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LOW-CARBON AND CLIMATE RESILIENT INDUSTRIAL DEVELOPMENT IN EGYPT, KENYA, SENEGAL AND SOUTH AFRICA

United Nations Industrial Development Organization (UNIDO)

INTRODUCTION

In order to create awareness and demonstrate the opportunities, as well as benefits, of low-carbon growth and climate resilient development in the productive industries in African countries, UNIDO applies Green Industry policy instruments, practices, and techniques. This is one of UNIDO's regional projects on low-carbon and climate resilient (LCCR) industrial development in four African countries: Egypt, Kenya, Senegal, and South Africa.

UNIDO is an agency of the United Nations that specialises in promoting industrial development for poverty reduction, inclusive globalisation, and environmental sustainability. The first phase of the LCCR project consists of two components: national level policy assessments, and vulnerability and low-carbon industry assessments in selected sub-industries. Results of these assessments will be the basis for producing synthesis reports of industry value chains.

Government action assesses the vulnerability and sensitivity of each industry to the impacts of climate change on the national industry, key resources, and locations with regard to the current climate and future climate change. This component maps previous and ongoing actions taken by the government in each country. Green Industry will assist the effective implementation and operationalisation of the existing national policies and strategies for industry.

Each country team assessed vulnerability and GHG emissions in two selected sub-industries. Quick preliminary vulnerability assessments were conducted at selected production facilities/enterprises to explore the need and opportunities for the application of Environmentally Sound Technologies (ESTs) and Green Industry techniques and practices. Methods for EST and Green Industry technological transfer will be planned and disseminated to promote low-carbon growth and climate resilient industrial development. This report synthesises policiesand vulnerability assessments produced by local consultants in the four African countries, as well as the value chain of industries in Egypt and South Africa

The goal of the assessment is to establish the industry vulnerability to climate change in the four case countries. The project focuses on industry structure, resource requirements and locations in the context of the projected impact of climate change. The objectives of the project assessment were:

1. To determine the technological, managerial and operational capacities of industries to achieve low-carbon and climate resilient industrial development.
2. To examine the challenges and opportunities inherent in the national frameworks for low-carbon and climate resilient industrial development.
3. To propose potential areas of improvement for low-carbon and climate resilient industrial development.

To achieve the objectives of this assessment, a combination of information types and sources was used and multiple methods followed. The information required for the assessment was obtained primarily through a series of consultative stakeholder workshops (Appendix 1) with various key representatives of government agencies in the focal industries and reviews of existing policies, strategies and action plans relating to low-carbon and climate resilience. Face-to-face interviews were conducted for the target participants who could not attend the workshops. The agencies chosen for the consultation process were informed of the relevance of their mandate to the initiative.

This report also uses climate information data to analyse current and future challenges in important industries in each country. Climate information section employs two sets of climate data on rainfall and temperature. The data were obtained from weADAPT.org and CIP (climate information portals). The period of data from weADAPT–CIP is 1979–2000. The observational data from the target governments and the FAO is used to compare the data of weADAPT–CIP. Anomalies are calculated relative to the historical period 1980–2000. The solid bars in the climate data represent the range between the middle 80% of projected changes and so excludes the upper and lower 10% as these are often considered to be outliers.

The aims of the climate information section are to give general knowledge and recommendations on climate information, including the projected trends of rainfall as well as the current condition of temperature to support a target sector. For example, in the Egypt case, this section assesses how current trends and long-term projected changes in temperatures and rainfall in Giza affect the potential for wheat cultivation, and how any impacts can be addressed.

Selected (sub)industries in the four case countries are as follows:

Number	Country	Industry	Sub-industry
1	Egypt	Agriculture	Wheat
2	Kenya	Agriculture	Tea
3	Senegal	Fisheries	Inland fisheries
4	South Africa	Agriculture	Maize

EGYPT

GEOGRAPHICAL LOCATION, DEMOGRAPHICS AND ECONOMIC ACTIVITIES

Egypt is located in the north east of Africa from latitude 22°N to 32°N". The total area is 1 001 450 km^2 with a coastal line of 3500 km on the Mediterranean area and Red Sea. Egypt is divided into Upper and Lower Egypt by the Nile River, which is the main source of water for drinking and agricultural purposes. The population of Egypt is approximately 82.5 million whereas 97% of the inhabitants live in three major regions: Cairo, Alexandria, and other places along the river banks. The density of the Egyptian population is about 1.500 people per square kilometre (United Nations, World Population Prospect, 2012). Egypt has a dry, hot, desert climate. In the winter season, the climate is mild with some rain in Lower Egypt and less rain and warm sunny days and cool nights in Upper Egypt. During the summer season, the climate is hot and dry all over Egypt and the average temperature ranges from 17 °C to 20 °C.

Agriculture, media, manufacturing, natural gas, and tourism are the main economic activities in Egypt. Due to a rapidly growing population and limited arable land, as well as Egypt's dependency on the Nile River, there is economic stress, which makes Egypt rely on the tourism industry as well as remittances from Egyptians who work abroad as main sources of income. Manufacturing (chemicals, food products, textiles, cement and building materials, paper products, derivatives of hydrocarbons, iron, steel, and car industries) is counted as one of the largest economic industries in Egypt, comprising roughly 25% of the GDP. Among these, the food industry remains the most important industry and the oldest economic activity in terms of GDP in Egypt (GAFI, 2014). Most of Egypt's food industry is privately owned. There were 5296 companies operating in the agribusiness industry with a total capital of EGP 14 billion in the year 2014. Though the GDP growth rate reached 2.2% in 2011–2012, the unemployment rate has risen from 9.4% to 13%. Egypt's economy has staggered since former President Hosni Mubarak's downfall, as continued political instability has spooked investors and hindered economic recovery (Egypt Independent, 2013).

Climate change in Egypt is projected due to the rise of the temperature and possible reduction of precipitation. Flash floods, earthquakes, desert locusts, and storms are the types of natural disasters that commonly occur in Egypt. The Nile river delta is also at risk due to rise in sea level. The flow rate within the Nile is quite sensitive to the change in climate, which is not only due to the temperature but also due to the economic activities. There are economic industries and activities that are expected to be affected by climate change and related hazards – such as agriculture, water, energy, health and transportation – and generally in the coastal zones. The road specifications and level are not designed for protecting the land from sea level rise caused by global warming (UNDP, 2010)

The coastal area in the Mediterranean shoreline is the most vulnerable to the rise of the sea level. The wetland of the Nile delta produces 60% of the fish caught in Egypt. Meanwhile, the Mediterranean coast has been developed for tourism activities and industrial towns. The rise of the sea level may lead to erosion, particularly in the endangered zones. When the shorelines recede towards agricultural land, the salinity of the groundwater will increase. The coral reef in the coastal area of the Red Sea region will bleach fast, which will lead to environmental pressure. There will be a negative impact on the social and economic aspects of the coastal zones in Egypt due to the climate change. However, with certain measures and rehabilitation processes, the environmental pressure and vulnerability of the area can be reduced (ENCPC, 2014).

INDUSTRIAL ANALYSIS AND CLIMATIC DISASTER FOR DIFFERENT INDUSTRIES

As the largest consumer of oil and natural gas, Egypt was responsible for 20% of the total oil consumption and about 40% of the total dry natural gas consumption in Africa in the year 2013. The government gives subsidies into this industry, which cost them $26 billion in 2012, and this contributes to the rise of the energy demand

and a higher budget deficit. In the water industry, agriculture, drinking, and industrial sources are the highest consumers. About 80% of the drinking water supplies come from the Nile canals and 20% from the ground water. A climate change prediction model identified water resources as one of the industries most vulnerable to climate change in Egypt. While industry is a growing sector in the Egyptian national economy (Ministry of Water Resources and Irrigation, 2013), there is no accurate estimate for the current industrial water requirement and consumption. Also in the agriculture industry, there is no estimation on its water consumption and it increases the crop failure occurrence due to the drought. Another effect is the spread of fungal plant diseases and drought.

The temperature rise will increase the water evaporation and the water consumption in the crops. Crops such as wheat, maize, cotton, rice, tomato and sugar cane will have the lowest yield and productivity if the temperature rises by 2 °C – 3.5 °C and will lead to the increasing of water consumption by 4.1% – 6.2%. For instance, the wheat productivity will fall by 9% if the temperature rises by 2 °C (IDSC, 2011). The temperature rise will also affect animal production (the ability to produce milk and meat) and its health. There will be an increase in diseases that are common to human and animals such as avian flu, foot and mouth disease, etc. Sudden climate change in some geographical areas will lead to multiple injuries and migration, which will result in an unhealthy population density. The migration then affects the social and economic impact.

POLICIES FOR VULNERABILITY TO CLIMATE CHANGE

Egypt first identified its vulnerabilities to climate change and desired response strategies in 1999 through its Initial National Communication. This was continued through its Second National Communication in 2010. The content of the Initial National Communication was determined, in part, by a series of background studies completed between 1995 and 1999. These studies included a vulnerability assessment of the country's freshwater resources, a review of the prior framework of the government's action plan on climate change, the assessment of the policy options addressing climate change (mitigation and adaptation) in the agriculture industry, adaptation to sea level rise, and an adaptation technology assessment.

The lead government bodies responsible for climate change are the Ministry of State for Environmental Affairs and the Egyptian Environmental Affairs Agency (EEAA). An Inter-Ministerial National Climate Change Committee composed of governmental and non-governmental stakeholders and chaired by EEAA was created in 1997. More recently, in 2009, a pre-ministerial decree to establish a national Centre for Climate Change was issued.

Policy actions are also ongoing in that, while not specifically integrating climate change adaptation, it addresses some of Egypt's key climate vulnerabilities. For example, to address the potential impacts of climate change on coastal areas, a National Committee for Integrated Coastal Zone Management has been established, and regulations introduced that require inclusion of Integrated Coastal Zone Management (ICZM) in development plans. Also, a National Integrated Coastal Zone Management Strategy is being developed. Elements of this strategy are expected to include 1) Upgrading adaptive capacity through establishment of institutional systems for monitoring, building databases, modelling and upgrading awareness; 2) Adopting a proactive no-regrets policy in planning and enforcing regulations for follow up; 3) Carrying out research on renewable energy, salt tolerant plants, desalination; and 4) Considering geo-engineering activities for protection against sea level rise.

Furthermore, through implementation of the 2005 National Water Resources Plan, Egypt could reduce its vulnerability to future water shortages. Measures in this plan include: improvement of irrigation systems, redesigning canal cross sections to reduce evaporation loss, improving drainage, and resolving conflicts between users more quickly.

Given the size and diversity of Egypt, and its recognised vulnerability to climate change impacts, particularly water scarcity and sea level rise, a high number of adaptation projects – relative to other countries in North

Africa – have been found to be underway in the country. However, this level of activity is moderate, at best, if compared to the degree of adaptation action in countries in eastern, western, and southern Africa. The number of projects being undertaken exclusively in Egypt is approximately equal to the participation in regional projects.

Egypt has also identified some cross-industrial actions that would contribute to its adaptation efforts including public awareness campaigns, development of climate models, increasing the capacity of researchers, encouraging exchange of data and information, and enhancing precipitation measurement networks in upstream countries of the Nile basin as well as the installation of modern early warning systems.

The Egyptian government has identified its vulnerabilities to climate change and has expressed the desire to respond with some strategies and actions since the 1990s. A climate change action plan has been developed to address mitigation and adaptation actions that focus merely on the agriculture industry and coastal area. However, the policy does not specifically integrate the climate change adaptation and key climate vulnerability. Cooperation between the government and other local and internationally funded project is present in some areas, though the level of activity is still moderate. Therefore, it is important to prepare some action plans through monitoring to improve the implementation procedure, planning, and resource allocation among the stakeholders. It is also important to propose actions that prioritise industries like water, agriculture, coastal zones, and health, and include the vulnerability of each industry and the proposed actions in each step. The government and related agencies, as well as other authorities, should separately identify and describe the roles and responsibilities of each industry (ENCPC, 2014).

VALUE CHAIN

Agriculture consumes the largest amount of the available water in Egypt, with its share exceeding 85% of the total demand for water(Ministry of Water Resources and Irrigation, 2014). The Egyptian economy has relied heavily on the agricultural sector for food, feed, fibre and other products. It provides livelihood for about 55% and employs 30% of the labour force, contributes approximately 17% of the GDP and 20% of all foreign exchange earnings (El-Nahrawy, 2012). In view of the expected increase in demand from other industries, such as municipal and industrial water supply, the development of Egypt's economy strongly depends on its ability to conserve and to manage its water resources.

Egyptian agricultural land can be classified into “Old-land” and “New-land”. Old-land comprises the lands of the Nile Valley and the Nile Delta, which have been irrigated and intensively cultivated since ancient times, and which represent about 80% of the cultivated area. New-land consists of lands that have been reclaimed (or are in the process of being reclaimed) relatively recently (International Fund for Agricultural Development, 2005); it represents about 20% of the cultivated area. The cultivated land base of Egypt is about 3.5 million hectares, with a total annual cropping area of about 6.2 million hectares, representing 176% of the total cultivated land area (Ministry of Agriculture and Land Reclamation, 2005).

The Ministry of Agriculture and Land Reclamation and the Ministry of Water Resources and Irrigation have set an integrated plan for land reclamation through several mega projects targeting about 3.7 million acres (1.4 million hectares) to be reclaimed by 2017 (UNDP, 2010). This strategy considers two types of mechanisms to procure the required water resources for reclaiming the targeted areas. The first mechanism entails the efficiency increase of the current agricultural water use, minimising irrigation water losses and the second entails increasing non-conventional water resources share in agriculture.

CLIMATE CHANGE CHALLENGE FOR WHEAT INDUSTRY

As explained above, agriculture is one the main economic activities in Egypt. Food processing industries, together with manufacturing chemicals, textiles, cement and building materials, paper products, derivatives of hydrocarbons, iron, steel and car industries, are counted as one of the largest economy sector in Egypt with

37.55% of the GDP (Index Mundi, 2014). Most of this food industry is privately owned and relies on agriculture. The formal sector of the industry generates an output of 31 billion Egyptian pounds (8% of total GDP) representing almost 25% of the industrial manufacturing output (Selim, 2009).

Agriculture is one of the sectors which are responsible for the most water consumption. About 80% of the drinking water supplies come from the Nile canals and 20% from the ground water. A climate change prediction model identified water resources as one of the sectors most vulnerable to climate change. While industry is a growing sector in the Egyptian national economy (Ministry of Water Resources and Irrigation, 2013), there is no accurate estimate for the current industrial water requirement and consumption. The crop yield will drop rapidly due to the climate change. Another effect is the spread of fungal plant diseases and drought.

The temperature rise will increase the water evaporation and the water consumption in the crops. Crops such as wheat, maize, cotton, rice, tomato and sugar cane have the lowest yield and productivity if the temperature rises by 2 - 3.5 C and will lead to the increasing of water consumption to 4.1% - 6.2%. For instance, the wheat productivity will fall by 9% if the temperature rises by 2°C (IDSC, 2011).

Wheat is the major winter cereal grain crop and the third major crop in terms of area planted, about 600,000 feddans[1] (El-Sheriff, n.d). Food industry depends on wheat industries, which rely on wheat production number. Wheat production potential in Egypt is assessed only under irrigated conditions from winter and summer rainfall, both for areas already irrigated and for those which may come under supplemental irrigation in future. Small areas of land that could grow wheat with irrigation from local groundwater sources such as springs are left out of consideration because of their limited extent and preferred alternative uses. Middle Egypt and the Nile Delta are suitable areas for wheat. The mean daily temperature during the wheat growing period at Giza (Middle Egypt) is 15.7 ^{o}C, and at Mansoura (Nile Delta) it is 16.4 ^{o}C (FAO, n.d-a). Giza has a harder challenge for growing wheat since the city has a higher increase in water requirements than Mansoura (Ouda, et al. 2016). Giza is the third largest city in Egypt and is located in the west bank of the Nile. The analysis below uses data from Cairo station because it is the station nearest to Giza; Giza is located 20 km southwest from central Cairo.

HISTORICAL CLIMATE DATA

The timing of the onset and the cessation of the winter season, during which there is some rain, is important for crop management including wheat cultivation. Figure 1 clearly shows that for the 1979–2000 period, the rainfall pattern in the Giza region was characterised by drought over the years. The climate monthly average shows that November to March have more than 3 mm rainfall. In April to October, the rainfall is even below 1 mm/month. Therefore, Giza has clear differences between winter and summer seasons.

The driest month has historically been July with the monthly average of around 0 mm from 1979 to 2000. The wettest month has been December with the average total monthly rainfall of 5.5 mm. The minimum average temperature was 9 C in January, while the maximum average temperature was 34 C from June to August.

