to 90 per cent; the underutilization of this industry may be attributed to unnecessary waste in the manufacturing environment, lack of integration in the supply chain and poor quality of products; hence, the implementation of quality improvement principles could greatly enhance capacity utilization and productivity.

Market Size of Soap and Detergents in Ethiopia:

No detailed data on the market size of Ethiopia's soap and detergents industry is currently available. A report did, however, publish Figures of market demand for laundry detergent for the period 1989-2002 (Table 41) and the projected demand for the period 2005-2015 (Table 41). Assuming that supply was driven by demand, the average annual supply of laundry detergent for the reference period, which includes domestic production and imports, reflects the effective demand for the product in the year 2002. Since the consumption of laundry detergent is associated with the rise of the urban population, demand for the product was assumed to grow by 4 per cent, corresponding to the annual growth rate of the urban population. Demand for laundry detergent for the year 2004 was thus estimated at 29,520 tonnes. This Figure was projected based on the 4 per cent annual growth rate of the urban population, who are the main users of the product.

Table 41 Market size of soap and detergents industry in Ethiopia

Year	Domestic Production	Import	Total Supply	Market Share (%)	
				Domestic Production	Imports
1989	9529	15661	25190	37.8	62.2
1990	7753	14706	22449	34.5	65.5
1991	3729	12537	16266	22.9	77.1
1992	4947	19592	24539	20.2	79.8
1993	15546	8856	24402	63.7	36.3
1994	13495	14149	64644	48.8	51.2
1995	13641	7838	21479	63.5	36.5
1996	16547	15229	31776	52.1	47.9
1997	12908	13766	26674	48.4	51.6
1998	9787	12910	22697	43.1	56.9
1999	13135	17504	30639	42.9	57.1
2000	17194	14200	31394	54.8	45.2
2001	14766	19792	34558	42.7	57.3
2002	19249	23147	42396	45.4	54.6
Average	**12301**	**14992**	**64293**	**44**	**56**

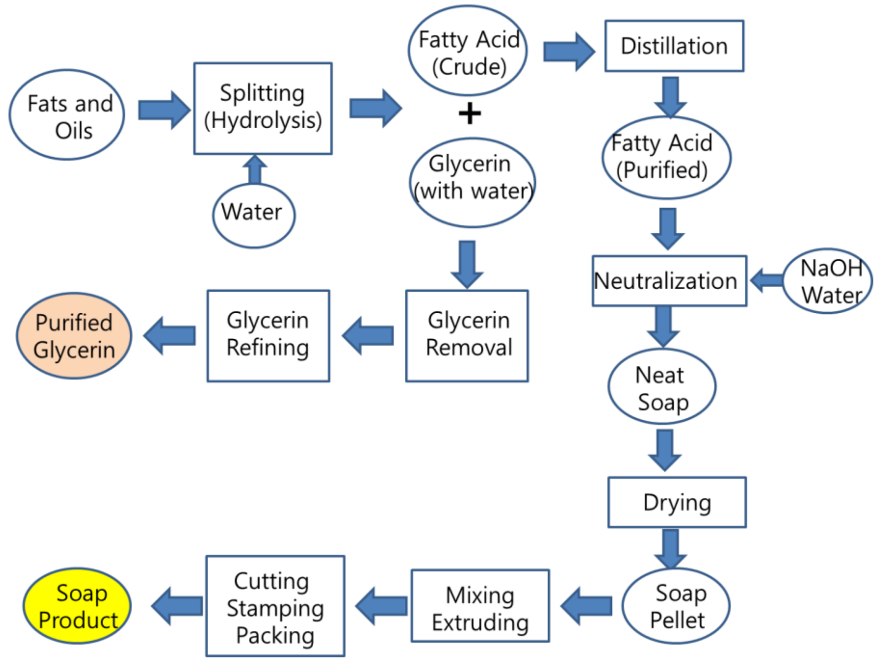
Sources: Customs Authority, External Trade Statistics, various years CSA, Statistical Abstract, 1990-2002.

Year	Projected Demand
2005	30701.0
2006	31929.0
2007	33206.2
2008	34534.4
2009	35915.8
2010	37352.5
2011	38846.6
2012	40400.4
2013	42016.4
2014	43697.1
2015	45445.0
2016	47262.8
2017	49153.3
2018	51119.4
2019	53164.2
2020	55290.8
2021	57502.4
2022	59802.5
2023	62194.6
2024	64682.4
2025	67269.7

4.2.1.4 Recommendation

Recommendation 1: Continuous Process for Soap Manufacturing: TRM draft page 87~88
The proposed continuous process in TRM can be summarized in more detailed steps as follows: Fats and Oils → Splitting by High Temperature and Pressure with Water and Catalyst → Glycerine and Fatty Acids → Glycerine removal → Distillation of Fatty Acids → Neutralization of Purified Fatty Acid with NaOH Solution → Neat Soap (30% water) → Drying → Soap Pellet (10% Water) → Mixing with Additives → Extruding → Cutting and Stamping → Packing.

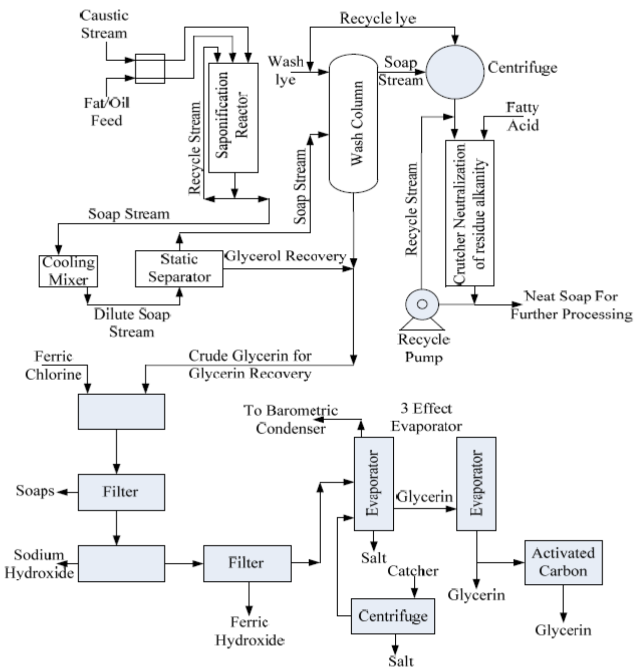
Figure 26 Schematic Diagram for Soap Manufacturing by Saponification



Whether soap production is based on the saponification process, fatty acid neutralization process, or a semi-boiled process, continuous methods of production have proven to be advantageous over older batch processes. Continuous systems improve yields, reduce energy consumption, require less in-process inventory, reduce production cycle times, improve finished product quality/consistency, increase flexibility and require smaller plant layouts. This continuous process can ensure a consistent and good quality of soap products, while the quality is not consistent and good when using the batch process. Moreover, this process produces glycerine as a by-product. Glycerine is an important industrial chemical for various applications, particularly when crude glycerine is properly purified and refined. The process of soap manufacturing based on fats and oils usually yields glycerol of about 10 per cent of the value of the soap produced. Due to the many uses of glycerine, its recovery is an important factor for reducing costs in soap manufacturing. It is also an important ingredient in cosmetics and adhesives. It therefore makes sense to focus on developing the refining technology of crude glycerine.

