TIPS FORUM 2017

INDUSTRIALISATION AND SUSTAINABLE GROWTH

CLIMATE CHANGE VULNERABILITY AND VALUE CHAIN ASSESSMENT IN EGYPT AND KENYA

June 2017

Takeshi Takama, Ibnu Budiman, Novelita Wahyu Mondamina,
Yudiandra Yuwono, Cynthia J Ismail
Sustainability & Resilience (su-re.co)

Paper presented at the TIPS Annual Forum 2017.

The Annual Forum 2017 is being hosted by Trade & Industrial Policy Strategies (TIPS) in partnership with the South African Research Chair in Industrial Development, based at the University of Johannesburg, and in association with the Green Economy Coalition (GEC). It is supported by the European Union and the Department of Trade and Industry.

Abstract

The vulnerability assessment for industrial development on climate change was conducted in Egypt and Kenya. The paper demonstrates practical vulnerability assessment framework and methodology especially on value added chains in tea and frozen vegetable. This paper applies the contextual vulnerability framework, which is defined by the IPCC and other creditable organisations. The framework is applied into a practical methodology using a participatory vulnerability value chain matrix and climate service approach as well as focus group discussion and policy assessment. The potential contextual vulnerabilities are confirmed by preliminary climate change projection in the sectors. For example, fruit juice is an important industry in Egypt. The low precipitation affects the optimal harvesting of fruits and heat waves disturb its cold transportation. The severe climate condition will get worse in the future, so that appropriate supports are needed.

The paper implies that climate change impacts the value chains of the selected industries. The impact is not only on agriculture, which most studies focused in developing countries, but also on post-harvesting processes including transportation and storages. Also, this study demonstrates how the contextual vulnerability framework, participatory value chain assessment, and a ready-made climate projection model are effective in these countries. This approach does not require a huge computational power and training processes; therefore, the approach will be applicable to many other developing countries. Moreover, the recommended actions and policies can be used to identify the area of supports from international aid organisations and investment opportunities from private sectors.

The results and methodology presented in this paper are robust and contribute significantly to future industrial assessments with climate change. To create awareness and demonstrate opportunities, as well as benefits, of low-carbon growth and climate resilient development in the productive industries in African countries, Green Industry policy instruments, practices and techniques need to be implemented.

Keywords – Vulnerability assessment, Climate change, Value chain assessment, Africa, Participatory approach

About the author/s

1. **Takeshi Takama – CEO of Sustainability and Resilience Co (su-re.co)**

   Email : ttak003@gmail.com or takeshi.takama@su-re.co

Takeshi works as an international expert on climate change, environment and energy for international and bilateral agencies for more than 10 years, including ADB, JICA, GIZ, and UN agencies as well as an associate for Stockholm Environment Institute and a professor at Udayana Univesity. His expertise includes Adaptation/Vulnerability for Climate Change (10 years), Renewable energy especially policy, development, and demand assessment of bio-energy (10 years), Green economy including micro-finance, trainings, and agro-business (3 years), Food security in African and Asian countries including rice, cacao, maize, and teff (7 years), Transportation especially on demands and mode choices (3 years), Education supervising master students at Oxford (5 years). His works were published in prestigious international journals and reported to policy makers, including the Ethiopian President in person. The latest achievements can be found in Takeshi's LinkedIn and his popular publications in Google Scholar.

2. **Ibnu Budiman – Researcher at Sustainability and Resilience Co (su-re.co)**

   Email: budimanibnu26@gmail.com

Ibnu has been working as researcher since 2011. He has done some research projects from University of Toronto, National University of Singapore, etc, with various themes from sustainability development, social issues, politics, and culture. Ibnu is also writer, speaker, facilitator and moderator in some media outlets, workshops, trainings and seminars about climate finance, environment, scientific and popular writing, public speaking, education, life skill, and management of organization in some local and national events. He writes also for several media such as Jakarta Post. His degree is Bachelor of Science from Department of Geography Universitas Indonesia. His thesis was about political geography, which was published as a book.

3. **Novelita Wahyu Mondamina**

   Email: novelita.mondamina@su-re.co

She graduated from Institut Teknologi Banding (ITB) in Chemistry then continued her study in University of Southampton, MSc Energy and Sustainability: Climate Change and Energy Resources with LPDP Scholarship. Before taking her Master degree, she was a teacher of Chemistry for Senior High School students and contributed as an assistant of Environment Advisor in PT.Indonesia Power, focusing on carbon emission reduction of power plants in Java-Madura-Bali.She is passionate to learn more regarding bioenergy potential and how it will contribute to energy development in Indonesia.

4. **Yudiandra Yuwono**

   Email: yudiandra.yuwono@su-re.co

Graduated as Environmental Engineer from Institut Teknologi Bandung in 2014, he worked in several different sectors since from mine water management, oil waste soil recovery, to sustainable technology NGO and across different places from Singapore to remote islands all over Indonesia. In mid-2016 he moved on to work with su-re.co as a researcher, involving in several projects with international agencies such as EU, UNIDO, ADB, and mainly responsible in a climate adaptation project with UNDP.