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[1] 1 feddan = 1.038 acre

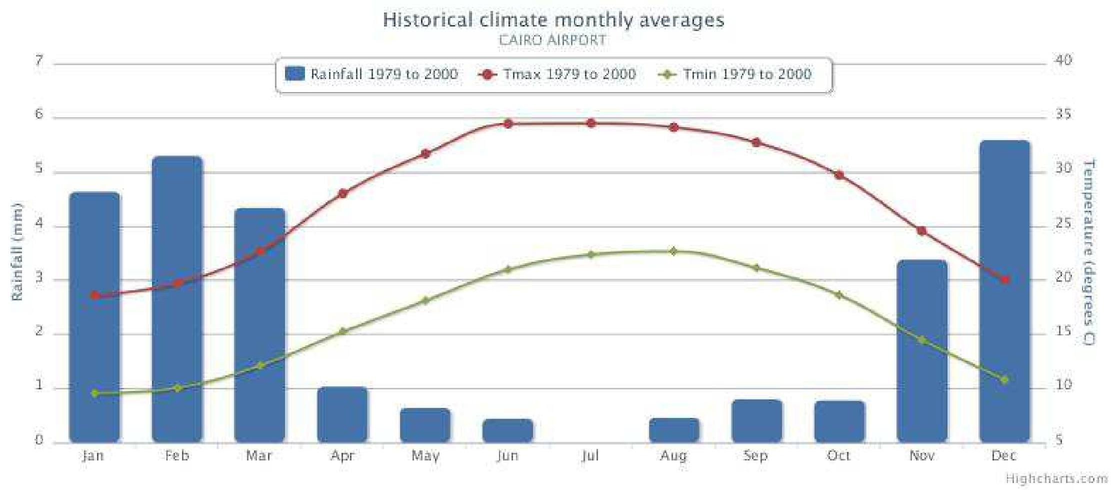

Figure 1. Historical Climate Monthly Average in Giza from 1979 to 2000. The temperature changes significantly throughout the year. There is clear mild winter and hot summer in Giza.

The total monthly rainfall data for the period of 1979–2000, as shown in Figure 2~~Figure 2~~, indicates that the highest total monthly rainfall occurred in March 1989, namely 26 mm.

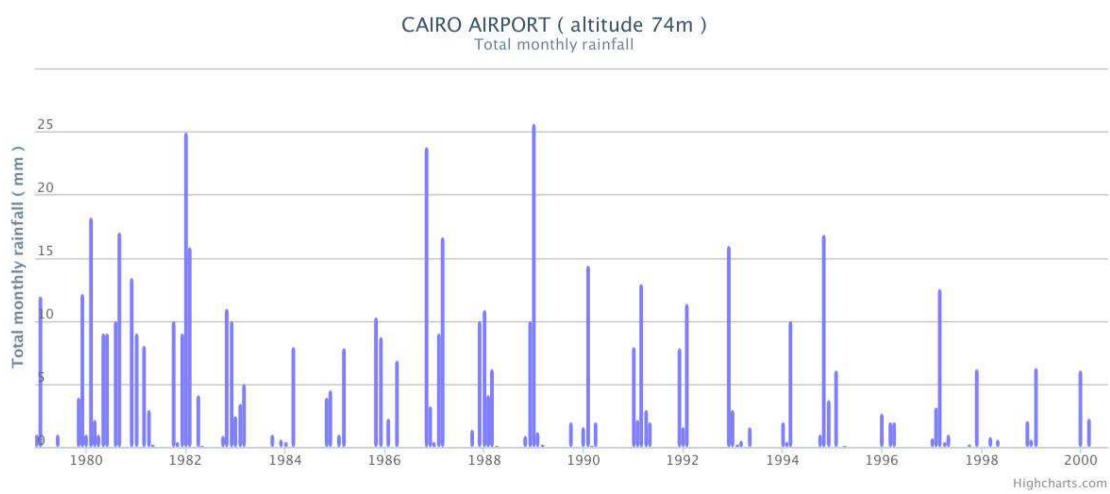

Figure 2. Total Monthly Rainfall in Giza

FUTURE CLIMATE PROJECTIONS

From the statistical downscaled data CMIP5 GCMs (General Circulation Models) for RCP (Representative Concentration Pathway) 4.5 scenario projection for Giza shown in Figure 3~~Figure 3~~, the total rainfall is likely to change in 2040–2060. The 2040–2060 projections indicate that the total monthly rainfall is likely to increase only in January, February, April and November. Most other models suggest that the total monthly rainfall will decrease in all months except April. Meanwhile, in December it is likely to decrease significantly compared to the observed rainfall. March is mildly wet, but it will get drier.

In addition to the rainfall projection, the average maximum temperature scenario projection (Figure 4~~Figure 4~~) indicate hotter conditions, especially from May to October. Generally, the result of projection shows similar patterns as the rainfall projection. The average maximum temperature is likely to increase over the years. All models suggest increases in average maximum temperature up to more than 35 °C, especially in May and October. June to August are projected to be the hottest months.

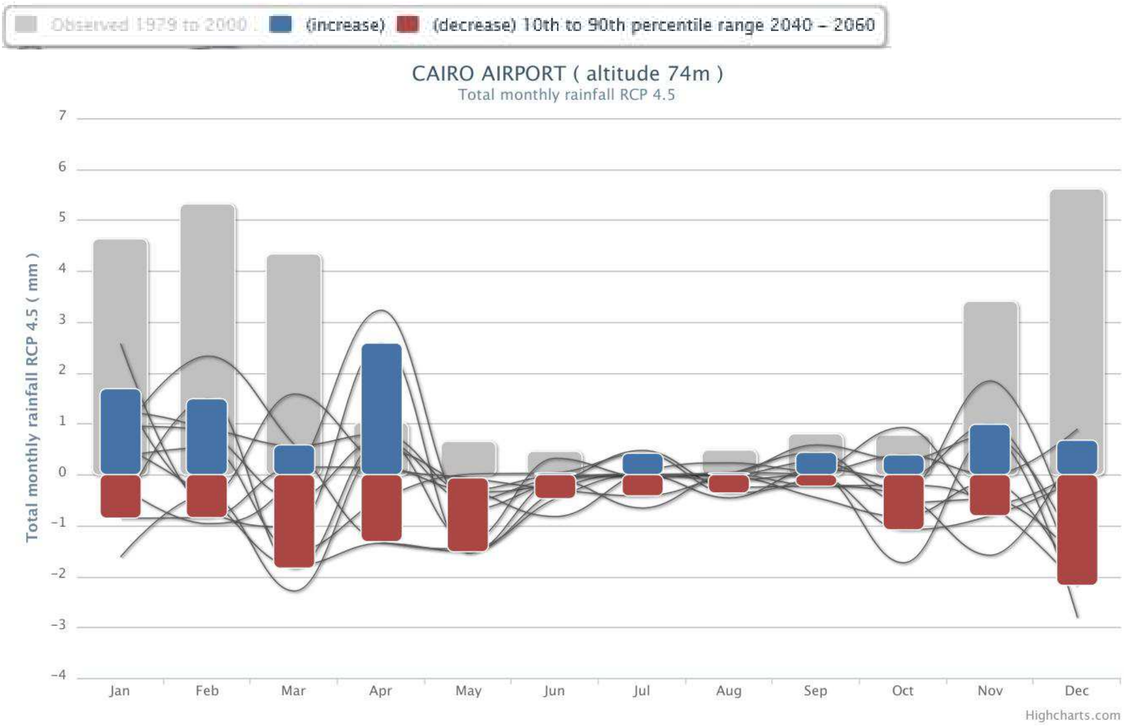

Figure 3. Total Monthly Rainfall Projection for Period of 2040–2060 Based on RCP 4.5 in Giza. The lines show the results for each of 7 climate models.

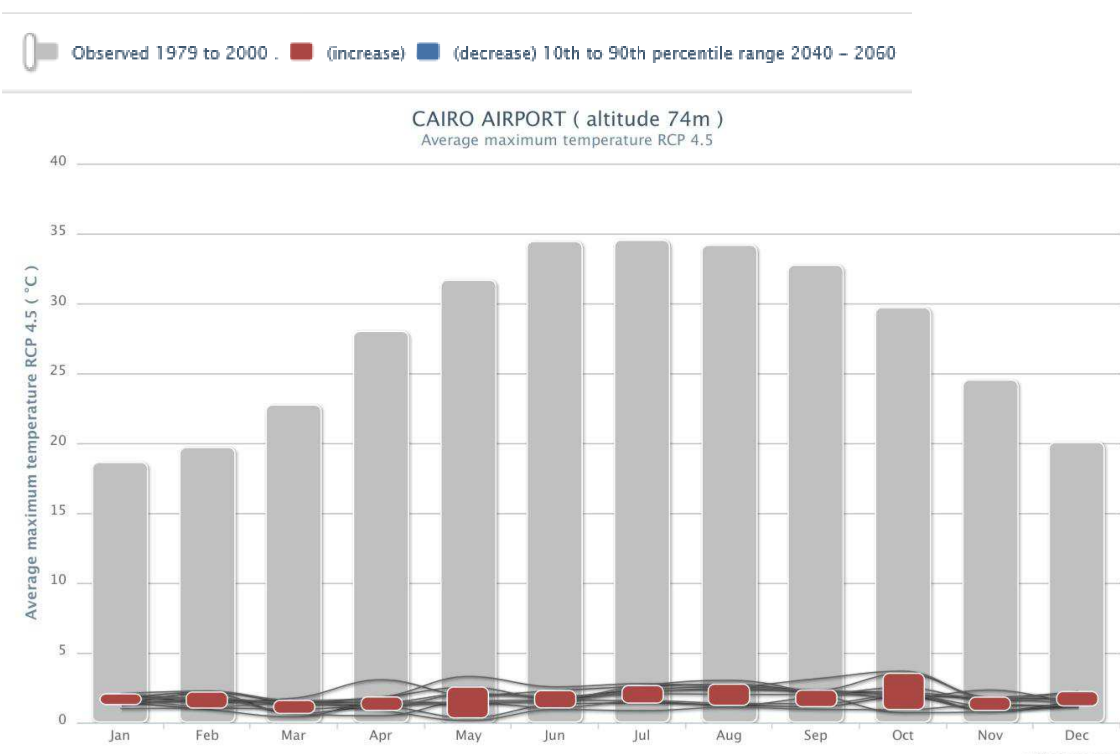

Figure 4. Average Maximum Temperature for Period of 2040–2060 based on RCP 4.5 in Giza. The lines show the results for each of 7 climate models.

THE CLIMATE COMPARISON WITH OTHER STATION

When we look through the data from the Ismalia station, the future climate projections based on RCP 4.5 Scenario suggest patterns almost similar to our earlier interpretations for the Cairo station. For example, in terms of rainfall (Figure 5~~Figure 5~~), amount of rainfall will decrease in most of the months. The average maximum temperature (Figure 6~~Figure 6~~) is also getting increasing all over the year in both stations. However, in contrast to Cairo station, the amount of rainfall increasing is projected in July and September in the Ismalia station. Likewise, the number of months getting drier is more in Ismalia.

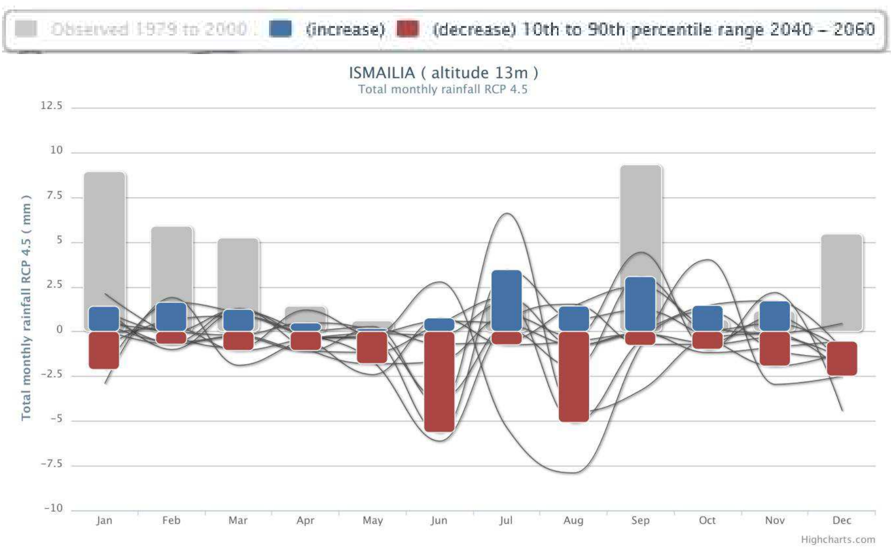

Figure 5. Total Monthly Rainfall Projection for Period of 2040–2060 based on RCIP 4.5 in Ismalia

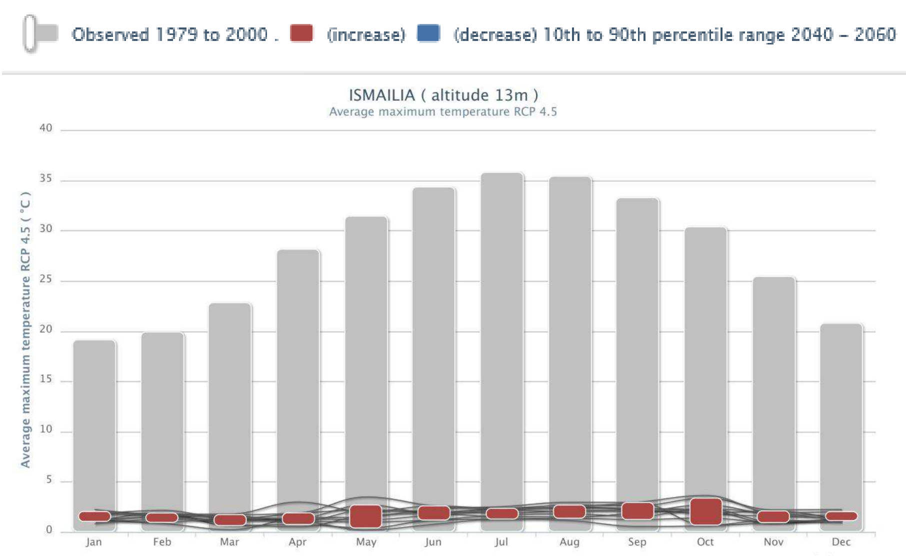

Figure 6. Average Maximum Temperature Projection for Period of 2040–2060 Based on B1 (2046–2065) in Ismalia

CONCLUSION AND RECOMMENDATION FOR WHEAT INDUSTRY

The growth requirements for wheat released by the FAO shows wheat grows best in the region that has an annual rainfall of 450–650 mm or 1000–1500 m^3 per cropping period per feddan (Ibrahim FN, Ibrahim, et al. 2003). It means that currently there is less rainfall than would be needed for optimal wheat production.

There are 3 levels of land suitability, namely S1 (minimum number), S2 (maximum number) and N (not suitable). Based on Table 1~~Table 1~~, a land will be very suitable for wheat cultivation if it has an annual rainfall about 664 mm. So, historical data for the Giza region (Figure 1) and the annual rainfall based on weADAPT–CIP indicate that Giza could be categorised as N area for wheat cultivation if the area doesn't have good irrigation, because the annual rainfall in this area is about 100 mm. In addition, based on the trend projection (Figures 3 and 4) for the period of 2045–2065, it is likely that monthly rainfall will decrease in this region (except in May and November). This could be a negative trend for wheat farmers in Giza as the suitability will decrease as a result of a decline in precipitation.

When we look at temperature, the other growth requirement for wheat, it could also be an obstacle for wheat cultivation. The current average temperature over the Giza region ranges from 15 ^{o}C to 25^{o}C (Figure 1), which is suitable for wheat growth. Based on Growth Degree Day tool, the temperature limiting criteria for potential growing season is 2^{o}C–30^{o}C (Neamatollahia, et al. 2012). However, in the future, the average maximum temperature is projected to increase to over 30^{o}C. This condition will be difficult for wheat cultivation.

Climate and climate change is one of the main issues for wheat cultivation. Our analysis suggests that efforts by the district government to improve water drainage structures and irrigation canals might help increase the suitability level for wheat cultivation. A further detailed technical study on the assessment and ranking of adaptation options would complement this work and would be important in making decisions regarding the vulnerable zone. Further research in creating the new wheat varieties that can possibly be planted in a region that has less annual rainfall is also important to help farmers in Giza.

Giza may also have virtually no land suitable for rainfed production in the future. Estimates of such potentials for other countries should be given, considering agroecological suitability for growing rainfed wheat only or, more realistically, a mix of several crops (Marquina, A. 2002). Good wheat production would make the wheat industry resilient, which would help the food industry to provide food security. There are some key industrial issues such as improving storage facilities, cold transportation efficiency and value added post-harvest production for small-quantity industry. Wasted wheat due to poor infrastructure in the storage network is a big problem in Egypt (McFeron, 2015). The projected climate can make this condition worse if there is no effort from stakeholders to repair the storage facilities. Poor transportation can also increase wasted wheat. For the small wheat industry which cannot afford good enough transportation facility for its distribution, it is better to consider value added post-harvest production such as biodegradable plastics, paint stripping, raw materials for cosmetics and ethanol.