Figure 27 illustrates another continuous soap manufacturing process which includes the process of glycerine refinement. Sweet water from wash column and lye from the static separator containing glycerol is processed to produce glycerine. The first step in glycerine recovery is pretreatment of lye to remove traces of soluble soap in the lye. Ferric chloride is added to the lye to precipitate the soluble soap as ferric soap, which is separated by filtration. The acidic filtrate after the removal of soap is acidic and contains excess ferric chloride. This is treated with caustic soda, and ferric chloride is separated as ferric hydroxide precipitates, which is separated by filtration. The filtrate after the removal of soap is then processed in the evaporator. In the multiple effect evaporator, glycerine is diluted with a concentration of 52 per cent glycerine. Some salt is separated at this stage. The concentrated liquid after the separation of the salt is centrifuged and the concentrated glycerine is processed by another single effect evaporator to achieve a concentration of about 84 per cent glycerine. This is referred to as crude glycerine which is further refined in a special distillation column at 140 oC and 755 mmHg. The distillation column contains three condensers in a series from which different fractions of glycerines are recovered and which are further treated with activated carbon to finalize the production of glycerine.

Figure 27 The continuous soap manufacturing process and glycerine refining system



Recommendation 2: Semi-Boiled Soap Manufacturing Process

The semi-boiled saponification process is a glycerine removal-free process that produces "neat soap" with all the glycerine that is contained in the initial fats and oils used. Semi-boiled saponification does not require the washing and fitting steps of the traditional full-boiled kettle soap process or the washing and neutralization of the continuous saponification systems that produce neat soap with only a small amount of glycerine.

The traditional market for semi-boiled soaps mainly targeted different laundry detergents. Currently, semi-boiled soap manufacturing is also gaining in importance for toilet/cosmetic soaps due to:

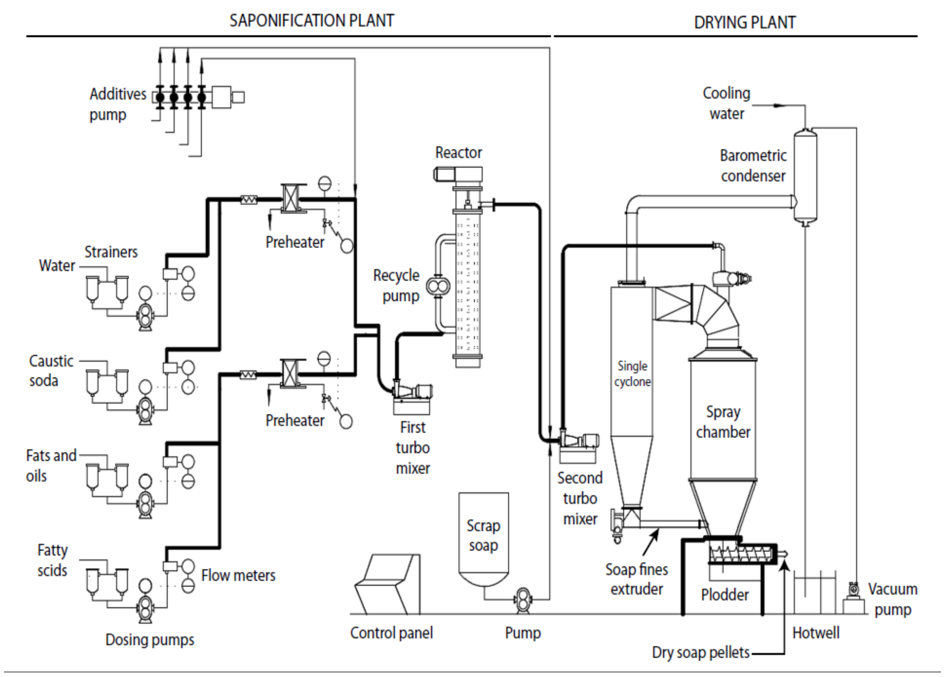
(1) the fluctuating cost of refined glycerine
(2) the increasing cost of many raw materials, especially those for spent-lye treatment
(3) the availability of complete glycerine processing plants.

Semi-boiled soap making is a simple, single-step process which offers the following advantages:

(1) savings in energy consumption
(2) reduced capital investment compared to other systems
(3) lower environmental impact (no by-products)
(4) requirement of less-skilled personnel due to process simplicity.

The high glycerine content of semi-boiled soap alters the soap's appearance, and results in a harder finished product at a given moisture content due to the increased viscosity of the liquid phase of the soap. To account for this, semi-boiled soaps are usually produced with a 58~60 per cent total fatty matter (TFM) content. Figure 28 illustrates the continuous process diagram for semi-boiled soap manufacturing systems.

Figure 28 Schematic Diagram for a Semi-boiled Soap Manufacturing System



Recommendation 3: Toilet or Cosmetic Soap Manufacturing

The above-mentioned continuous soap manufacturing processes c an produce the quality soap pellets, which can be used to produce toilet or cosmetic soaps to cleanse the body or face. Without any additional equipment or facilities, it is possible to manufacture good quality soap products by producing high quality soap pellets and by subsequently mixing these pellets with any skin care ingredients and fragrances. Since cleaning soap can be sold at a higher price than laundry soap, it would be possible to improve the economic efficiency of the soap manufacturing process.

Recommendation 4: Batch-type Soap Manufacturing
Since batch-type soap manufacturing processes, which are mainly operated by small companies, lag far behind imported products in terms of product quality and productivity, it is recommended that the government provide technical guidance or any appropriate assistance to domestic enterprises to meet consumer needs for higher quality.
By utilizing overseas experts who possess in-depth knowledge and practical experience in the latest soap manufacturing technology, the government can provide comprehensive education for all local soap manufacturing firms and customized technology advice or guidance for individual companies at their production facilities. The high quality soap produced by domestic soap companies can replace import soap products and be exported to neighbouring countries, leading to the profitable and sustainable growth of the domestic soap production industry.

4.2.2 Pulp and Paper Industry

The pulp and paper industry comprises companies that use wood as a raw material and produce pulp, paper, paperboard and other cellulose-based products.

4.2.2.1 Characteristics of the Pulp and Paper Industry

The pulp and paper manufacturing industry is energy- and raw material-intensive, with high capital costs and long investment cycles. The following characteristics apply to the industry:

- local business due to high transportation costs;
- paper industry is growing in similar patterns as GDP development;
- raw materials and recycled paper are very important in the pulp and paper industry;
- energy and waste control is important in terms of the environment and costs.