Table 1. Land Suitability Level for Wheat (FAO, n.d-b)

REQUIREMENT	**LAND SUITABILITY LEVEL**		
	S1 (minimum)	S2 (maximum)	N (not suitable)
TEMPERATURE (OC)	2	30	<2 and >30
WATER REQUIREMENT/ANNUAL RAINFALL (MM)	556 (Applied irrigation under current climate)	664 (under climate change)	<450 and >664
ELEVATION (M)	0	3000	>3000

PH	6	8	<6 and >8

Wheat cultivation growth requirements for the Giza region suggest that it currently has insufficient rainfall for optimum wheat production. Although efforts to improve water drainage structures and irrigation channels may help to combat projected decreases in rainfall for wheat and other crops such as maize, rice, tomato and sugar cane, new crop varieties that can accommodate increases in temperature, to address the spread of fungal diseases and drought, will be needed. Other adaptation measures are needed in Egypt to address sea-level rise, storms and an increasing competition for water, will also be needed through improved coordination, the preparation of action plans, the establishment of monitoring processes to improve implementation procedures, planning and resource allocation amongst stakeholders.

KENYA

GEOGRAPHICAL LOCATION, DEMOGRAPHICS AND ECONOMIC ACTIVITIES

Kenya is located across the equator in East Africa from latitude 6°S to 6°N. The land area is approximately 582 646 km^2. On the west side of Kenya, the climate is tropical, but characterised by diverse topography that comprises the coastal plains of the Eastern Plateau, Great Rift Valley, highlands and the Lake basin. In 2009, Kenya's population was estimated at 39.8 million with growth rate of 2.6%. About 31 million of the population lives in rural area while the urban population is about 8 million, with a growth rate of about 4%. That growth, grazing pattern of strong population together with deforestation and climate change causes much environmental damage (USDs 2010).

Vulnerability of low-carbon and climate resilient industrial development is a major environmental challenge in Kenya. Livelihood and economic activities in Kenya are highly vulnerable to climate change in space and time. Most of the area in Kenya is dry, with less that 500 mm of rainfall per year, which limits the potential of agro based economic activities. Land degradation is a major issue in Kenya, partly determined by grazing and deforestation; while biomass use is at 78% of the energy consumed in the country (MENR, 2010).

INDUSTRIAL ANALYSIS AND CLIMATIC DISASTER FOR DIFFERENT INDUSTRIES

The frost that occurred during 2011 mostly affected tea production across the country and resulted in diminished turnover of processed tea (GoK, 2011). In a technological capacity, Kenya's energy system is highly dependent on climate sensitive hydropower. Droughts decrease river flow, whilst floods lead to siltation – both affecting energy output. Another aspect that exposes industries to high vulnerability of climate change comes from the structural ownership. The assessment divulged that a majority of industries are characterised by weak business ownership structures, primarily functioning as family entities or sole proprietorships. Another aspect of vulnerability is the decreased supply of agricultural commodities, which triggers industrial processes to shut down and, consequently, has the effect of staff layoff.

The vulnerability of climate change in Kenya threatens industrial shut-down, and changing temperatures and precipitation are leading to decreases in availability and increased prices of critical raw materials in the supply chain. Despite these challenges, opportunities for enhancing the operational capacity of industries for low-carbon and climate resilient development in terms of reducing energy and water scarcity is presented in the adoption of Resource Efficient and Cleaner Production (RECP) programmes that have been initiated in some parts of the country such as LVEMP in the lake Victoria basin (KNCPC, 2014).

Aspects of the operational capacities of industries were also examined as part of the larger orientation of the country to low-carbon and climate change resilient development. Several operational capacity dynamics of the industries were considered. To begin with, the technical skills at the managerial level of the industries were found to be very low. This has had the effect of jeopardising the opportunities by highlighting issues relating to climate change in the routine activities as well as diminishing the sense of commitment of top management of the industries to pursue actions and strategies that are responsive to the search for low-carbon and climate change resilient industrial development.

POLICIES FOR VULNERABILITY TO CLIMATE CHANGE

Kenya is endowed with a very rich set of policy, legislative, and institutional frameworks critical to advancing the course of low-carbon and climate change resilient industrial development. These instruments are embedded in various industrial operational structures of governance in the country. The Constitution of Kenya (2010) creates the space for development of responsive policies, legislations and strategies on climate change adaptation and mitigation by providing for the right to a clean and healthy environment. Part two of the constitution on environment and natural resources grants the state specific powers to institute measures to promote sustainable use of natural resources, enhance public participation in environmental governance, establish environmental impact assessment, and audit and equitable distribution of natural resources. The constitution further provides for distribution of functions between national and county governments, thereby paving the field for multilevel actions and programmes on environmental sustainability. To this end, the extent to which the policies and legislation of the country adequately respond to climate change issues is largely dependent on the degree to which the parliament promulgates legislations.

The Kenya Vision 2030 is the blueprint that espouses economic, social and political pillars. Environmental issues are encapsulated in the social pillar. The vision proposes strategies to improve the environment. They include: promoting environmental conservation; improving pollution and waste management through the design and application of economic incentives; commissioning of public-private partnerships (PPPs) for improved efficiency in water and sanitation delivery; enhancing disaster preparedness in all disaster prone areas; and improving the capacity for adaption to climate change. It emphasises application of efficient energy use in consumption and production processes, including enhancing energy with exploitation of more renewable energy sources. Reform of public sectors is also stated as fundamental to national development. In addition, the vision recognises the centrality of science, technology and innovations (STIs) across the pillars but does not peg specific STIs on strategic goals for promotion of environmental sustainability.

To this extent, the vision provides important direction for addressing issues of climate change in both adaptation and mitigation. Mitigation is, however, implicitly taken care of in the context of energy efficiency, renewable energy, environmental conservation, and pollution and waste management.

In addition to the Constitution and the Kenya Vision 2030, there are other policy and legislative frameworks that directly or indirectly address climate change. One of the frameworks is the Environmental Management and Coordination Act (MENR, 1999), which is the principal instrument of the government for the management of the environment. With respect to implementation of EMCA, the National Environment Management Authority (NEMA) is mandated to exercise general supervision and coordination of matters relating to the environment. It plays a role in mainstreaming the environment into policies, plans and programmes, and to prepare the annual state-of-environment report.

NEMA found its scope was too wide and often in conflict with the mandate of other ministries and agencies. Faced with the choice of enhancing the capacity of NEMA to deal with climate change issues, Kenya opted for it. This is provided for in the National Climate Change Bill 2014 which establishes the National Climate Change Council will be a body corporate whose function will be to advise national and county governments on legislation and other measures for climate change mitigation and adaptation, coordinate, prepare reports, and undertake negotiations on climate change matters.

CLIMATE CHANGE CHALLENGE FOR TEA INDUSTRY

Kenya is the largest tea growing country in Africa and the fourth-largest producer of tea in the world after India, China and Sri Lanka, and is the only country in Africa to produce a substantial amount of tea for the world market. Most of the tea in Kenya, around 90%, is grown on farming operations of one acre or less. Tea is central to Kenya's economy and contributes 4% of the GDP with tea export, representing 26% of the total export earnings (Ratetea, 2015).

Tea is grown in the areas at high altitude – more than 1500 m above sea level – with adequate rainfall and low temperatures. The annual rainfall needed is 1200 mm up to 1400 mm and well distributed throughout the year, while the temperature required is 16–29˚C (Omondi, 2015). In Kenya, tea farming can be divided into the highlands on the east and west of the Rift Valley, including Kericho and Nandi in the western highlands and Nyambene and Nyeri in the eastern highlands (SoftKenya, n.d).

One of the main problems facing the tea industries in Kenya is climate change, including drought, rising temperature, hail and frost. The increasing impact of climate change is generating unpredictable harvest, leaving many small scale tea farmers and the industries struggling to plan for the future. This section shows how the climate information will support tea industries to determine the suitability of a tea plantation in the future to increase tea production, especially for the Kericho region as one of the major tea plantations in the western Rift Valley.

HISTORICAL CLIMATE DATA

The long-term monthly climatology of total rainfall and monthly average maximum and minimum temperatures are showed in Figure 7~~Figure 7~~. The driest month in the period of 1979–2000 has historically been in December, with average monthly rainfall around 80 mm, and the wettest was in May, with an average of 250 mm. During the period, the average monthly rainfall was about 150 mm, indicating that the Kericho region has enough precipitation for tea plantation.

Historically, the highest average maximum temperature was in February and the lowest was in July, but the difference is not much. The minimum temperature recorded was 10.53˚C in September and the maximum was 25.60˚C in February. The gap between average maximum temperature and minimum temperature is significant.

These monthly climatology values calculated from the historical monthly record data, as shown in Figure 8 below, indicated different climate variables for the location. This is useful for identifying particular climate events such as floods and droughts as well as observing long term variability or trends. The data indicated that the highest total monthly rainfall during the period occurred in May 1987 with 450 mm and the lowest was in February 1997.

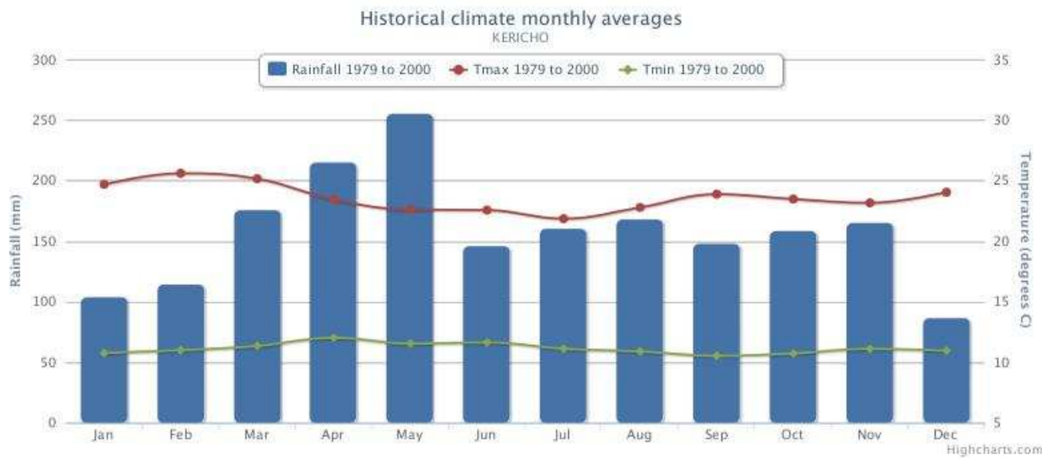

Figure 7. Historical Climate Monthly Average in Kericho, 1979–2000

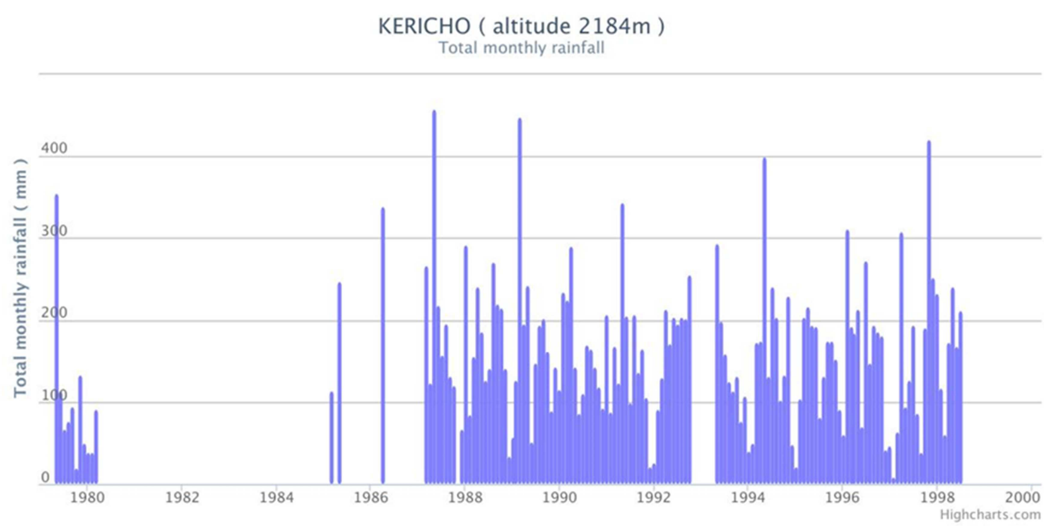

Figure 8. Total monthly rainfall in Kericho, 1979–2000

FUTURE CLIMATE PROJECTIONS

The projected future changes for the location across 10 different statistically downscaled CMIP3 GCMs for RCP 4.5. According to midterm projected changes for the period of 2040-2060 shown in Figure 9~~Figure 9~~, in general, the total monthly rainfall is predicted to increase throughout the year. However, decrease in total monthly rainfall is also possible and can take place almost a whole year except in January, February and July.

The highest increase of total monthly rainfall in the period is expected to occur in November with an increase of more or less 38 mm. Overall, the highest decrease in total monthly rainfall is predicted to occur in June. However, such decrease will not affect the total rainfall in the region. The Kericho region is predicted to still receive total monthly rainfall in sufficient quantities.

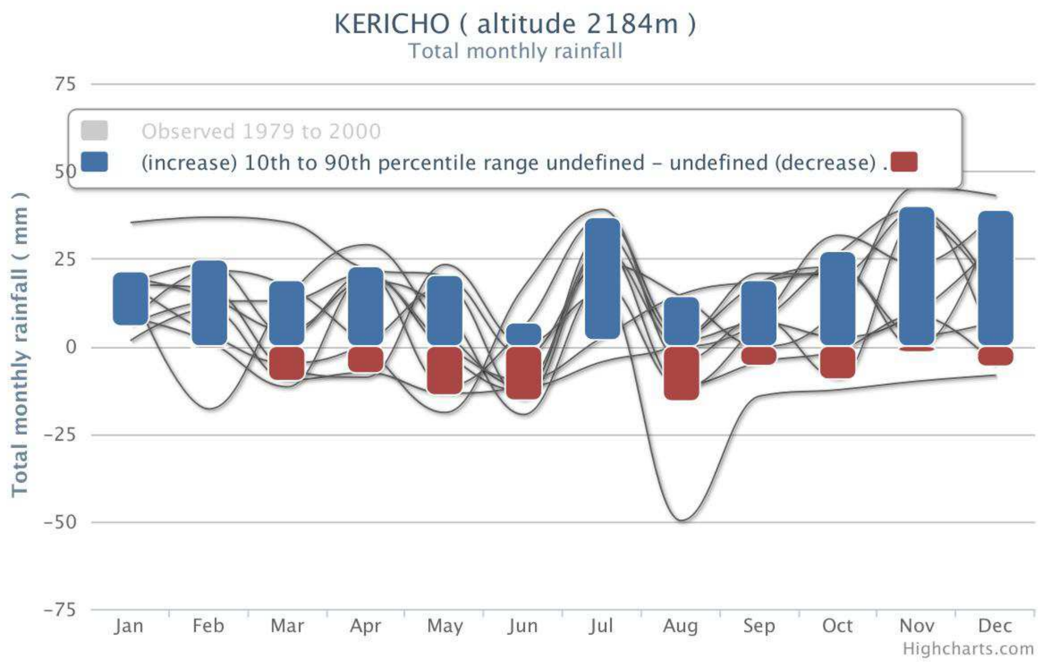

Figure 9. Projected Changes in Total Monthly Rainfall RCP 4.5 in Kericho Station, 2040–2060 (CIP. 2001)

For the long-term projection, as shown in Figure 10~~Figure 10~~, total monthly rainfall decrease is less than those for the midterm projection. The decrease of total monthly rainfall is predicted to occur in a few months only, namely, March, April, May, June, and slightly in December; however, the change is more drastic. The total monthly rainfall in May does not increase; however, the total monthly rainfall in the Kericho region is still more than 100 mm.