Paper for recycling represents a major source of the paper industry's raw material, which is why the industry is heavily advocating recycling. The recycling rate of paper in Europe reached 71.5 per cent in 2015. The total amount of paper collected and recycled in paper mills in 2015 amounted to nearly 56 million tonnes, an increase of 28.1 per cent since 2000. 18.2 per cent was exported for recycling in third countries. (Confederation of European Paper Industries, Homepage).

The recycling of paper is also a major source of raw material for the Republic of Korea's paper industry, with recycled paper accounting for 78 per cent and pulp for 22 per cent (of which about 83 per cent is imported). The quality of waste paper is an important factor in the recycling process.
Continuous technological improvements can further reduce environmental impacts and optimize the use of resources such as raw materials, water and energy.

4.2.2.2 Global Trends of the Pulp and Paper Industry

The pulp and paper industry as a whole is growing, albeit at a slower pace than before, as other products are filling the gap left by the shrinking graphic-paper and newsprint market. Packaging is increasing all over the world, along with tissue papers and pulp for hygiene products. Although it is still a relatively small market, pulp for textile applications is growing. A broad search for new applications and uses of wood and its components is underway in numerous labs and development centres. The pulp and paper industry is not disappearing, but it is changing, morphing and developing.

Table 42 Global prospects of the paper industry by segment and region

2016 ~ 2021	Product Group	Japan	Western Europe	North America	China	Other Asia	Eastern Europe	Latin America
Tissue	Tissue	☁	☁	☁	☼	☼	☼	☼
Graphic Paper	Mechanical	☂	☂	☂	☂	☼	☼	☁
	Newsprint	☂	☂	☂	☂	☂	☂	☂
Packaging Paper	Carton board	☁	☁	☁	☼	☼	☼	☼
	Container board	☁	☁	☼	☼	☼	☼	☼

☼ CAGR > 2%, ☁ CAGR 0~2%, ☂ CAGR < 0%

Source: Paper & Forest Products, May 2017

Various paper products segments of the pulp and paper industry are growing, but the growth is very slow or even negative in developed countries. The newsprint paper market shows a negative growth in all areas (Table 42).

Global Trends of Raw Materials & R&D

The pulp and paper industry is highly advanced in terms of automation of production facilities. Availability of wood resources is crucial for the paper industry's competitiveness. The automated production scale would need to reach at least 250~300 kt to be considered competitive.

As the production scale increases, energy efficiency and waste control problems emerge along with environmental issues; hence, numerous efforts are being undertaken to resolve them.
In addition, countries that lack forests, like the Republic of Korea, are focusing on developing paper recycling technologies such as de-inking. Meanwhile, countries with abundant forest resources like China, Indonesia and Canada are continuing to expand their forest resources.

4.2.2.3 Pulp and Paper Industry in Ethiopia

Ethiopia does not produce its own pulp. There is one paper producing factory in Ethiopia, located in Wenji. The paper mill uses imported pulp and waste paper as raw material inputs. The mills produce 12,490 tonnes of paper of different qualities per year and 10,241 tonnes of corrugated paper. However, local production cannot meet local demand for paper in Ethiopia. Therefore, Ethiopia imports pulp and paper products. According to the Central Statistics Authority in Ethiopia, pulp wood is imported at an annual cost of ETB 148 million, and about ETB 2.2 billion annually is spent on imports of finished paper products (Table 43).

Table 43 The amount of pulp and paper commodities imports and costs

Commodity imported	2010/11		2011/12		2012/13	
	Tonnes	Birr('000)	Tonnes	Birr('000)	Tonnes	Birr('000)
Pulp wood	5,583	44,850	10,346	119,193	12,673	147,082
Paper & paper board	73,345	1,221,765	83,188	1,785,735	99,642	2,128,721

Pulp and paper consumption per capita of Ethiopia is less than 1 kg which is far behind world average (56 kg) and Africa (7.7 kg) (see Table 44). This result implies that the pulp and paper industry in Ethiopia has great potential for development.

Table 44 Pulp and paper demand capacity in Ethiopia compare to world and Africa

	Population ('000)*	Consumption per Capita*	Consumption**		Net Import		Production	
			2015	2016	2015	2016	2015	2016
Ethiopia	102,374	0.9 kg	86	93	67	74	19	19
Africa	1,178,741	7.7 kg	8,958	9,119	4,347	4,335	4,611	4,784
World	7,323,187	56.5 kg	409,677	413,582	2,971	2,699	406,706	410,883

*(2016, est) **(1,000 tonnes)

Source: Addis Ababa University Addis Ababa Institute of Technology School of Chemical and Bio Engineering, 2015

Demand for pulp and paper products is related to the country's overall economic development. Growth in the manufacturing sector and agro-industries will result in more demand for suitable packaging.

4.2.3 Recommendations for Chemical Products

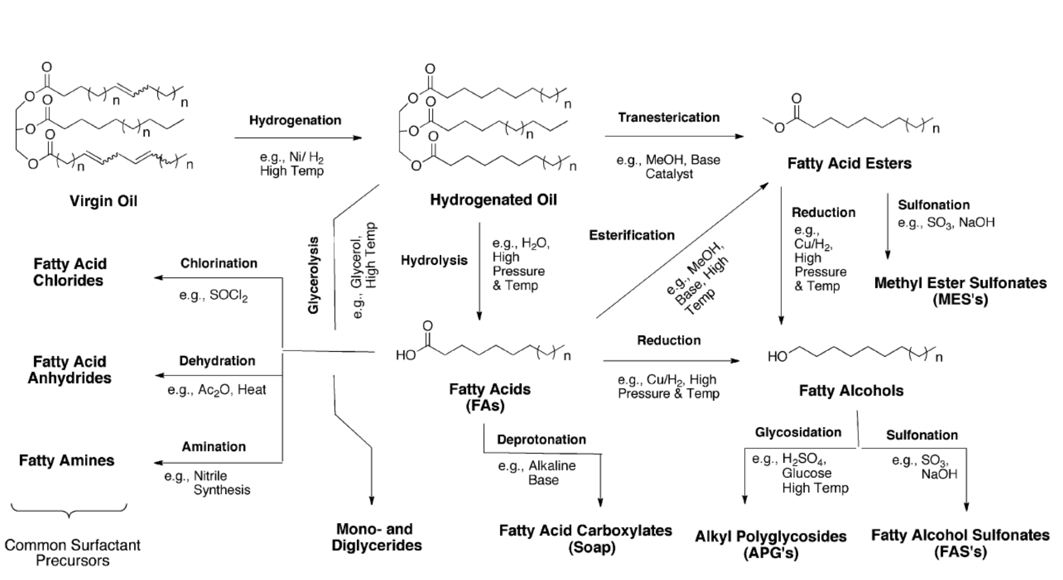
Recommendation of Soap and Detergents Industry:
Recommendation 1: Cosmetics Industry

The 'clean life' that started with the use of laundry and toilet soap has led to the improvement of the quality of life. With the standard of living improving, it is therefore normal that demand for shampoo, skin care cosmetics and colour cosmetics increases among consumers. Beginning with the production and sale of soap, entry into the cosmetics industry should be considered if consumer needs can be better understood and ways to meet these can be devised. Global cosmetics firms in the U.S., France and Japan, such as Procter and Gamble, also started manufacturing and selling laundry detergent and cosmetic soap at very early business stages, and at a later stage, entered the cosmetics industry to meet the demands of the ever-growing cosmetics market.

Recommendation 2: Surfactant Industry

The surfactant referred to here is a surfactant that is superior in performance to soap and is manufactured using sulfation and neutralization with fatty acids or fatty alcohol. These surfactants are important chemicals used in various sub-sectors such as shampoo, laundry detergent, dishwashing detergent and other industrial detergents. The broad application of surfactant is attributable to its excellent physical chemical properties, such as foaming, detergency, emulsifying, dispersing, wetting, anti-static effect and antimicrobial effects. In recent years, various plant-derived surfactants prepared from fatty acids derived from vegetable oils and fatty alcohols as basic raw materials have been used for many personal care and industrial products in place of petroleum-derived surfactants. [Figure 29]

Figure 29 Common transformations of vegetable oils in the production of surfactants



Recommendations for the Pulp and Paper Industry:

The pulp and paper industry in Ethiopia is expected to grow steadily along with the country's economic development due to an improvement in living standards and the development of the local packaging industry. However, there is currently no pulp factory in Ethiopia, meaning investment in this industry is urgent. Since the paper industry developed without a pulp factory in Ethiopia, investments in paper recycling and the installation of collection systems for waste paper are recommended. The quality of waste paper is crucial. Training of workforce in waste paper collection systems is time consuming.

▶ Case 1: The Government of the Republic of Korea's Policy: Saving and Recycling of Resources

The Government of the Republic of Korea implemented the 'Act on the promotion of saving and recycling of resources' in 2004. The purpose of this act was to contribute to the preservation of the environment and foster the sound development of the national economy by facilitating use of recycled resources and controlling the generation of waste.

Paper and newsprint created a large amount of waste; paper (41 per cent), plastics (24 per cent), metals (3 per cent) and glass (2 per cent). The recycling of paper increased between 2005 and 2009 by an average of 4.7 per cent. Not only the amount of paper but also the quality of recycled paper improved significantly following the promulgation of the act, which saved the processing costs to use recycled paper as a raw material input for paper products.

Table 45 Recycling of Paper in the Republic of Korea

Year			2003	2004	2005	2006	2007	2008	2009
Paper Production			10,999	11,182	11,279	11,279	11,602	10,642	10,481
Paper Consumption(A)			9,965	9,909	9,868	9,889	9,893	8,690	8,439
Raw Materials	Total (%)		10,897 (100)	11,479 (100)	11,436 (100)	11,599 (100)	12,275 (100)	12,023 (100)	11,703 (100)
	Pulp (%)		2,988 (27.1)	3,082 (26.8)	2,935 (25.7)	2,983 (25.3)	3,129 (25.5)	2,910 (24.2)	2,768 (23.7)
	Recycling Paper	Total	7,942 (72.9)	8,397 (73.2)	8,501 (74.3)	8,667 (74.7)	9,146 (74.5)	9,113 (75.8)	8,935 (76.3)
		Local(B)	6,611	6,875	7,086	7,455	7,998	7,901	7,851
		Import	1,331	1,522	1,415	1,212	1,148	1,211	1,084
Local Recycling (B/A, %)			66.3	69.4	71.8	75.4	80.8	90.0	93.0

(Unit: 1,000 tonnes/year)

Table 46 Summary of review for the soap and detergents industry	
Market	1. Domestic laundry soap market 2. Domestic toilet/cosmetic soap market 3. Foreign laundry detergent market 4. Foreign toilet/cosmetic soap market
Major Players	1. Public /government development for continuous soap process 2. Private/ local development for batch soap process (quality improvement)
Technology	1. Process design and production equipment for continuous soap production should be provided by foreign soap equipment manufacturers in Italy, India or China. 2. Production or operating technology should be provided by equipment manufactures along with supplying their equipment. 3. Key technologies: hydrolysis, saponification, glycerine removal and refining, drying, formulation. 4. Key technologies could be acquired from soap equipment suppliers and foreign experts.
R&D	1. Engineers and researchers should be involved and educated from the initial stage of process design. 2. Technical experts or consultants should be involved from the initial stage of process design to provide critical reviews on process design and project progress. 3. Engineers will be in charge of operation supervision and researchers are in charge of quality control and improvement. 4. Collaboration between researchers from universities and soap producers is highly recommended.
Human Resources	1. Engineers and researchers; university-educated with some experience in soap industry. 2. Technicians: well-educated and trained, with some experience in the soap industry 3. Some foreign experts and consultants could be hired to stabilize soap production and the establishment of new facilities.
Finance	1. Fair amount of capital investment is required for production facilities. 2. Estimated capital can be provided by soap equipment manufacturers after determining production capacity.
Connective Technology	1. Cosmetics industry. 2. Surfactant industry. Alkali chemicals.

Table 47 Summary of review for the paper and pulp industry	
Market	Applications, global trends, Ethiopia status (supply/demand) ◦ Developed countries: 1) Newspaper, printing paper demand is decreasing due to ICT developments, 2) Container board, etc.: Packaging demands are increasing
Major Players	Initially, development in the public sector, later transfer to private sector
Technology	Licensing package and process development ◦ Licensor's package is required ◦ Local quality development
R&D	Process and manufacturing development, purification technology R&D targets and strategy ◦ Recycling paper R&D - Development of neutral pH paper - Coating technology development - De-inking technology development
Human Resources	Engineers/technicians ◦ International collaboration in R&D and in early stages of production*
Finance	Facility-oriented, economic scale
Connective Technology	◦ Cosmetics industry, packaging industry ◦ Surfactant industry, caustic soda, soda ash

* Chinese human resources supporting strategy: In the beginning of China's industrial development, there were not enough skilled and experienced experts in the paper industry. Accordingly, they hired Chinese workers for simple manual labour and employed technicians for management and quality maintenance from the Republic of Korea and Taiwan ROC, resulting in a rapid development of China's paper industry.

4.3 Petrochemicals (PVC, PE, PP)

As a basic chemical, alkali chemicals are used to modify the physical properties of materials based on chemical reactions like acid/base reactions or oxidation-reduction reactions. These changed materials can be used in many applications. For example, caustic soda is used to change wood particles to pulp materials, which is a raw material input for paper.