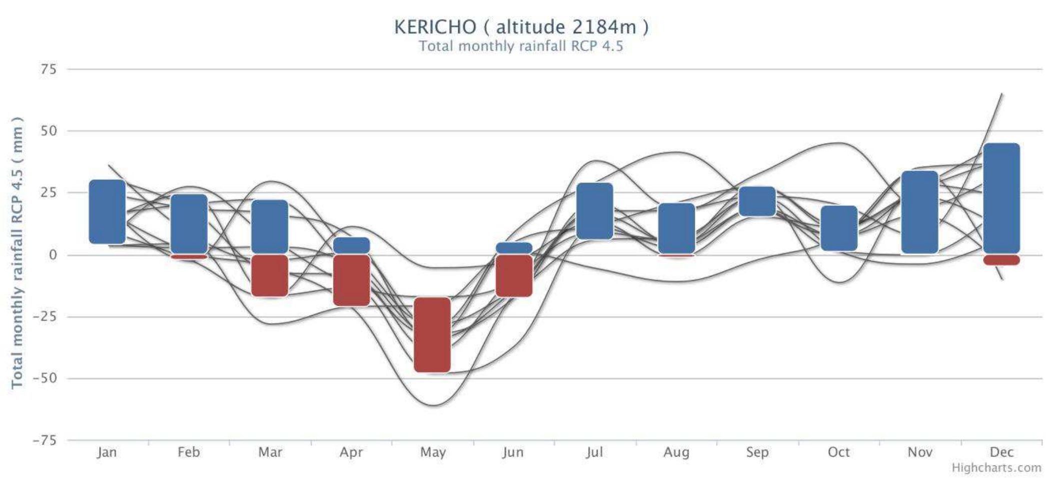

Figure 10. Projected Changes in Total Monthly Rainfall RCP 4.5 in Kericho Station, 2070–2090 (CIP, 2001)

The average maximum temperature in the period of 2040–2060 (Figure 11~~Figure 11~~) indicates a rise in average maximum temperature throughout the year by a range of 0.4˚C to 1˚C. The highest increase is predicted to occur in June and September, whereas the lowest possible to occur in April. Meanwhile, the average minimum temperature is predicted to increase by a range of 0.6˚C to 1.2˚C, as shown in Figure 12~~Figure 12~~. This projection indicates that differences between maximum and minimum temperatures in the period of 2040–

2060 become smaller compared to the observed period (1979–2000). The maximum temperature is projected to reach 26.6˚C, while the minimum temperature is forecast to reach 9.3˚C.

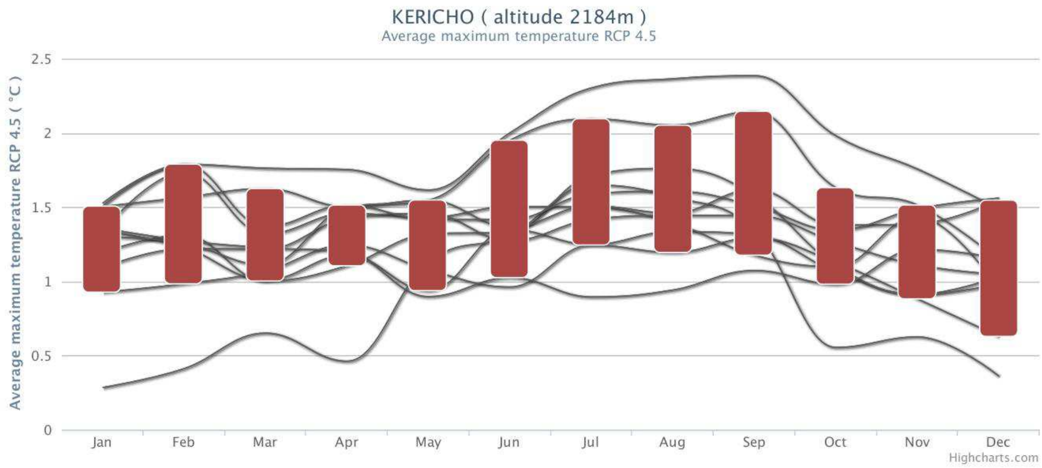

Figure 11. Projected Changes in Average Maximum Temperature RCP 4.5 in Kericho Station, 2040–2060 (CIP, 2001)

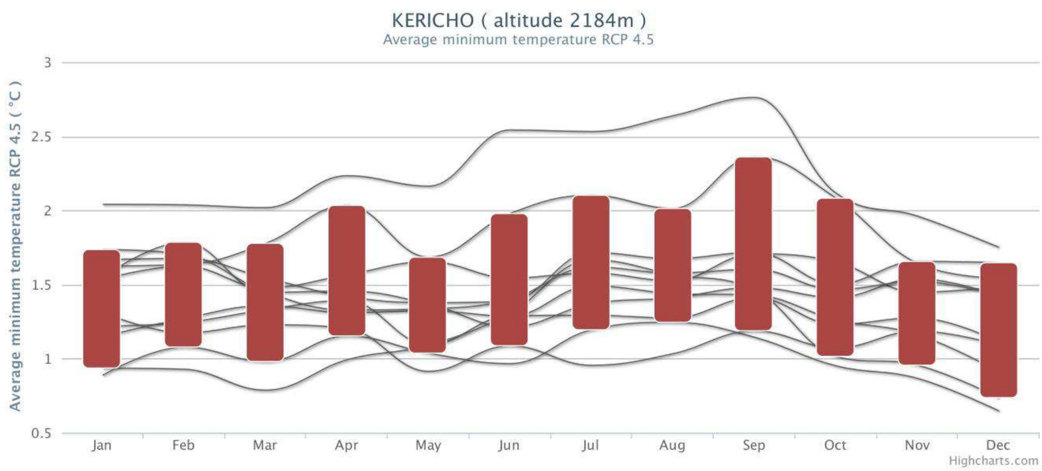

Figure 12. Projected Changes in Average Minimum Temperature RCP 4.5 in Kericho Station, 2040–2060 (CIP, 2001)

In the projection for long term period (2070–2090), as shown in Figure 13~~Figure 13~~ and Figure 14~~Figure 14~~ below, both average maximum and minimum temperatures are expected to experience a slight increase compared to the midterm projection.

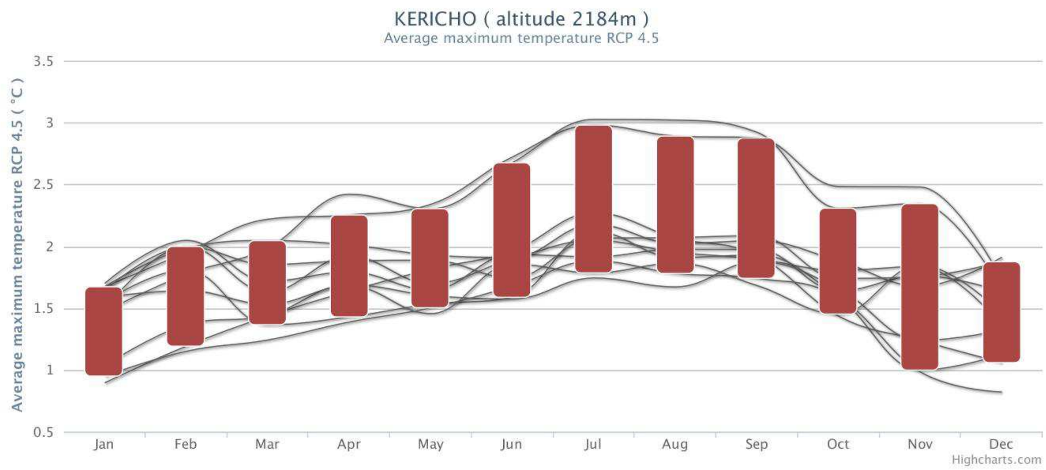

Figure 13. Projected Changes in Average Maximum Temperature RCP 4.5 in Kericho Station, 2070–2090 (CIP, 2001)

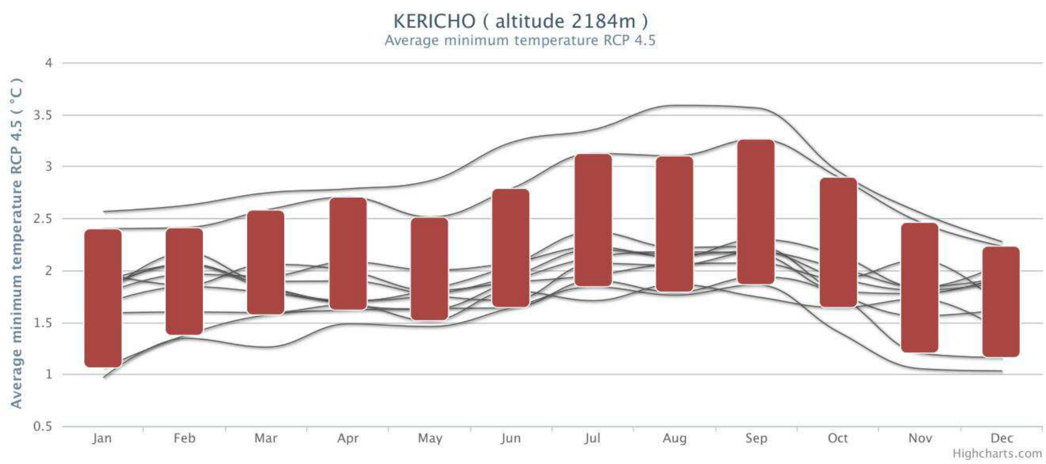

Figure 14. Projected Changes in Average Minimum Temperature RCP 4.5 in Kericho Station, 2070–2090 (CIP, 2001)

THE CLIMATE COMPARISON WITH OTHER STATION

The total monthly rainfall in the Nakuru region is expected to increase in the midterm (2040–2060) period, according to scenario RCIP 4.5, as shown in Figure ~~Figure 15~~. The historical climate monthly average and the projection for the midterm period shows that the Nakuru region is still drier than the Kericho region in spite of the predicted increase in the future.

The projected temperature of Nakuru station show that the average average maxiumum in the region will be less than in the Kericho region. The highest average maximum temperature in the period of 2040–2060 will occurr in July and August with increasing by 2.25^{0}C, while the lowest will be in December with increasing nearly 0.5^{0}C. Meanwhile, the projected highest and lowest average monthly maximum temperature in the Kericho region is increasing by 3^0 and 1^0 C respectively. Moreover, the hot period occurred from June to September.

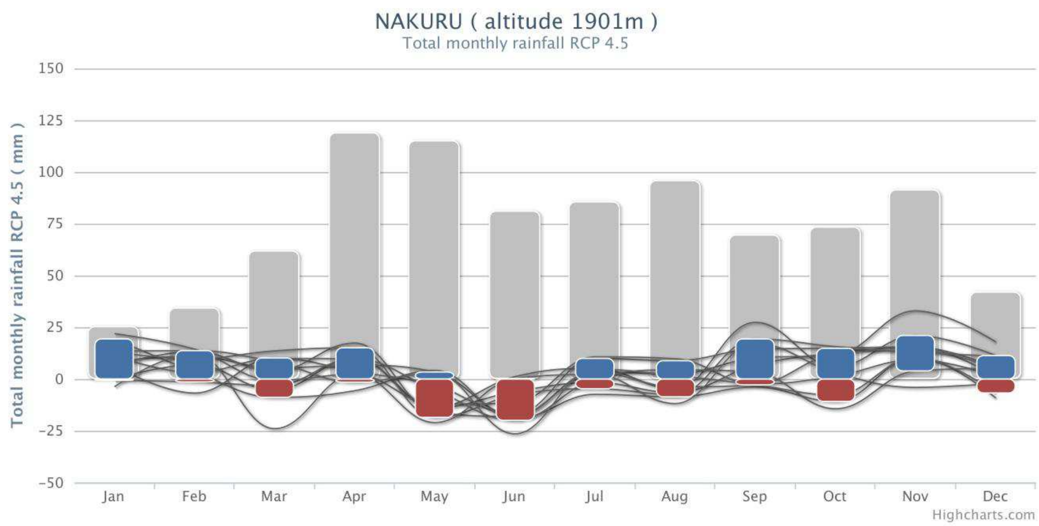

Figure 5. Projected Changes in Total Monthly Rainfall Scenario RCP 4.5 in Nakuru, 2040–2060

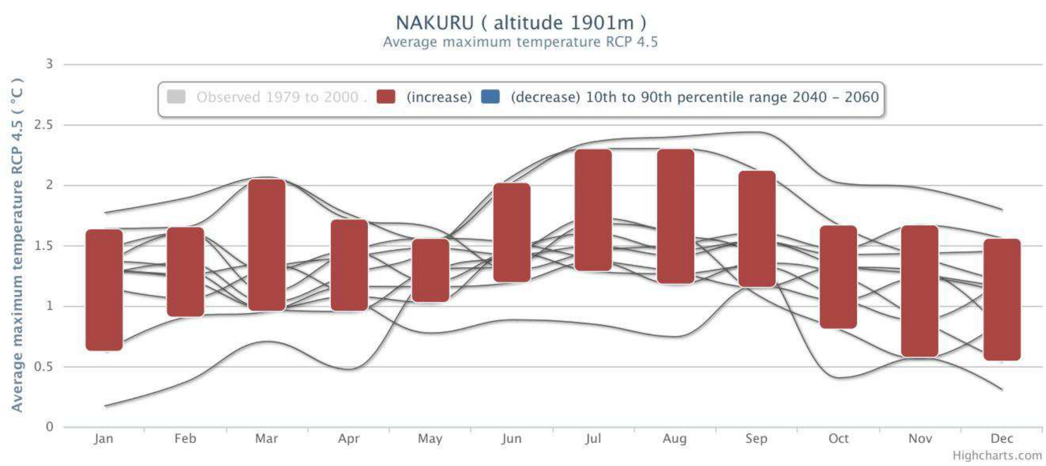

Figure 15. Projected average maximum temperature in Nakuru, 2040–2060

CONCLUSION AND RECOMMENDATION FOR TEA INDUSTRY

Kenya posses a rich set of policy, legislative and institutional frameworks to implement low-carbon and climate resilient industrial development that are embedded in various industrial operational structures of its governance. Opportunities exist to enhance the implementation of existing legislation.

Climate and geography are key factors in determining both where tea can be grown and how the tea grows. In the Kericho region, climate change models projections for rainfall suggests that it will be suitable for tea plantation until the year 2090, however adaptation measures such as a new tea species that are resistant to low temperature, hail and frost, will still be needed as temperatures the minimum temperature is too low and which will affect the growth and the quality of tea. The Nakuru area is less suitable for planting tea because the average monthly rainfall is less than 100 mm and not spread evenly throughout the year. To adapt to these conditions, the tea researcher or the government might have adaptation measures such as a new tea species that are resistant to low temperature, hail and frost. As tea industries depend on the tea plantations, the latter may have to support the adaptation actions by the farmers. Renewable energy technologies may help to make the storage and the transportation system more efficient and sustainable; allowing the tea production industry to allocate its budget to help the production stage adaptation with climate change. The industries need to connect energy-agriculture nexus to produce sustainable energy for supporting tea value chain. It is also important to take into account to increase value added post-harvest production for small plantations.

SENEGAL

GEOGRAPHICAL LOCATION, DEMOGRAPHICS AND ECONOMIC ACTIVITIES

Senegal is located in the far west of Africa. The total area of Senegal is approximately 196,722 km^2. It is a flat country and the highest point of the country is Fouta Djallon foothill. The population of Senegal is about 13.9 million with most of the population living in urban areas in the west and the centre of the country. The annual demographic growth rate is about 2.7%. The power supply is provided by thermal power plant. The energy system in Senegal relies on traditional biomass like wood and charcoal, and is dependent on oil imports (ISW, 2010).

The poverty rate in Senegal is 46.7% of the population. The unemployment rate is about 25.7% of the total population. The informal industry employs 48.8% of the labour force and it contributes 41.6 % of the Senegal GDP and for the non-agricultural industry is 57.7% (ANSD, 2013). The agriculture industry contributes a small GDP of 13.7%; livestock 3.7%, and fisheries 1.3%, while employing almost 60 % of the workforce. The Senegalese economic activities are diverse, but the country is vulnerable to external factors such as international economy and fluctuation of the world's prices. The country's activities are also dependent on natural resources, which amplifies their vulnerability to climate change.

Senegal has two types of distinct seasons: the dry season from November to April and the rainy season from May to October. Of the total area of Senegal, 700 km is the coastline area. The annual average rainfall is 687 mm (FAO aquastat, 2005). The northern part of Senegal has less rainfall (300 mm) than the southern part (1500 mm). In spite of the low rainfall, Senegal is well endowed with water resources which represent, potentially, 7 billion m^3 per annum and renewable groundwater 3.5 km^3/year. Arable soil represents 19% of the total surface in Senegal, with 66 % of it is being cultivated. Only 2 % of this area is under irrigated cultivation. The vegetation consists of steppes, savanna and forest. Forest areas occupy 45.1% of the national territory (8 673 000 hectares), of which 18.4% are primary forests (Planchon, 2014).

INDUSTRIAL ANALYSIS AND CLIMATIC DISASTER FOR DIFFERENT INDUSTRIES

Climate change in Senegal goes beyond the current annual climate. It also affects the productive industries and biophysical environment. Projections predict a temperature increase of up to 3%, with most of the warming area in the coastal zones. The rainfall rate or events will decrease rapidly. Climate change will further increase the number of urban dwellers facing water shortage. In some cities, water availability will decrease owing to climate change, whereas other cities will see increases, with more cities having less water than having increased flows. Climate change does not greatly change the aggregate number of urban residents facing seasonal shortage, although the effect for particular cities may be large (McDonald, et.al. 2011). It also alters water quality and salinity, as well as increase tension between agriculture industries, industrial industries, and domestic industries. The assessment of damage caused by floods indicates that the government will lose US$ 104 million and the rehabilitation will amount to US$ 204.4 million. The impact is amplified by deficiency of regional planning and the lack of respect for town planning.