On the other hand, petrochemicals and polymers, as a typical example, play an important role in 21st century lifestyles and the national economy because they are utilized in various end products across a range of industries. Based on their beneficial properties like light weight, durability, from transparent to various colours, easy transformation into various forms and competitive prices, they substitute paper, glass and steel, and their application is expanding. Ethiopia has a high population and thus faces tremendous challenges in terms of providing sufficient food, medicines and adequate housing to its population. The development of the petrochemical industry is crucial and could contribute to Ethiopia's transformation from an agriculture-led to an industry-led economy.

Polyolefin (PE, PP, PVC) is a strategic chemical in the NTRM, and details for local information and implementation plans are necessary, including a feedstock strategy.

The petrochemical industry is predominantly based on feedstock derived from crude oil and natural gas. Naphtha and kerosene (linear alkyl benzene) are derived from crude oil. Steam cracking/ catalytic reforming of low and high aromatic naphtha in oil refineries provide olefins (ethylene, propylene and butadiene) and aromatics (benzene, toluene and xylenes). Natural gas contains methane (CH_4), ethane (C_2H_6), propane (C_3H_8) and butane (C_4H_{10}). Rich natural gas, which contains C2 and C3 in extractable quantity, is used in the production of ethylene and propylene. Methane can be converted into synthesis gas and other C1 derivatives.

The possibilities of Ethiopia's natural gas and its components and crude oil should be considered and various scenarios evaluated.

Developing the chemical sub-sectors proposed is complex and very challenging. It involves developing project ideas, feasibility studies and engineering designs and construction, operation and marketing (input/output balance) and financing, among others.

4.3.1 Polyethylene and Polypropylene (PE and PP)

4.3.1.1 Global Trends of PE and PP

The global market research company, IHS, reports that the global market of polyethylene reached around 100 million tonnes, which represents the largest part of the global olefin market (260 million tonnes). It is expected to grow steadily at a CAGR 4.2 per cent.

The packaging industry is the main driver of petrochemical market growth together with other end-use industries such as automotive, construction, electrical and consumer goods.

The results of market research have shown that the main market segments for plastics converters are packaging (39.9 per cent), building and construction (19.7 per cent), automobile (10 per cent), electrical and electronics (6.2 per cent), household, leisure and sports (4.2 per cent), agriculture (3.3 per cent) and others (16.7 per cent).

The packaging and construction industry are two of Ethiopia's fastest growing industries and source extensively from the plastics industry. These results imply that the plastics market will continue to grow rapidly in Ethiopia.

Polypropylene and polyethylene are key raw material inputs for food packaging, and PVC (polyvinyl chloride) is a major source for housing materials like window frames (Table 48).

Table 48 European demand for plastics converters by polymer type (2016)		
Polymer	Share (%)	Application
PP	19.3%	Food packaging, sweets and snacks wrappers, hinged caps, microwave-proof containers, pipes, automotive parts, bank notes, etc.
PE-LD, PE-LLD	17.5%	Reusable bags, trays and containers, agricultural film (PE-LD), food packaging film (PE-LLD), etc.
PE-HD, PE-MD	17.5%	Toys (PE-HD, PE-MD), milk bottles, shampoo bottles, pipes, houseware (PE-HD), etc.
PVC	10%	Window frames, profiles, floor and wall covering, pipes, cable insulation, garden hoses, inflatable pools, etc.

Global PE and PP demand is expected to increase, owing to rising demand for packaged goods and the changing lifestyle of consumers. Additionally, easy availability and affordable PE prices are likely to contribute to market growth. PE is used in various applications, including packaging and toys, cable coverings, buckets, lid, containers bottle, film and membrane manufacture. The penetration of plastics in flexible packaging has advanced quickly and steadily. PE and PP film, in particular, accounted for 37 per cent and 25 per cent in the packaging industry (Table 49).

Table 49 Plastics in Flexible Packaging		
Packaging materials		Share (%)
Plastics	Polyethylene	37 %
	Polypropylene	25 %
	Polyvinylchloride (OVC)	3 %
	Polyethyleneterephthalate (PET)	3 %
Paper		20 %
Aluminium foil		5 %
Others		7 %

Source: PIRA, “The Future of Global Markets for Flexible Packaging 2205, www.intertechpira.com

4.3.1.2 Current Status of Petrochemicals in Ethiopia

Ethiopia’s plastics industry is growing fast. The Country Cluster of EUROMAP (European Plastics and Rubber Machinery) confirms a significant growth of Ethiopia’s plastics industry.

EUROMAP also expect Ethiopia's consumption of plastics to increase considerably and steadily (Table 50). Ethiopia's plastics consumption has risen 17.5 per cent annually over the past ten years, from 44 kt in 2007 to 220 kt in 2017, and is estimated to reach 308 kt in 2020.

Table 50 Plastics consumption in Ethiopia

Consumption	'07	'08	'09	'10	'11	'12	'13	'14	'15	'16	'18	'20	CAGR
Plastic*	44	51	57	55	57	81	94	114	172	195	248	308	16.2%
Plastic per Capita**	0.6	0.6	0.7	0.7	0.7	0.9	1.1	1.3	1.9	2.1	2.6	3.2	13.7%

2016~2020: estimated
Plastic*- kilotonnes, Plastic per capita** - kg

The per capita consumption of plastics in Ethiopia has increased by about 15 per cent annually over the last ten years, from 0.6 kg in 2007 to 2.4 kg in 2017, and is estimated to reach 3.2 kg in 2020.

Plastics will gradually become the material of choice for extensive usage due to their unique and diverse set of properties. Additionally, easy availability and affordable PE prices will promote the growth of the plastics industry. Government policies and initiatives fostering plastics manufacturing in the country and competitive rivalry in the industry is bound to grow significantly.
Due to low penetration levels of plastic products in Ethiopia's market, especially in rural areas, the per capita consumption of plastics is low compared to other countries (Table 51).

Table 51 Per Capita Plastics Consumption

Country	Plastics Consumption
USA	109 kg/person
Europe	65 kg/person
China	38 kg/person
Brazil	32 kg/person
India	11 kg/person
Ethiopia*	2.5 kg/person
World	28 kg/person

*EUROMAP, estimated

Source: AIPMA and Plastic India, TATA Strategic Analysis

To manufacture finished products, polymers are processed through various types, namely extrusion, injection moulding, blow moulding and roto moulding. The extrusion process is the most commonly used process in Ethiopia and accounts for 50.3 per cent of total consumption by downstream plastics processing industries. Various products manufactured through these processes are presented in Table 52.

Table 52 Processes in the Plastics Industry		
Process	Share	Applications
Extrusion	50.3%	Films & sheets, fibres & filaments pipe, conduits & profiles, other applications
Injection Moulding	24.9%	Industrial household, thermo-ware, luggage
Blow Moulding	18.4%	Bottles, containers, toys and housewares
Others	6.3%	Water tanks

Ethiopia is the second largest importer of plastics in their primary forms in eastern and central Africa. As Ethiopia does not process any plastics or raw material inputs to plastics at all, 100 per cent of raw material inputs and resins are imported, mainly from the Middle East, Europe and Asia. Imports of raw material inputs to plastics grew by 19.4 per cent annually between 2007 and 2015, from 43 kt to 178 kt (Table 53).

Table 53 Ethiopia's imports of plastics in a primary form

2007	2008	2009	2010	2011	2012	2013	2014	2015	CAGR
43	50	59	56	58	80	96	113	178	19.9%

Unit: kilotonnes

Source: Ethiopian Revenue & Customs Authority

Ethiopia's plastics and packaging industry has become increasingly sophisticated with new technologies being introduced in the market. The plastics and packaging industry consists of different sub-sectors, including plastics, plastics flexible packaging and polythene bags. Ethiopia's plastics industry is an emerging industry with the potential of driving growth within the country's manufacturing industry.

4.3.2 Polyvinyl Chloride (PVC)

Polyvinyl chloride (PVC) is the third-most widely produced polymer, after polyethylene and polypropylene. PVC is one the most widely used plastics and is produced by polymerization of the monomer vinyl chloride. PVC has an amorphous structure with polar chlorine atoms and has fire retardant properties and oil/chemical resistance. PVC is widely used in construction, packaging, automotive and electrical industries due to its many properties such as light weight, good mechanical strength, abrasion resistance and toughness. PVC has two basic forms: rigid and flexible. The rigid form of PVC can be used in the manufacturing of pipes, doors and windows and plastic bottles. The flexible form of PVC can be used in plumbing, electrical cable insulation, imitation leather, signage and medical tubes.

4.3.2.1 Global Trends of PVC

The global polyvinyl chloride (PVC) market is growing steadily at a CAGR 5~6 per cent in the next five years. Construction and infrastructure spending in emerging markets will be a major contributor to the PVC market's growth.

Table 54 Global PVC Market Estimation

2013	2015	2017	2018	2020
38.5 Mt	42.17 Mt	46.49 Mt	48.81 Mt	53.81 Mt

MT: million tonnes Source: statista (www.statsta.com)

Asia-Pacific is the largest market for PVC, accounting for over 50 per cent of the global PVC market. The Asia-Pacific region is expected to continue growing over a forecasted period due to the high growth potential of the building and construction industry. China represents the largest market for PVC in the Asia-Pacific region. Europe is the second largest market for PVC, followed by North America.

Some of the major drivers contributing to the overall growth of the PVC market include high growth in the building and construction industry, automobile industry and medical devices. Some of the major restraints for the PVC market include increasing competition from steel and concrete pipes and prohibited use of PVC in the construction of green buildings.

The automotive industry is one of the most dynamic industries and belongs to the major consumers of plastics. On average, 150.0 kg of plastics is used in the manufacturing of a vehicle, of which nearly 10.0 per cent is PVC-based plastics.

Future major growth opportunities for PVC include the manufacturing of high efficiency pumps, growing demand for electric vehicles, the emerging wood plastics composites market, and renewable PVC developments.

4.3.2.2 Current Status of PVC in Ethiopia

There are a total of 350 plastics manufacturing firms in Ethiopia, which produce 12 categories of goods including automotive tires, wood & plastic home partitions, PVC tiles and small household furniture. The total volume of plastic products is around ETB 12 billion (over USD 0.5 billion). There is no resin manufacturer in Ethiopia, and about 90 per cent of inputs are imported (about 170 kt of resin including PVC and PE).

Table 55 Projected Demand for PVC Resin

2013	2015	2017	2019	2021	2023	2025
11,121	13,456	16,282	19,701	23,838	28,844	34,901

Unit: tonnes Source: Ethiopian Chemical & Construction Input Industries Development Institute

[47] Thomas Wynes & Matilda Alexon, The Final Frontier-Decarbonising Europe's energy intensive industries, 25 May 2016, Institute for European Studies, Vrije Universiteit Brussel

The government is trying to reduce the import of raw materials to reduce costs. A quarter billion dollar investment is underway to set up a PVC factory in the Mekele City area. It is expected to be operational at the end of 2020. The leading markets for plastics/ PVC in Ethiopia are the packaging, building and construction and automotive/transport industries.

4.3.3 Review and Recommendation for Petrochemicals

Current and future local demand for polyolefin is a very important starting point for Ethiopia's roadmap. Ethiopia's plastic per capita use is likely to increase to at least 4 kg. If we consider Ethiopia's total population of 100 million, about 400 kt of polyolefin will be required by 2025. Based on the PVC demand in Table 30, we can deduce some estimates. Demand for PVC resin will be around 35,000 tonnes. The global average share of PVC in PE is around 9 per cent, which means PE demand in 2025 will be about 350,000 tonnes, implying that far more than 400 kt of polyolefin will be needed by 2025.
-In the Roadmap, polyolefin demand was projected at about 300 kt in 2025.

Many projects are being considered involving the production of natural gas and crude oil production in Ethiopia. These study results will have a profound impact on the development of the chemical industry. Key technology discussions will involve NCC (naphtha cracking) and ECC (ethane cracking).
Most chemical and plastic (C&P) products are derivatives of oil and natural gas. In terms of pricing, most of these follow the oil price, even if the product can be produced using natural gas. Aside from price, there are other issues involving oil or gas and the diversity of products. The ethane cracking process (ECC) produces mostly ethylene (about 75 per cent), while the naphtha cracking (NCC) process produces diverse outputs such as ethylene, propylene, butadiene, and BTXs (Table 56).
A decision to establish an ECC or NCC facility in Ethiopia is beyond this review and is a decision the government will have to take.

R&D
Training for process technology and safe operations are included in the licensor's package.
Special R&D projects could be prepared and implemented, like solid handling and piping work.