In the agriculture industry, it is expected that cereal production will decrease by 30% per capita by the year 2025. This will result in significant change in the food industries and will affect food production quality as well as quantity of milk and meat production. In the coastal areas, human activities put pressure on coastal development and the fragile environment. Coastal erosion is the biggest threat in Senegal. The Senegalese authorities are aware on the climate change and realising that it must be integrated into the policy of socio-economy development of the country. The government has initiated a decisive turn towards emergence through the emerging Senegal plan. Other funded projects also initiated and proposed some actions for mainstreaming the climate change in the industrial policy, particularly in the food processing industry. The key measurements include climate change adaptation, environment assessments, and climate risk management tools.

One of the projects, the Bureau de Mise a Niveau has a mission to promote enterprises through the implementation of upgrading programmes that enable competitiveness and the mitigation of environmental impact in Senegal. It also promotes the Green Industry in agro food processing industries. The methodology of the project is based on a consultancy and participatory approach based on SWOT (strength, weakness, opportunity, and threat) analysis on how climate change interacts with socioeconomic issues, especially agro food industry and vulnerability existence in Senegal. The SWOT analysis is used as a strategic guideline among stakeholders in industrial industries and to find the relevance of the climate change and dynamic interaction with the strategic exploitation of the environment in Senegal. It will enable the stakeholders to define the scenario for temporal horizon of the climate projection for the periods 2031-2050 and 2081-2100.

POLICIES FOR VULNERABILITY TO CLIMATE CHANGE

The industrial policy of Senegal follows a horizontal approach based on the improvement of the private business environment and it is characterised by the private industry promotion through SMEs (small medium enterprises). The SMEs are regarded as essential sources of employment, a driving force for economic development, richness creation, and fighters against poverty. Due to the private industry involvement, upgrading policy is needed in the industrial restructuring policy in Senegal. The upgrading policy aims to accompany enterprises in an improvement process based on competitiveness key factors while planning ahead up to 2020 and rebalancing factory constructions. It will fill the gap of regional disparities characterised by a strong concentration of companies, especially in the Dakar region.

Industry vulnerability to climate change in Senegal is expressed differently depending on whether it concerns territory or specific industrial industries. Various documents of environmental strategy do not mention specific industrial industry vulnerability. The industrial industry vulnerability in relation to climate change is expressed in sensitive areas, such as coastal areas. It is shown by industry dependence on agricultural raw materials and fishery, industry access to resources for adaptation actions, and quality of industrial equipment or obsolescence.

The policy of climatic risk is analysed at three levels: vision in medium and long term, strategic industry orientations and implementation from a strategic viewpoint of vision in the long term, and operational viewpoint. The operation goes through industry policies and programmes set up by mitigation adaptation requirements. The strategic framework analysis will be done by international climate commitments of Senegal, the National Strategy of Economic and Social Development, and the Emerging Senegal Plan (PSE). The PSE constitutes the framework of new development strategy defined by the Senegalese authorities over the period 2014–2035. It is based on an integration approach of all public development policies including SNDES (Stratégie Nationale de Développement Economique et Social) which resumes the last two axes. It is articulated around three major axes: structural transformation of economy and growth, human capital and social protection and sustainable development, governance, institutions, peace and security. The climate change issue is also addressed at city/province level.

Based on the policies and regulations mentioned above, Senegal participated in the programme entitled "Towards territories emitting fewer greenhouses gases and more resilient to climate change”. The programme helps to develop the original cooperation between Senegalese regions and French regions in the fight against climate change. Due to its geographical location on the Atlantic Ocean seafront and a flagrant imbalance of industrial facilities and human settlements, Senegal has identified risks and disasters as constraints to its economic and social development. Risks can be related either to natural hazards, particularly flooding, or to technological hazards from industry.

The Senegalese government also promotes actions for taking account of food industry vulnerability in adapting to climate change. It aims to integrate adaptation to climate change into industry policies, carry out an environmental assessment of the Emerging Senegal Plan and integrate climate risk assessment in the different components of the PSE, encourage the development of management tools for climate risk across firms, assess industry needs for information, and perform vulnerability studies. The study on the vulnerability of industry to climate change has shown political and institutional initiatives to adapt to climate change. However, several of the initiatives and sustainable policies still need to be improved.

CLIMATE CHANGE CHALLENGE FOR FISHERY INDUSTRY

Senegal has a coastline of 718 km and a well-stocked river system, including the Saloum river, the Gambia river and the Senegal river, which cover an area of 340,000 km^2. The fisheries industry plays a prime role in the Senegalese economy and society, particularly in the area of export and the satisfaction of food needs and employment (Ndiaye, n.d). The industry accounts for 11% GDP and 17% jobs (West Africa Trade, 2008). It employs some 84 600 mainly fulltime fishers operating in marine or inland waters. Another estimated 47 800 people work in auxiliary activities, including in particular artisanal fish processing and marketing. This gives a total of 129 500 jobs in the Senegalese fisheries sector according to the BNP case study. 92 percent of this total work in small-scale activities. Two-thirds of the employment are in marine fisheries. Other sources cite some 600 000 employments in fisheries related activities, including also occasional and indirect employment (FAO, 2008). Senegal has the highest consumption of fish in Africa with 37 kg/capita/year (Peterson, et al., 2006). Fisheries is essential for Senegalese population food security and economic growth because it is also the first provider of export earnings.

Inland fisheries production has been decreasing steadily as Senegal suffers from severe water constraints, despite an extensive water network that includes the Senegal, Gambia and Casamance rivers. Some areas of the country receive less than 300 mm of water per year and rainfall has decreased by an average of 10 to 20 mm per year since the 1980s (CILSS in Peterson, et al., 2006). In the worst case, this would mean a reduction in rainfall by 720mm has been happened to date, which is quite a lot and severe condition. Senegal river is one of the three main rivers where inland fisheries are found. The analysis below uses climate data from Saint-Louis Station because this city is located near the mouth of the Senegal river.

HISTORICAL CLIMATE DATA

The long-term monthly climatology of total rainfall and monthly average minimum and maximum temperatures of St. Louis climate station in the period of 1979–2000 are shown in Figure 16~~Figure 17~~. These monthly climatology values are calculated from the historical monthly record data shown in Figure 17~~Figure 18~~.

The average monthly rainfall in the Saint-Louis area was very low except in the wet season between July and October. The wettest month has historically been September with an average rainfall of 89 mm, while the driest month has been April. The highest total monthly rainfall in the period of 1979–2000 in Saint Louis has occurred in September 1987 with around 247 mm. However, in general, Saint-Louis region has low total average monthly rainfall and it tends to experience drought. The average temperature in the Saint-Louis region ranged from 17°C to 34°C. The change in maximum temperature is mild throughout the year compared to the minimal temperature.

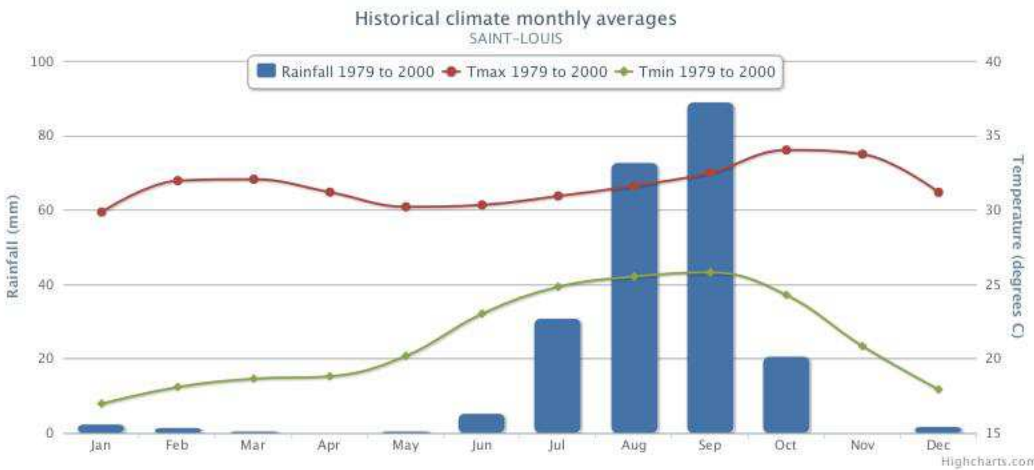

Figure 16~~17~~. Historical Climate Monthly Average in Saint-Louis, 1979–2000 (CIP, 2001)

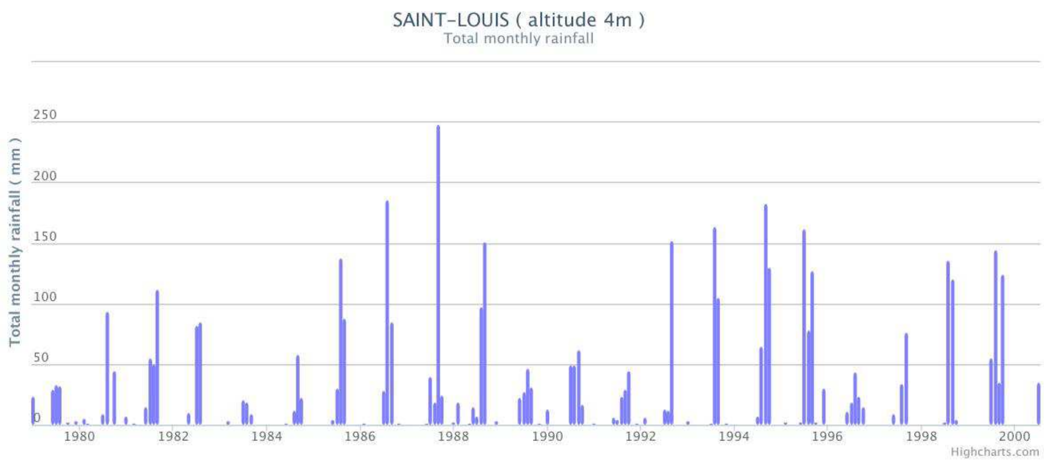

Figure 17~~18~~. Total Monthly Rainfall in the Period of 1979–2000 in Saint-Louis (CIP, 2001)

FUTURE CLIMATE PROJECTION

Projected climate changes for Saint-Louis are modelled across 10 different statistically downscaled CMIP5 CMs for RCP 4.5. In the midterm period in Figure 18~~Figure 19~~, the projection indicates an increase in total monthly rainfall throughout the year. However, during the long-term period, a few models indicate a possible decrease in total monthly rainfall. The highest decrease is predicted in August. In general, the total monthly rainfall may still increase, but in the period of 2040–2060, it will depend on the month. For the long-term projection (2070–2090), the total monthly rainfall is increasing in late rainy season, but it is uncertain (Figure 19~~Figure 20~~). Generally, the variability in precipitation will increase during the rainy season.

The average maximum temperature in the midterm period becomes higher. The change is more significant during the drier months (Figure 20~~Figure 21~~).

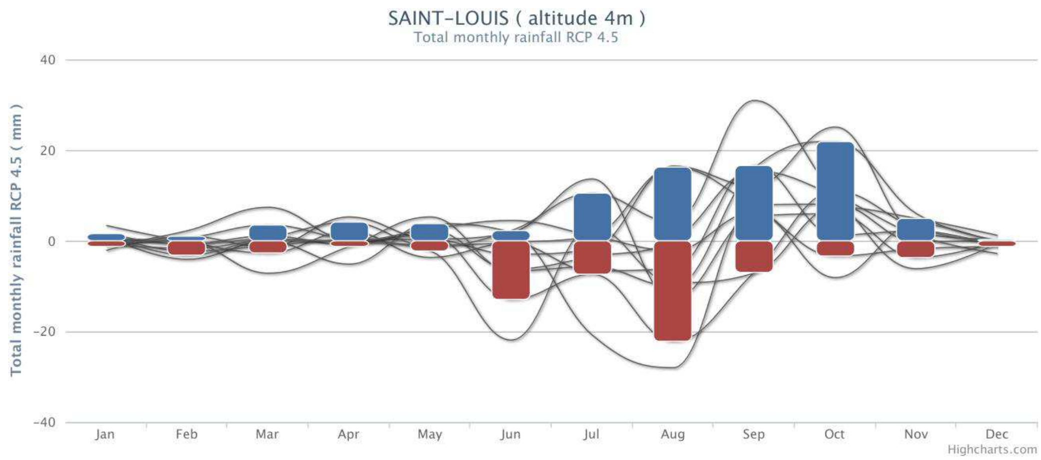

Figure 1819. Projected Changes in Total Monthly Rainfall RCP 4.5 in Saint-Louis, 2040–2060 (CIP, 2001)

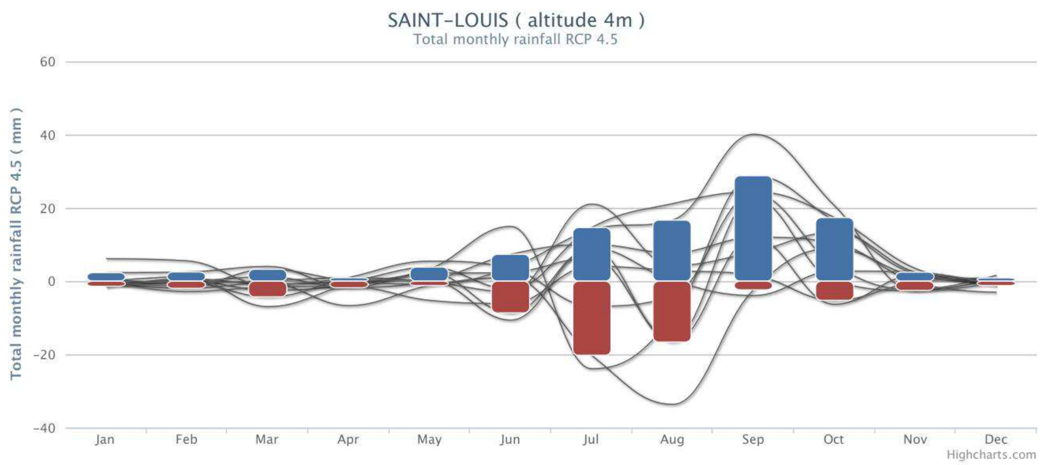

Figure 1920. Projected Changes in Total Monthly Rainfall RCP 4.5 in Saint-Louis, 2070–2090 (CIP, 2001)

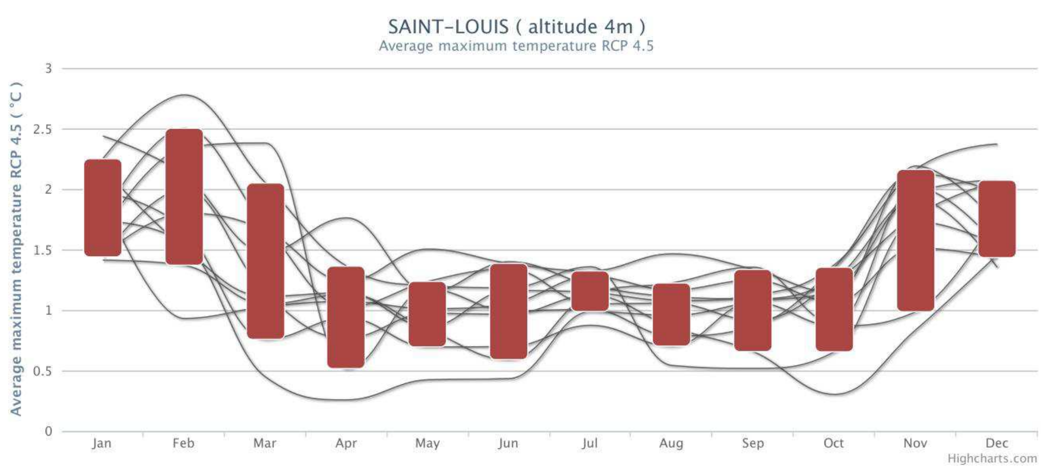

Figure 2021. Projected changes in average maximum temperature RCP 4.5 in Saint-Louis, 2040–2060 (CIP, 2001)

THE CLIMATE COMPARISON WITH OTHER STATIONS

Rosso station is the nearest station from Saint-Louis station. The decrease in total monthly rainfall in Rosso station is expected to be more than in the Saint-Louis station for mid-term period projection (Figure 21~~Figure 22~~). Rosso region is predicted to be drier than the Saint-Louis region. The projected average maximum temperature in Rosso station has almost similar pattern to that of the Saint-Louis station. However, the projected temperature increase in Saint-Louis is higher than in Rosso (up to 2.5°C).

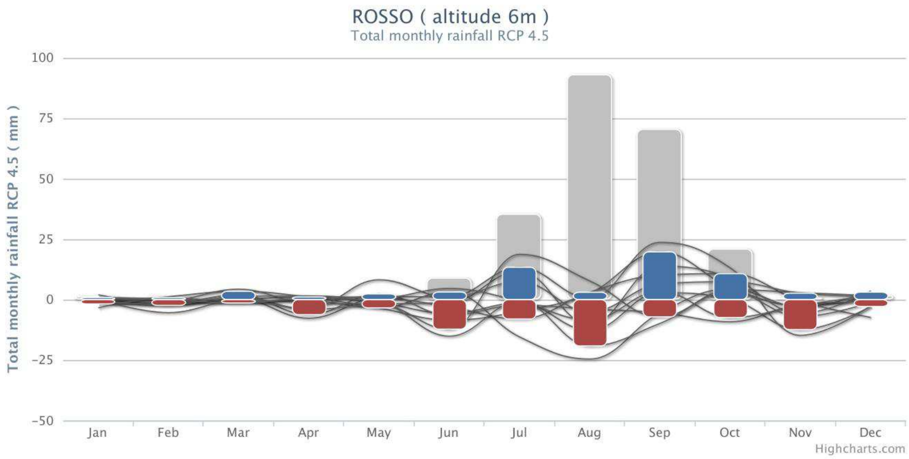

Figure 21~~22~~. Projected Changes in Total Monthly Rainfall Scenario RCP 4.5 in Rosso Station, 2046–2065 (CIP, 2001)

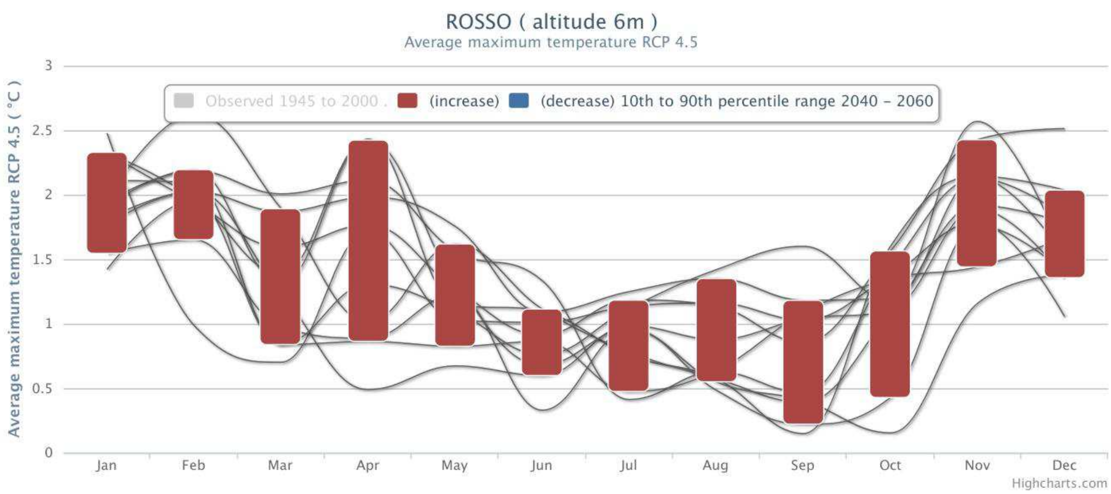

Figure 23 Projected Changes in Average Maximum Temperature Scenario RCP 4.5 in Rosso Station, 2040–2060

CONCLUSION AND RECOMMENDATION FOR FISHERIES INDUSTRY

The Senegalese government has the technical capacity to integrate climate change in their development policies and plans through several of their political and institutional initiatives. Opportunities exist to improve regional planning, the implementation of town plans, and the use of renewable energy.

Fish and fishery products play a fundamental role in food industry to support food security for the Senegalese population. However, for long-term period the projection predicted that the part of the Senegal river represented by the Saint-Louis station will experience decrease in total monthly rainfall. It could potentially reduce the fish production in the area. Inland fish are vulnerable to climate change because they have limited habitat availability and they have a more direct link with terrestrial systems, human land use patterns and human water use. To overcome the problem, the government of Senegal and related stakeholders have to work more on promoting the integrated programme of irrigation and aquaculture.

The integrated programme will help the fisheries industries to increase the exports as well as small-scale fishing to cover the domestic market. The fishing industry supports jobs for the Senegal population, counting in those who work in processing, supply, marketing and distribution. The stakeholders need to pay serious attention to this issue to make this industry sustainable for people's livelihoods.

The fishing industry has to strengthen its communities through provision of services such as insurance and weather warnings to reduce the climate risks. It also has to support participatory natural resource management and sustainable fishing operations, as well as assistance in post-harvest processing and preservation to maximise value added, employment and minimising waste from both fisheries and aquaculture industries.

SOUTH AFRICA

GEOGRAPHICAL LOCATION, DEMOGRAPHICS AND ECONOMIC ACTIVITIES

South Africa is located between latitudes 22°S and 35.5°S and longitudes 16°E and 33°E. It has a coastline of 2798 km and the surface area is 1 219 602 km^2. The land is divided into the interior plateau and the area between the plateau and the coast. The climate is temperate, ranging from dry regions in the north to the west and warm and humid climate in the eastern area. Average annual rainfall in South Africa is about 450 mm. The precipitation is quite variable, with uneven distribution and seasonal rainfall. The typical weather in South Africa is the southern hemisphere type, with the coldest days from June to August. The southern and eastern parts have the lowest temperatures. The climate trends in South Africa show an increase of rainfall intensity during the summer and spring seasons in the central interior and the south eastern part. South Africa is projected to become warmer with slight increase in temperature, which exceeds 35°C, whereas low temperature is less frequent (DEA, 2013).

The economy activities in South Africa are mining, agriculture, fisheries, vehicle manufacture, food processing, textiles, telecommunications, energy, financial and business services, real estate, transportation, tourism and trading. The highest contribution to the national economy, with a share of 33.8% of GVA (gross value added) is by the Gauteng Province. This province has the largest share of the population (23.9%) from the population of South Africa, which was estimated to be about 54 million in the year 2014, of which 27.6 million were female. Meanwhile, the smallest population (2.2%) is located in the Northern Cape (Stats SA 2014a).

INDUSTRIAL ANALYSIS AND CLIMATIC DISASTER FOR DIFFERENT INDUSTRIES

About 81% of the total land area (100.7 million hectares) in South Africa consists of agricultural land with 84 million hectares covered by natural pastures and the rest of the area (16.7 million hectares) are cultivated for crop production. The agricultural industry is divided into three activities: animal production, field crops and horticultural products. Agriculture industry contribution to the GDP has decreased over past decades, but it still plays an important role in the country's economic activities. The agro processing industry is becoming more important in South Africa. The forestry, timber, pulp and paper industries also play a major role in employment and contribute to the economy, especially for the rural community. Over 80% of the entire planted area of commercial plantation is certified by the Forest Stewardship Council and certified ISO 14001 as being sustainable managed (DAFF 2014). In its fishing industry, South Africa has a well-established business worth an estimated six billion rand per annum and contributes to about 1% of South Africa's GDP (DEA, 2013). The fishery industry faces challenges to ensure sustainability of fish resources usage. Overexploitation and illegal harvesting are some of the problems in the fishery industry. There is no assessment of the supply chain of the fish industry and therefore there is a need for measurements management and implementation of rebuilding strategies (WWF, 2011). This industry is quite vulnerable to climate change. Fishery productivity and diversity in South Africa can change due to the changing of sea surface temperature, water flow, distribution, the size of the resources, and condition and connectivity of species resources.

Another industry is mining; it contributes to 8% of the GDP and provides direct and indirect jobs to the community (FCO 2015). However, socioeconomic benefits of the mining industry have been under threat due to the recent spates of strikes and labour unrest. It also causes environmental impacts such as water pollution, significant greenhouse gas emission, and large amounts of water and energy consumption. The extreme weather has a direct impact on mining production, which has implications for the metal value chain.

Mining industry products are related to infrastructure for the transportation and tourism industries. The transportation industry contributes 9% of the GDP and about 750 000 people are employed in this industry (Stats SA, 2014b). Transportation industry produces greenhouse gases. This is mainly due to the fossil fuel dependence. Climate change can be a threat for this industry, especially in supply chain services. Therefore, integrating the climate change information into transportation industry planning can help to minimise risks to infrastructure and the supply chain from extreme weather events.

The tourism industry in South Africa is dependent on natural assets and its environments which are expected to be impacted by climate change. The impact could have effects on socioeconomic components of the regions and undermine the tourism industry's capacity to contribute to the country's economy. The industry is considered to be highly climate sensitive. A key factor of the industry vulnerability is nature-based tourism. A number of studies have highlighted that climate change is very likely to pose a significant threat to the biodiversity in South Africa (Driver et al. 2012).

All the industries above are dependent on energy industry such as electricity. The electricity production and supply industry are the largest GHG emitters in South Africa (DEA 2014). The increasing emissions from the industry were attributed to increase in consumption of coal resources. There are many old coal fired power plants in South Africa. These power plants operate less efficiently to generate electricity and use high temperature. High temperature may cause air heater pack in the power plant and emit more particulate matter. Electricity production is also dependent on water resources which makes it more vulnerable to climate change. The water is stored in dams and reservoirs and supplied via inter-basin transfer schemes, pumping stations, and pipelines. The electricity industry uses about 3% of the national water supply (DWA 2013).

For their energy need, the agro-food processing industry is largely dependent on electricity. The largest consumer of this energy is the sugar milling and refining component of the food industry. The agro-food processing industry is vulnerable to competitive land uses. The companies and firms may choose to locate themselves further away from urban areas, closer to agricultural suppliers, or remain within urban agglomerations closer to customer markets (Donovan 2009; Lambert and McNamara 2009). The agro-food processing industry is dependent on water supplies. The municipal supply of water will decrease in the future due to lower rainfall coupled with an increase in the future consumption of water, resulting in a deficit in the municipal water supply.

POLICIES FOR VULNERABILITY TO CLIMATE CHANGE

South Africa is approaching the limits of increasing productivity from a declining resource. As such, the government has prioritised the expansion of the plantation area in South Africa in regions where it is economically, environmentally, and socially appropriate to do so (DAFF 2013b). Increasing the area under forestry is considered a priority in the Industrial Policy Action Plan of the Department of Trade and Industry (DTI). However, the areas that are both available and suitable for commercial forestry in South Africa are limited and much of this limitation is driven by a competition for water, which is a scarce resource in the semiarid country (Dyer 2007). This limited availability of suitable forest land has contributed to the decline in the rate of new afforestation in South Africa, in addition to factors related to water legislation and stricter procedures around granting the necessary water licenses (DAFF 2014b).

Forestry is one of the key industries of climate change and it needs to be considered an important national policy concern. The different tree species and hybrids planted in commercial forests in South Africa have different climatic constraints and it determines the climatically optimum growth areas where these species can be matched for optimal growth and volume production. Changes in temperature and rainfall regimes are likely to impact the extent and location of land climatically suitable for specific genotypes (Warburton and Schulze 2008; DEA 2013).

Meanwhile, the food division is quite dominant in the economy share and contributes approximately 31% of the GDP (DAFF 2013a). It is recognised by the industrial policy plan action (IPAP) for creating and initiating a new job. The risk and uncertainty of agriculture activities in South Africa is influenced by climate change issues such as environmental degradation and water scarcity. As South Africa is regarded as a water scarce country with high variability in the climate conditions and limited fertile land, the challenge for the agriculture industry is to remain productive and to contribute to food security.

VALUE CHAIN

South Africa is known for diverse and wide variation in the fruit and vegetable industry. The process of producing commodities such as fruits and vegetables right up to consumption proceeds along a value chain (Musvoto, 2015). The fruit and vegetable industry in South Africa is comprised of a number of sub-industries, and these include vegetable, potato, citrus, subtropical fruit and deciduous fruit like apples, pear, apricots, peaches, nectarines, plums, and table grapes. The fruit processing industry in South Africa is growing rapidly; some of the product is sold on the local market and some it exported. The value chain of this industry includes processing, distribution, and sale. A key element of food value chains is the cold supply chain. The cold supply chain is defined as the procurement, warehousing, transportation, and retailing of the food product under controlled temperature conditions. In the livestock industry, the value chain pays more attention to the final stage of production prior to slaughter; cattle and sheep are sent through a feedlot for finishing. DAFF (2013) estimates that about 80% of broiler producers are small and micro enterprises.

The value chain of the broiler industry includes a primary industry that focuses on production, like rearing the birds, which requires inputs from chicken breeders in the form of chicks, feed from feed companies for maize production, and veterinary supplies from pharmaceutical companies. In the secondary industry, there are abattoirs, wholesalers, importers, exporters, and retailers. Electricity is also a significant input due to the need to maintain a cold chain which chills and freezes the products. A large amount of waste is generated in chicken abattoirs and some of the waste can be processed into by-products. The waste which is not processed into by-products is disposed of in various ways – by burial, rendering, land application, municipal landfill, collection by farmers for animal feeding, burning and composting, depending on waste type (Molapo, 2009).

CLIMATE CHALLENGES FOR MAIZE INDUSTRY

South Africa's (SA) worst water shortages for 23 years have caused a decline in farming output that will lower its GDP and cause food-price increases. The drought devastating parts of SA caused the country's farmers to lose up to USD 634 million in 2015 (Yende, 2015). The food industries are in a vulnerable condition.

The worst affected are KwaZulu-Natal, The Free State, Limpopo, North West and The Northern Cape, where farmers growing white maize, yellow maize, soya beans and sunflowers have incurred major losses. Meanwhile, the small population can possibly make The Northern Cape more vulnerable to drought.

The Northern Cape has fertile agricultural land. In the Orange River Valley, especially at Upington, Kakamas and Keimoes, grapes and other fruits are cultivated intensively. Wheat, fruit, peanuts, maize and cotton are produced at the Vaalharts Irrigation Scheme near Warrenton (South Africa, 2015). Maize farming in South Africa was practiced by the indigenous Indians inside the country for thousands of years up to the present. White maize is the staple food of the majority of the South African population.

The agriculture in South Africa contributes about 10% of the formal occupation. South Africa comes with double farming economy, with the well-developed profitable farming as well as the substance-based production of crops within the profound rural areas. Despite the fact that the origin of maize is still unknown, maize farming in South Africa has been one of the occupations of most indigenous people. The first known proof of maize is the fossil of pollen grains which are approximately 80,000 years in age and that are nearly similar to the recent maize pollen (Inica, n.d).

As it is well known that climate plays an important role in the production of maize, it is important to conduct more assessments on climatic factors, including the current conditions and the projected trends. The assessments use climate information from Kimberley station, the nearest station in Warrenton where maize is produced in the North Cape. The impact of climate change on maize may add significantly to the development challenges of ensuring food security and reducing poverty. This article aims to provide information to readers on the use of climate information for supporting the maize industry – particularly over the Northern Cape region.

HISTORICAL CLIMATE DATA

The historical seasonality plot below shows the long term monthly climatology of total rainfall and monthly average minimum and maximum temperatures. This provides a useful overview of the annual seasonality for a location as it indicates warm and cool periods as well as wet and dry periods. Different climate regimes will have very different seasonality. These monthly climatology values are calculated from the historical monthly record data given in Figure 23Figure 25.

During 1941–2001,the Northern Cape had a longer dry season, i.e. April to December, and a shorter rainy season, i.e. January to March (Figure 22Figure 24). The wettest month has historically been March, with a monthly average of almost 70 mm from 1941 to 2001. On the other hand, the driest months have historically been June and July with almost no rain. Historically, the minimum average temperature recorded was below 5˚C in June and July, while the maximum average temperature was 32˚C in January.

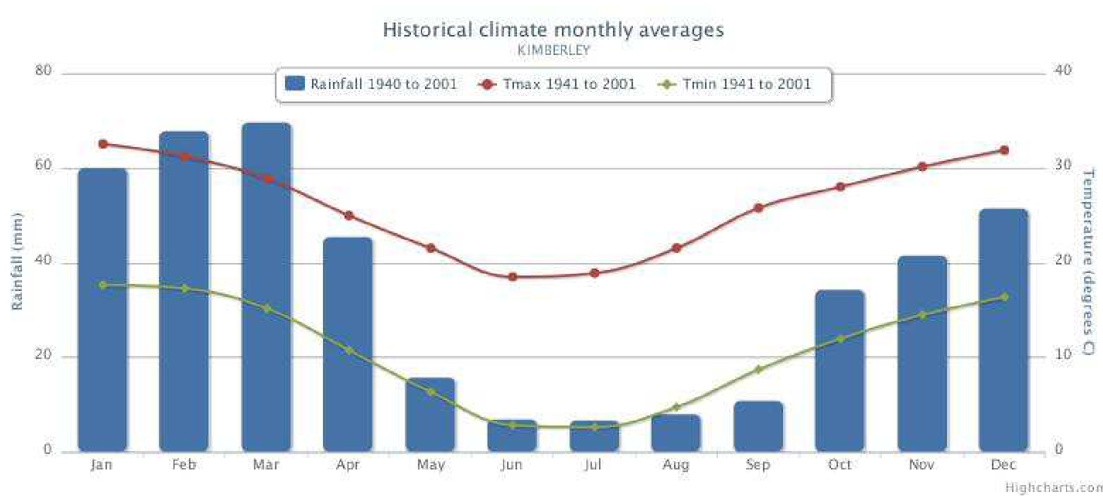

Figure 2224. Historical Climate Monthly Averages in Kimberley, Northern Cape (CIP, 2001)

The historical climate records plot in Figure 23~~Figure 25~~ shows the historical record of different climate variables for the location. This is useful for identifying particular climate events such as floods and droughts as well as observing long term variability or trends.