Table 56 Cracking method and olefin ratio

Process	Olefin		Non-olefin		etc
	ethylene	propylene	butadiene	BTX	
NCC	31 %	15 %	11 %	24 %	19 %
CTO	100 %		none		none
ECC	75 %	2 %	3 %	5 %	15 %

Source: Hana Economic Research Center, Deloitte reorganized

Table 57 Summary of review for the petrochemical industry	
Market	Applications, global trends, Ethiopia status (supply/demand) ◦ The estimation of polyolefin demand in Ethiopia needs to be defined and ready for various scenarios
Major Players	Initially, development in the public sector, later transfer to private sector ◦ Public sector; requirement of large investments and high risk
Technology	Licensing package and process development ◦ Licensor's package is required
R&D	Process and manufacturing development, purification technology R&D targets and strategy ◦ Technology for manufacturing needs to collaborate with licensor. ◦ Operation training and typical safety study, R&D
Human Resources	Engineers/technicians ◦ Training for operation
Finance	Facility-oriented, economic scale ◦ Study of PVC factory using imported VCM scale of 15,000 tonnes per annum, estimated total investment ETB 539 million and production costs per year of ETB 247 million
Connective Technology	◦ Chlorine industry for PVC ◦ Plastics industry, construction industry, packaging industry ◦ Companies using chlorine and caustic soda should be balanced ◦ Chlorine-PVC(VCM)-ethylene are connected ◦ Pulp and paper, food processing, soap and detergents, and water treatment are connected to the alkali industry

Potential for plant-based Chemical Industry in Ethiopia

Feedstock is one of key factors in petrochemical industry. In fact, most of the current feedstock are from crude oil and natural gas. However, there is a rising concern on recent climate changes; therefore, using biomass through decarbonization is actively being studied for a continuous growth. Since petrochemical industry is especially a typical energy intensive industry, the expectations for biomass-based chemical industry is growing. According to a study conducted by EU, with the current technology, 10% of the current EU ethylene production can be replaced by the ethanols extracted from sugar cane, corn starch and sugar beets pulp (a residue after sugar extraction).[47]

For the analysis of deep mitigation in the production of petrochemicals, two main options could be considered; Firstly, replacing the fossil fuel based feedstock with biomass-based alternatives, and secondly, reducing the production volumes of some important petrochemical products through enhanced recycling. Among these options, Ethiopia should consider using biomass as a feedstock because the fact that agro-industry, the most important industry in Ethiopia, creates a lot of biomass, as shown in Table 58, makes this choice very convenient.

Table 58 Biomass potential and reserve in Ethiopia

No	Biomass residue	Area (province)	Name of Deposits	Biomass residue (Ton/year)
1	Dry processed Coffee	SNNPR	Coffee Residue[1]	49,496
		Oromiya	Coffee Residue	132,911
		Gambela	Coffee Residue	1,458
		other	Coffee Residue	158
2	Wet processed Coffee	SNNPR	Coffee Residue	16533
		Oromiya	Coffee Residue	6959
		Gambela	Coffee Residue	1519
		other	Coffee Residue	9
3	Cotton	Tigray	Cotton Residue[2]	42,822
		Afar	Cotton Residue	46,100
		others	Cotton Residue	150,000
4	Saw dust	SNNPR & Oromia	Sawmill residues	25,0006[3]
5	Khat	Addis Ababa	Chat residue	7,094
		Harrage &Dire Dawa	Chat residue	105,000
6	Bamboo Tree	All regions		1,000,000
7	JATROPHA	All regions	Jatropha Husk	0.4/1[4]
8	Castor	SNNPR,Oromiya and others	Castor hask	
9	**Molasses**	Currently 8 factory are producing molasses, other 5factory under construction		202,856.28 tone/annum
10	**Floriculture residue**	Amhara, oromiya and SNNP	Floriculture residue	300,000 tone/annum, estimation

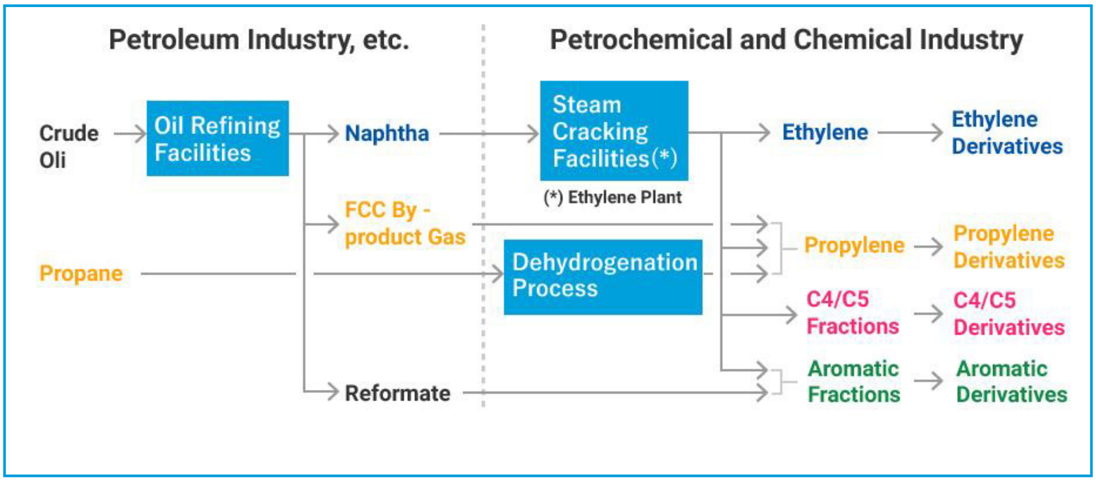
[1] 90 % of the residue is coffee husk
[2] Residue to product ratio is 2.755 at 12 % moisture content
[3] Estimation from Ethiopian rural energy Development and promotion center (EREDPC)
[4] The Jatropha fruit is 40 % pulp, 30 % kernel and 30 oil. About 0.4 tones of pulp will be available from 1 tone of seed processed

Source: UNIDO, Ministry of mining, and EREDPC

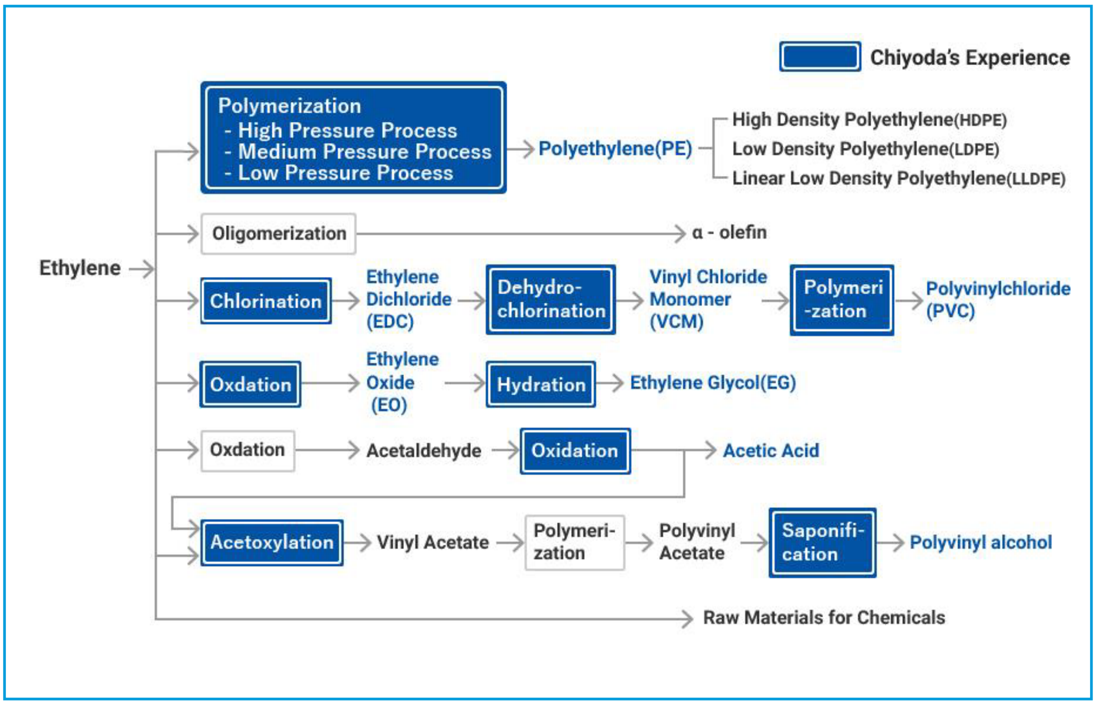
These new alternatives and attempts are very challenging and time-consuming. They will also require a combination of new process technologies, innovative products and business model revolutions. Therefore, these bio-transformation developments should proceed in the long term.