As shown in Figure 23~~Figure 25~~, the data from 1940 to 2000 indicate that, historically, total monthly rainfall peaks have predominantly occurred during the rainy season (February and March), but there was remarkable rainfall variation over the years. The records show months with particularly high rainfall, with totals of more than 60 mm, e.g. February 1946 and March 1988, whilst the drought period at Northern Cape has occurred in 1964 to 1965.

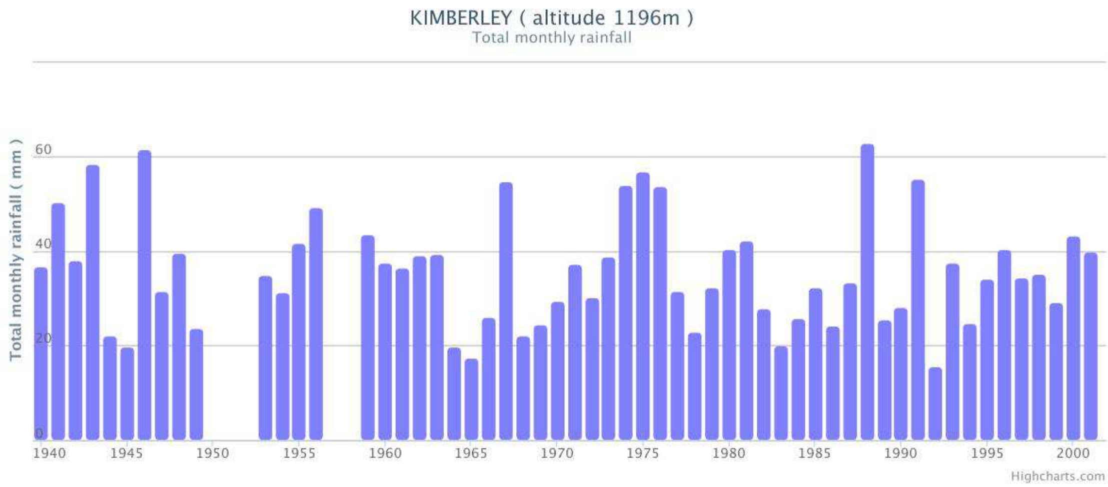

Figure 23~~25~~. Total Monthly Rainfall in Kimberley, Northern Cape

FUTURE CLIMATE PROJECTIONS

The plot below (Figure 24~~Figure 26~~) shows the range of projected future changes for this location across 10 different statistically downscaled CMIP5 GCMs for scenario RCP 4.5. This total monthly rainfall is the scenario for future period 2040 to 2060. The result of Scenario model RCP 4.5 has the pattern where the dry season (April–December) monthly precipitation shows little change compared to the historical level. In contrast, the rainy season (January–March) monthly precipitation is expected to change in either direction with different magnitudes.

In general, the rainfall and the temperature scenario has a matching pattern, decrease of rainfall and increase of temperature. We looked first at medium to mid-term projection, as our goal is to know how the climate risks may evolve in the longer term, to ensure that medium-term choices are sustainable in the longer term. We also looked at the projection of average maximum temperature for the same period, as shown in Figure 25~~Figure 27~~. Looking at both the projections, it can be seen that the projections support each other's patterns. In 2040–2060, the total monthly rainfall is expected to decrease in December, so that the dry seasons will become the worst in Northern Cape. For the projected temperature, there is slight variation in changes projected for both the seasons. About half the models predict an increase in rainfall in dry season, and the other half predict a decrease in rainy season – changes in monthly precipitation are uncertain.

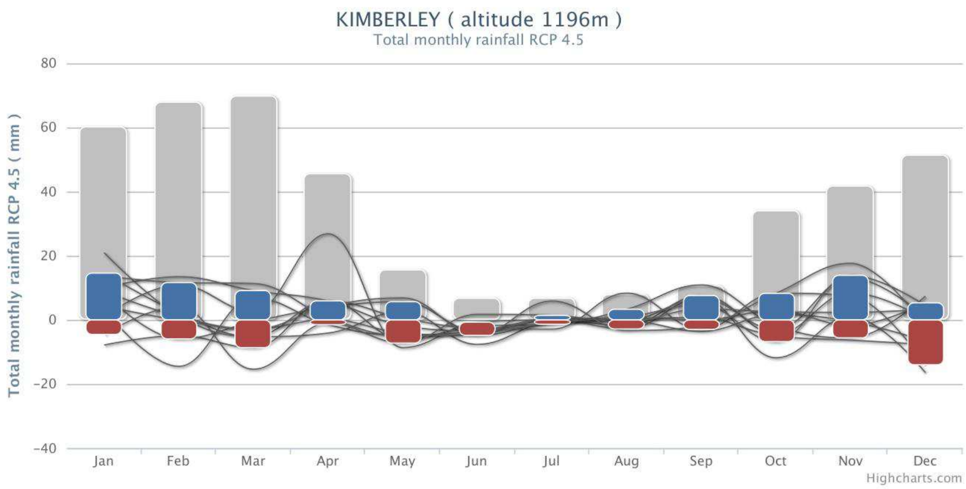

Figure 24~~26~~. Projected Changes in Total Monthly Rainfall Scenario RCP 4.5, Northern Cape, 2040–2060.

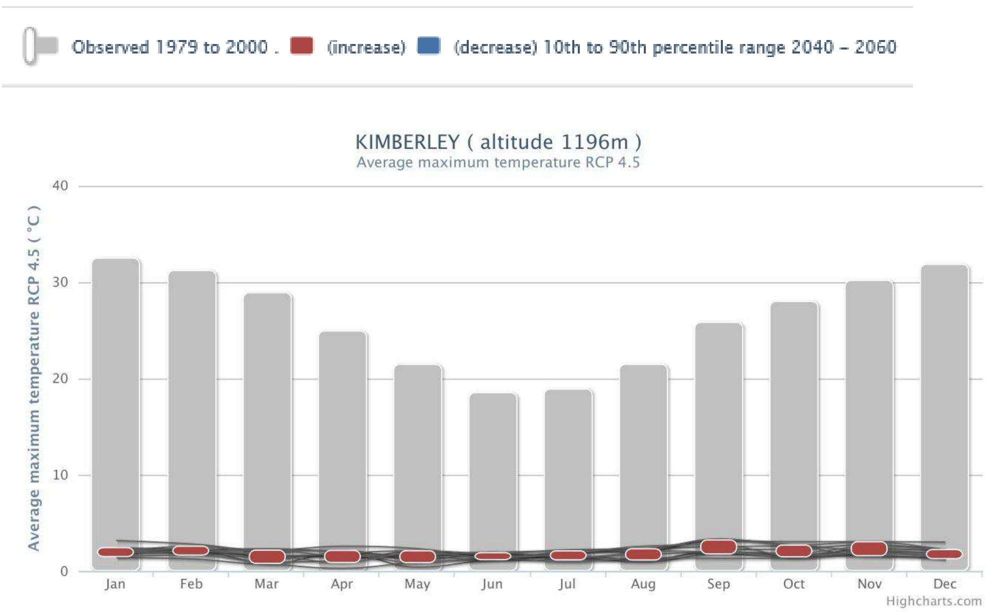

Figure 25~~27~~. Projected Changes in Average Maximum Temperature Scenario RCP 4.5, Northern Cape, 2040–2060.

THE CLIMATE COMPARISON WITH OTHER STATIONS

Looking through the data of the Ottosdal station, its future climate projections suggest patterns similar to our earlier interpretations for the Kimberley station, except in February. During February, the rainfall in Ottosdal is increasing, but at Kimberley it is decreasing. However, when we compare with the Douglas station, the future climate projection is quite different. This difference may be influenced by the type of the area, such as rural or urban, and its topography. Kimberley is an urban area and Douglas is a rural area.

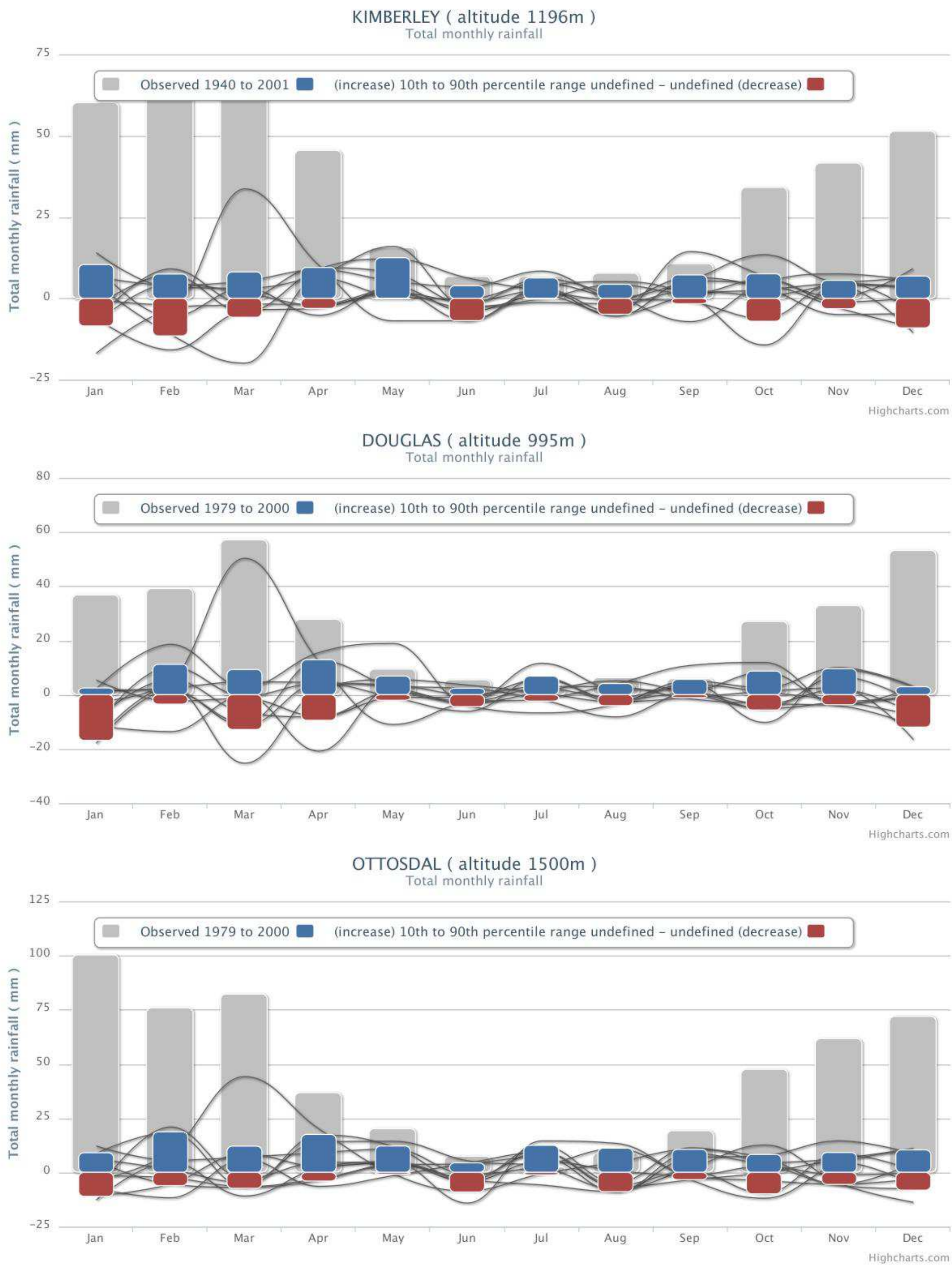

Figure 26~~28~~. Projected Change in Monthly Rainfall Data Using SRES A2 for Kimberley (top), SRES A2 for Douglas (middle) SRES A2 for Ottosdal (bottom) (CIP, 2001)

CONCLUSION AND RECOMMENDATION FOR THE MAIZE INDUSTRY

South Africa has the technical, managerial and operation capacity needed to attain low-carbon and climate resilient industrial growth. Opportunities include the expansion of the use of renewable energy, particularly solar, whilst challenges relate largely to lower projected rainfall and in meeting increasing demands of water.

According to climate suitability as shown in Table 2 and historical climate monthly average (Figure 1) Northern Cape temperature is suitable for the cultivation of maize from a climate perspective, but the productivity of maize in Northern Cape was still below the average for SA (Department: Agriculture, Forestry and Fisheries, 2013). It might be due to the rainfall still being less than optimal. The water requirement for maize plants is critical at the development stage, the mid-season stage and the late season stage (approximately 1 month after planting). The minimum water required in the critical period is equivalent to rainfall of 85 mm/month and Northern Cape has a rainfall of less than 85 mm/month from January to March. Maize is very suitable to be planted in the regions that have rainfall of 500–800 mm/year. However, in SA (including The Northern Cape), an estimated 80–90% of the area planted with maize is dryland which applies water use efficiency.

Table 2. Climate Suitability for Maize

Characteristics	Climate Suitability for maize
Average temperature (^{o}C)	15–20
Rainfall (mm/year)	500–800

Source: FAO

Rainfall changes as shown in Figure 26-27, projected changes in the total monthly rainfall under downscaled CMIP5 GCMs for scenario RCP 4.5for 2040–2060, will only have a small impact on the production of maize. Nevertheless, there is still need to give attention for building industry and community resilience. To increase the production of maize in Northern Cape, it is recommended that the government build an efficient irrigation system to ensure the availability of water for the crops and also create new varieties that are more resistant to drought to combat potential impacts of periodic drought and water shortages due to other competing water demands for production of other crops, energy production, tourism, mining and meeting policy objectives to increase forested lands and expand plantation areas. also, there is a reasonable chance that Northern Cape will get drier, so it is important to consider adaptation plans for maize farming, as well as other industries that are water dependent.

Good production of maize will lead to its industry increasing. The maize industry is an important earner of foreign exchange through the export of maize and maize products. The industry exports mostly to BLNS (Botswana, Lesotho, Namibia and Swaziland) countries, Zimbabwe, Kenya, Mozambique, Zambia, and Mauritius and, in some years, to Japan. White maize meal is the staple food of a large section of the African population and this accounts for 94% of white maize meal consumption as well as food processing is recognized as a potential source of job creation. The international maize market, especially the US market, has a dominant influence on the local exports, particularly in terms of food aid (DAFF, 2012). In order to cover all the maize demand and job creation targets, the industry also needs to consider the storage technology and the transportation to keep the quality of maize good.

OVERALL CONCLUSION

Wheat cultivation growth requirements for the Giza region suggest that it currently has insufficient rainfall for optimum wheat production. Although efforts to improve water drainage structures and irrigation channels may help to combat projected decreases in rainfall for wheat and other crops such as maize, rice, tomato and sugar cane, new crop varieties that can accommodate increases in temperature, to address the spread of fungal diseases and drought, will be needed, in addition to improvements in storage facilities and transportation efficiency. Smaller producers should consider value added post-harvest production such as biodegradable plastics, paint stripping, raw materials for cosmetics and ethanol. Other adaptation measures are needed in Egypt to address sea-level rise, storms and an increasing competition for water, will also be needed through improved coordination, the preparation of action plans, the establishment of monitoring processes to improve implementation procedures, planning and resource allocation amongst stakeholders.

Kenya posses a rich set of policy, legislative and institutional frameworks to implement low-carbon and climate resilient industrial development that are embedded in various industrial operational structures of its governance. Opportunities exist to enhance the implementation of existing legislation.

In the Kericho region, climate change models projections for rainfall suggests that it will be suitable for tea plantation until the year 2090, however adaptation measures such as a new tea species that are resistant to low temperature, hail and frost, will still be needed as temperatures the minimum temperature is too low and which will affect the growth and the quality of tea. The Nakuru area is less suitable for planting tea because the average monthly rainfall is less than 100 mm and not spread evenly throughout the year. As tea industries depend on the tea plantations, the latter may have to support the adaptation actions by the farmers. Renewable energy technologies may help to make the storage and the transportation system more efficient and sustainable; allowing the tea production industry to allocate its budget to help the production stage adaptation with climate change.

The Senegalese government has the technical capacity to integrate climate change in their development policies and plans through several of their political and institutional initiatives. Opportunities exist to improve regional planning, the implementation of town plans, and the use of renewable energy.

Mid-term climate change projections for the Senegal river indicate a decrease in total monthly rainfall that could further reduce fish production in the area. As fisheries contribute to export earnings, food security and employment, opportunities exist to promote integrated irrigation and aquaculture programmes to increase exports and small-scale fishing to meet the local market demands. In addition, it will be important to ensure that the sustainability of this industry is improved through supporting participatory natural resource management, improving operations, post-harvesting processing and preservation, and waste minimization. Fisher communities can also be strengthened through the provision of insurance and weather warnings to reduce climate risks.