5. Annex

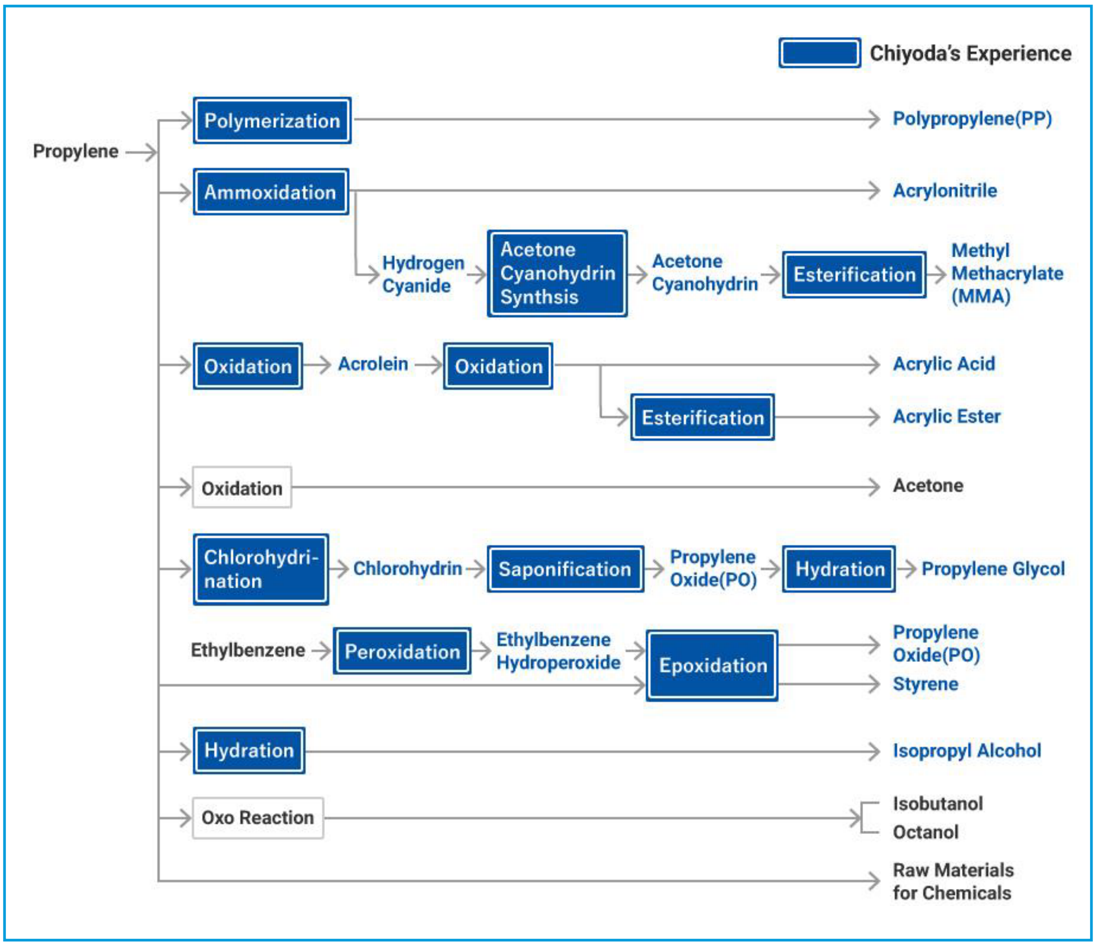
[Appendix 1] Flow Chart of Polyolefin
Source: www.chiyodacorp.com



Ethylene and its derivatives



Propylene and its derivatives



[Appendix 2] Competency hierarchy and its identification of chemistry

Source: Kyeongseok Oh, “Challenge of Korean National Competency standards for chemical engineers,The journal of Competency-based Education, vol 2, (#3), Sept., 2017

Group of work function		Set of work function		Key work function (competency)		Competency ID
01	Chemicals and chemical process management	01	Chemical material management	01	Chemical analysis	17010101
				02	Chemical assay and evaluation	17010102
				03	Chemical storage management	17010103
		02	Chemical process management	01	Chemical process design	17010201
				02	Operation of chemical process	17010202
				03	Maintenance of chemical process	17010203
		03	Chemicals R&D	01	Chemical R&D	17010301
02	Petroleum, commodity chemicals production	01	Petroleum, natural gas production	01	Petroleum production	17020101
		02	Organic chemicals production	01	Petrochemicals production	17020201
				02	Synthetic resin production	17020202
				03	Synthetic intermediate production	17020203
				04	Synthetic rubber production	17020204
				05	Polymer composites production	17020205
				06	Reactive polymer production	17020206
		03	Inorganic chemicals production	01	Inorganic fertilizer production	17020301
				02	Acidic and basic chemicals production	17020302

Group of work function		Set of work function		Key work function (competency)		Competency ID
03	Fine chemical production	01	Traditional fine chemicals production	01	Medicine production	17030101
				02	Agricultural chemicals production	17030102
				03	Cosmetic chemicals production	17030103
		02	Function-added chemicals production	01	Surfactant production	17030201
				02	Additive production	17030202
				03	Dye and coloring agent production	17030203
				04	Painting agent production	17030204
				05	Adhesives production	17030205
		03	Bioprocessed medicine production	01	Bioprocessed medicine production	17030301
		04	Bioprocessed chemicals production	01	Bulk biochemicals production	17030401
				02	Bioplastics production	17030402
				03	Specialty biochemical production	17030403
04	Plastics production	01	Plastics production	01	Injection molding and extrusion	17040101
				02	Plastic coating	17040102
				03	Blow molding and Injection molding	17040103
				04	Plastic compounding	17040104

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