South Africa has the technical, managerial and operation capacity needed to attain low-carbon and climate resilient industrial growth. Opportunities include the expansion of the use of renewable energy, particularly solar, whilst challenges relate largely to lower projected rainfall and in meeting increasing demands of water.

Medium to mid-term climate change projections for the Northern Cape, South Africa, indicates a general decrease in rainfall and increase in temperature that has a low impact on maize production. Nevertheless, increasing the production of maize will require the building of an efficient irrigation system to ensure the availability of water, and the development of new drought resistant maize varieties, to combat potential impacts of periodic drought and water shortages due to other competing water demands for production of other crops, energy production, tourism, mining and meeting policy objectives to increase forested lands and expand plantation areas.

As white maize is a staple food of a large section of the African population, and as food processing is recognized as a potential source of job creation, consideration should be given to improving storage technology and transportation infrastructure and planning, so that both market demands and job creation targets can be satisfied and fulfilled.

As there is also a reasonable chance that the Northern Cape will become drier, it will be important to consider adaptation plans for maize farming, as well as other industries that are water dependent.

Analysis of the current and potential climate conditions to four selected sub-industries reveals a spectrum of situations ranging from lower impact in South Africa and Kenya, to those that exacerbate current non-optimal conditions in Egypt and Senegal. In all of these countries, projected decreases in rainfall and increasing water demands pose a challenge, and suggests that technological, managerial and operational capacities of all industries and other stakeholders must be strengthened to understand current water requirements and consumption and to enhance the efficient use of water in order to increase or maintain current production levels and to meet other basic and industrial needs. In addition, crop varieties that are resistant to low temperatures in Kenya, and those that are drought resistant in South Africa and Egypt, may need to be developed, in additional to the development of adaptation plans for some industries.

Further industrial development in all of the countries related to food processing will require improvement of post-harvest processing, storage technology, and transportation infrastructure and planning. Opportunities exist to ensure that low-carbon technologies are used in these improvements and to ensure that they are resilient to natural hazards.

There are many opportunities on which current national frameworks for low-carbon and climate resilient industrial development could be built upon. These include:

i) Policy shifts that encourage the use of low-carbon energy production, and that are not sensitive to high temperatures and dependent on current levels of water availability;
ii) The re-visiting of some policy objectives that require current or unrealistic levels of water availability;
iii) Improvements to regional planning; and
iv) Strengthening the implementation of town plans and existing legislation
v) Upgrading of industrial restructuring policies to take into account private industry involvement and reduce internal regional disparities

Improvements on efficient use of resources will allow budgets to be allocated for industries that will need to adapt to changes in climate.

Potential areas of improvement for low-carbon and climate resilient industrial development include:

i) Fully-scale assessment of climate change impacts on all major current economic and economic development activities and their value chains and expressing these in terms of industrial vulnerability
ii) Assistance to be provided to smaller producers to reduce their climate risks through the provision of insurance and weather warnings, and engagement in value-added post-harvest production to diversify their sources of income
iii) Improved coordination amongst stakeholders to prepare action plans, establish monitoring processes, planning and resource allocation amongst stakeholders, particularly in relation to water use
iv) Identifying and applying measures and rehabilitation processes to reduce environmental pressures of vulnerable areas

v) Increasing the number of adaptation activities, and ensuring full integration of climate change into industrial development plans to secure the supply of commodities
vi) Improving structural ownership of industries,
vii) Identifying opportunities to integrate cross-industrial initiatives, and
viii) Improving overall sustainability of industrial activities e.g. through thorough supply chain analysis

REFERENCES

ANSD, 2012. *Industrial sector in Senegal.* Available from: <http://www.ansd.sn/>. [14 October 2015].

ANSD, 2013. *Labor in Senegal.* Available from: <http://www.ansd.sn/>. [14 October2015].

CIP, 2001. Future climate projections of Ottosdal Station. Retrieved 17 February 2016. http://cip.csag.uct.ac.za/webclient2/datasets/africa-merged/#nodes/cmip3-anomalies?folder_id=24&extent=46322

CIP, 2001. Historical seasonality of Kimberley Station. Retrieved 17 February 2016. http://cip.csag.uct.ac.za/webclient2/datasets/africa-merged/#nodes/seasonality-cmip3?folder_id=24&extent=46667

CIP. 2001. Future total monthly rainfall of Kericho. Retrieved 18 February 2016. http://cip.csag.uct.ac.za/webclient2/datasets/africa-merged/#nodes/cmip3-anomalies?folder_id=24&extent=46298

CIP. 2001. Historical climate monthly average of Senegal. Retrieved 25 February 2016. http://cip.csag.uct.ac.za/webclient2/datasets/africa-merged/#nodes/cmip3-anomalies?folder_id=24&extent=46495

CIP. 2001. Historical climate monthly average of Kenya. Retrieved 18 February 2016. http://cip.csag.uct.ac.za/webclient2/datasets/africa-merged/#nodes/seasonality-cmip3?folder_id=24&extent=46298

DAFF, 2012. *Maize market value chain profile.* Department of Agriculture, Forestry and Fisheries. Retrieved from http://www.nda.agric.za/docs/AMCP/Maize2012.pdf 10 March 2016.

DAFF, 2013. *A profile of the South African tomato market value chain 2013*. Directorate Marketing. Available from: <http://www.nda.agric.za/doaDev/sideMenu/Marketing/Annual%20Publications/Commodity%20Profiles/field%20crops/Tomato%20Market%20Value%20Chain%20Profile%202013.pdf>. [14 October 2015].

DAFF, 2013a, *Trade profile of South Africa's agro-processing products to bric countries*. Directorate: Agro-Processing Support, Pretoria.

DAFF, 2013b, *Strategic Plan for the Department of Agriculture, Forestry and Fisheries*. Directorate Communication Services Private Bag X144, Pretoria 0001. ISBN: 978-1-86871-371-4. Available from: http://www.daff.gov.za/doaDev/topMenu/DAFF%20Strategic%20Plan%202013.pdf. Accessed [23 April 2015].

DAFF, 2014, *Report on commercial timber resources and primary roundwood processing in South Africa (2011/2012)*. Department of Agriculture, Forestry and Fisheries. Forestry Technical and Information Services, Forestry Economics Services CC, South Africa. (Accessed 22 April 2015) Available from:

<http://www.forestry.co.za/uploads/File/industry_info/statistical_data/Nov%202014%20- %20Timber%20Statistics%20Report%202011%20-%202012.pdf.>. [22 April 2015].

DEA, 2013, *Long-Term Adaptation Scenarios Flagship Research Programme (LTAS) for South Africa*, Department of Environmental Affairs, Pretoria, South Africa.

DEA, 2014, *GHG Inventory for South Africa 2000 – 2010*. Retrieved Available from: <https://www.environment.gov.za/sites/default/files/docs/greenhousegas_invetorysouthafrica.pdf>. Accessed [20 February 2015].

Department: Agriculture, Forestry and Fisheries, 2013. *Trends in SA Agriculture*. Retrieved 17 February 2016. http://www.econostatistics.co.za/TrendsinSAAgriculture13.pdf

Donovan, D.J. 2009, *Food Processing Location Trends*. Retrieved Available from: <http://www.tradeandindustrydev.com/industry/food-processing/food-processing-location-trends- 635>. Accessed [20 February 2015].

Driver, A., Sink, K., Nel, J., Holness, S., Van Niekerk, L., Daniels, F., Jonas, Z., Majiedt, P., Harris, L. and Maze, K. 2012, *National Biodiversity Assessment 2011: An assessment of South Africa's biodiversity and ecosystems*, Synthesis Report. South African National Biodiversity Institute and Department of Environmental Affairs, Pretoria.

DWA, 2013, *National Water Resource Strategy*. Retrieved Available from: <https://www.dwaf.gov.za/nwrs/LinkClick.aspx?fileticket=u_qFQycClbI%3dandtabid=91andmid=496.> Accessed [20 February 2015].

Dyer, C., 2007, "*Forestry faces big issues to remain sustainable – a role for forestry research*" (Editorial). Southern Hemisphere Forestry Journal, vol 69, no. 1, pp. iii-iv.

Egypt Independent, 2012. *Unemployment rate rises to 13 percent.* Retrieved from http://www.egyptindependent.com/news/unemployment-rate-rises-13-percent

El-Nahrawy, Mohamed A. 2012. *Country Pasture/Forage Resource Profile-Egypt.* Retrieved from http://www.fao.org/ag/agp/agpc/doc/counprof/egypt/egypt.html

El-Sherif, M. n.d. *Agriculture in Egypt.* Retrieved from http://www.fao.org/docrep/v9978e/v9978e0e.htm 3 March 2016.

ENCPC, 2014. *Low Carbon and Climate Resilient Industrial Development in Egypt Project*. National Industry Vulnerability.

FAO aquastat, 2005. *Géographie, climat et population Senegal.* Food and Agriculture Organization of the United Nations.

FAO FIRMS, 2008. *Fishery production system report 2008-Senegal Fisheries sector.* Retrieved from http://firms.fao.org/firms/fishery/472/en

FAO, n.d. *Crop Water Information: Maize*. Retrieved 17 February 2016. http://www.fao.org/nr/water/cropinfo_maize.html

FAO, n.d-a. *Crop Water Information: Wheat.* Retrieved from http://www.fao.org/nr/water/cropinfo_wheat.html 3 March 2016.

FAO, n.d-b. *Egypt production potential.* http://www.fao.org/ag/Agp/agpc/doc/field/Wheat/africa/egypt/egyptagec.htm Retrieved from 2 March 2016

FCO, 2015, *South Africa-mining sector- an update*. Available from: <https://www.gov.uk/government/publications/south- africa-mining-sector-an-update/south-africa-mining-sector-an-update.>. [20 October 2015]

General Authority for Investment, GAFI, 2014. *Investment in Egypt.* General Authority for Investment, Available from: < http://www.gafi.gov.eg/en/InvestEgypt/whyegypt.aspx%202014>.

GoK, 2011. *Tea Production in Kenya.*

Ibrahim, Fouad N. Ibrahim, Barbara. 2003. *Egypt: An Economic Geography*. I.B Tauris & Co. Ltd. London. Retrieved from https://books.google.co.id/books?id=rdyv_lA95aUC&redir_esc=y 3 March 2016.

IDSC, 2011. *Egypt's National Strategy for Adaptation to Climate Change And Disaster Risk Reduction*, Egypt's Cabinet Information and Decision Support Centre. December 2011

Index Mundi, 2014. *Egypt Economy Profile 2014*. Retrieved from http://www.indexmundi.com/egypt/economy_profile.html

Inica, n.d. *Maize Farming in South Africa-Knowing the Maize Farming System in South Africa*. Retrieved 17 February 2016. http://www.inica.org/Maize-Farming-in-South-Africa.htm

International Fund for Agricultural Development, 2005. *Agricultural land in Egypt.*

ISW, 2010. *Energy resources in Senegal*.

KNCPC, 2014. *Project on Low Carbon and Climate Resilient Industrial Development in Kenya. National Vulnerability Assessment Report*. Kenya Industrial Research and Development Institute (KIRDI) Complex. Nairobi

Lambert, D. M., McNamara, K. T., and Garrett, M. I. (2006). *Food industry investment flows: implications for rural development*. The Review of Regional Studies, 36(2), 140-162.

Marquina, Antonio. 2002. *Environmental Challenges in the Mediterranean 2000-2050*. NATO Sciences Series. Earth and Environemental Sciences Vol 37. Kluwer Academic Publishers. Dodrecht, The Netherlands. Retrieved from http://www.springer.com/kr/book/9781402019487 3 March 2016.

McDonald, Robert I. Pamela, Green. Deborah, Balk. Fekete, Balazs M. Carmen, Revenga. Megan, Todd. Montgomery, Mark. 2011. *Urban growth, climate change, and freshwater availability*. Retrieved from www.pnas.org/cgi/doi/10.1073/pnas.1011615108

McFerron, Whitney. 2015. *Pigeons grow fat in Egypt as poor storage means wasted wheat*. Retrieved from http://www.bloomberg.com/news/articles/2015-12-08/pigeons-grow-fat-in-egypt-as-poor-storage-means-wasted-wheat 10 March 2016.

MENR, 2010). *Land degradation in Kenya*.

MENR, EMCA, 1999. *Environmental management and coordination act.* National Environment Management Authority. Kenya.

Ministry of Agriculture and Land Reclamation, 2005. *Agriculture landuse in Egypt.*

Ministry of Water Resources and Irrigation, 2013. *Industrial water requirement and consumption.*

Ministry of Water Resources and Irrigation, 2014. *Water Scarcity in Egypt.*

Molapo, N. A. 2009. *Waste handling practices in the South African high-throughput poultry abattoirs*. Dissertation submitted in fulfilment of the requirements for the degree: Magister Technologiae, Central University of Technology, Free State. Available from: <http://ir.cut.ac.za/bitstream/handle/123456789/36/Molapo%2c%20Ntahli%20Ashley.pdf?sequence=3>.

Musvoto, Constantia. 2015. *Value Chain Based Assessment for Mitigation and Adaptation*. Natural Resources and Environment. CSIR: South Africa.

Ndiaye, O. n.d. International Fish Trade and Food Security Case of Senegal. Retrieved 26 February 2016. http://www.fao.org/docrep/006/y4961e/y4961e0i.htm

Neamatollahia, Ehsan. Bannayan, Mohammad. Jahansuz, Mohammad Reza. Struik, Paul. Farid, Alireza. 2012. *Agro-ecological zoning for wheat (Triticum aestivum), sugar beet (Beta vulgaris) and corn (Zea mays).* The Egyptian Journal of Remote Sensing and Space Science. Volume 15, Issue 1, June 2012, Pages 99–112. Ministry of Higher Education and Scientific Research, Egypt. Retrieved from http://www.sciencedirect.com/science/article/pii/S1110982312000075 3 March 2016.

Omondi, D. 2015. Climate Change Bites Kenyan Tea Farmer. Retrieved 25 February 2016. http://www.europe.undp.org/content/geneva/en/home/presscenter/articles/2015/11/10/climate-change-bites-kenyan-tea-farmers.html

Ouda, Samiha. Abd El-Latif, Khaled, Khalil, Fouad. 2016. *Water Requirements for Major Crops*. SpringerBriefs in Water Science and Technology. Water and Environment Research Institute, Agricultural Research Center, Giza, Egypt. Retrieved from www.springer.com/cda/content/.../cda.../9783319217703-c2.pdf?...0 3 March 2016.

Peterson, J., Kalende, M., Sanni, D. & N'Gom, M. 2006. The potential for integrated irrigation-aquaculture (IIA) in Senegal. Rome, FAO. 181 pp.

Planchon, Fatou. 2014. *Vulnerability assessment of the Senegalese industry to climate change*. Bureau de Mise à Niveau des Entreprises. Dakar

Ratetea. 2015. Kenya. Retrieved 18 February 2016. http://ratetea.com/region/kenya/4/

Selim, Tarek, H. 2009. *The Egyptian Food Processing Industry: Formalization versus Informalization within the Nation's Food Security Policy.* Alfred P. Sloan Industry Studies Association General Industry Studies Annual Conference, Chicago.

SoftKenya. n.d. *Tea Farming in Kenya*. Retrieved 10 March 2016. http://softkenya.com/farming/tea-in-kenya/

Southafrica.info, 2015. *Northern Cape province, South Africa.* Retrieved 16 February 2016. http://www.southafrica.info/about/geography/northern-cape.htm#.VsLxNI9OJYc#ixzz40K7Vx6pc

Stats SA, (2014a). *Mid-year population estimates*, 2014. Retrieved Available from: <http://beta2.statssa.gov.za/publications/P0302/P03022014.pdf>. Accessed [20 February 2015].

Stats SA, 2014b, *Gross Domestic Product (GDP), 3rd Quarter 2014*. Available from: <http://beta2.statssa.gov.za/publications/P0441/P04413rdQuarter2014.pdf>. [20 February 2015]. Stats 2013d

UNDP, 2010. *Egypt Second National Communication*, Under the United Nations Convention on Climate Change., May 2010

United Nations, 2012. *World Population Prospects.:* The 2012 Revision Available onfrom: <http://esa.un.org/wpp/unpp/panel_indicators.htm>. [20 October 2015]

USDs, 2010. *Environmental damage in Kenya*.

Warburton, M. L. and Schulze, R. E. 2008, "*Potential impacts of climate change on climatically suitable growth areas of Pinus and Eucalyptus: results from a sensitivity study in South Africa*". Southern Forests, vol. 70, no. 1, pp 27–36.

West Africa Trade, 2008. *West African Fisheries Profiles – Senegal*. USAID-West Africa.

WWF, 2011, *Fisheries: Facts and Trends South Africa*. South Africa Report Series. http://awsassets.wwf.org.za/downloads/wwf_a4_fish_facts_report_lr.pdf.

Yende, Sizwe sama. 2015. *The high cost of SA's worst drought in 23 years*. Retrieved 16 February 2016. http://city-press.news24.com/News/The-high-cost-of-SAs-worst-drought-in-23-years-20150708