5. **Cynthia Juwita Ismail – Researcher at Sustainability and Resilience Co (su-re.co)**

Email: cynthia.ismail@su-re.co

She graduated from Institut Teknologi Bandung (ITB) in Chemistry. She involved in climate change mitigation especially energy sector since 2012 working at PT Indonesia Power as a research assistant. Then, she pursued her Master Degree in Management and Engineering of Environment and Energy in Universidad Politecnica Madrid, Ecole des Mines de Nantes and KTH, The Royal Institute in 2013-2015. Following that, she continued working at PT Indonesia Power for 6 months before joining su-re.co in 2016 as a junior researcher. During this exposure, she has been involving in projects with international agencies e.g. EU (i.e. GreenWIN and TRANSrisk), UNIDO, and ADB in related to climate change adaptation and mitigation.

1. Introduction

An innovative and practical framework was developed to assess the value chain of two African countries namely Egypt and Kenya. This analytical framework had to be simple and practical because the assessment should be conducted rapidly with a workshop and a desktop assessment. This framework starts with understanding the bottlenecks of a value chain as exposure units in the vulnerability assessment. This process is designed as a workshop exercise and followed by policy and action assessments. Climatic and other information, which will be useful for the policies and actions supporting the vulnerable value chain, is linked by online climate service tools namely, CIP of The University of Cape Town and weADAPT.

Uncertainties from climate change will never disappear in the future although climate change projection models have been improving. Even in this situation, a vulnerability assessment and adaptation policies and actions will be useful as inactiveness is not a solution in the climate change era. Moreover, the contextualized information gathered during the climate and policy & activity assessments including assumptions and issues raised will be as important as the semi-quantitative result of the vulnerability matrix. Therefore, this analytical framework is appropriate for the two cases and highly transferable to the similar projects in the developing countries. Value chains are affected by climate change and this framework empowers industrial analysts to incorporate the climate change vulnerability assessment into their industrial analysis.

2. Background

As previously mentioned, the countries selected as the focus are Egypt and Kenya. Both countries do have their own different background to justify each selection.

2.1 Egypt

Agriculture is one of the main economic activities in Egypt and 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 5,296 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%.

Fruit growing plays a major role in Egypt's agriculture (Zaki 1992). The fruit-planted area has expanded over the last three decades to reach about 200 000 feddans (84 000ha). A wide variety of tropical and sub-tropical fruits are produced, including: grapes, bananas, mangoes, guavas, apples, peaches, nectarines, strawberries, apricots, pears, pomegranates and mangoes, but 30-50% of total fruit production is citrus fruits, primarily oranges that represent 65-85% of that figure (El Shereif 2016). Production is mainly concentrated along, and dependent upon, the River Nile and delta. Egypt has competitive advantage in the processing of fruit juices, arising from the availability of fruits during off-seasons and also through a direct cost/quality advantage (Ecorys 2005). In addition, most of the required fruits (industry inputs) are planted in Egypt and consequently there is no need to import such inputs. The sector has grown from 713,000 USD to 13.5 million USD in six years from 2007 to 2012 (Selim 2009).

Climate change in Egypt is projected to increase temperatures and potentially reduce precipitation which would potentially also affect the agribusiness industry (UNDP 2010). Flash floods, earthquakes, desert locusts and storms are the types of natural disasters that commonly occur in

Egypt. The flow rate within the Nile is quite sensitive to abstractions for industry and agriculture, which is due to the economic activities.

2.2 Kenya

Most of the area in Kenya is dry, with less than 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). One of main industries in Kenya is tea industry. It is started from tea plantations which are situated in the highland areas of the Great Rift Valley, Mt. Kenya, the Aberdares, and the Nyambene Hills in the Central Kenya and the Mau escarpment, Kericho Highlands, Nandi and Kisii Highlands and the Cherangani Hills; with altitudes between 1500m and 2700m above the sea level. In 2007 it was estimated that 149 000ha was planted (Amde et al. 2009). Factories are located near the place of production. However, the tea industry has been confronted by high production costs, poor infrastructure, low levels of value addition and product diversification, inadequate research, development and extension, and declining global tea prices (Amde et al. 2009). These current obstacles are more exposed to the change of climate variability.

The value addition of tea starts at the factory, where processing and grading are done. After grading, most of the tea is sold mainly through the Mombasa Tea Auction, some through direct contracted sales, and a little at factory gate (CPDA 2008). Traditionally, tea out of Kenyan factories is known for its high quality, so it usually attracts good prices. The second stage of the value addition is the blending and packaging stage. Although the Government of Kenya (GOK), the Tea Board of Kenya (TBK) and other stakeholders had made efforts so that this stage is carried in the country, it mainly occurs in the consumer countries and is controlled by the big multinational tea companies (Kagira, Kimani, and Githii 2012).

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 2016).

3. Methodology

The methodological framework of vulnerability matrix, policy and action, and climate variable linkage assessments were adopted from previous operational projects including CARE International, Stockholm Environment Institute, weADAPT.org, and University of Cape Town (For example, see (CARE International 2009) and (Stockholm Environment Institute 2007)).

Overall, the methodological framework has three sets of assessments, namely a vulnerability matrix assessment, a policy and action assessment, and a climate linkage assessment as shown in Figure 1. A vulnerability matrix was developed first to identify processes that are sensitive to climatic disasters in a targeted supply chain. Disasters affecting these key processes was also identified. In the policy and action assessment, what the policies and previous actions for the key processes and disasters were identified as well as determining the potential actions and policies to be conducted in the future. Lastly, the different types of climate and other required information to make the policies and operational actions were identified with the Climate Information Portal (CIP) (CSAG 2016).

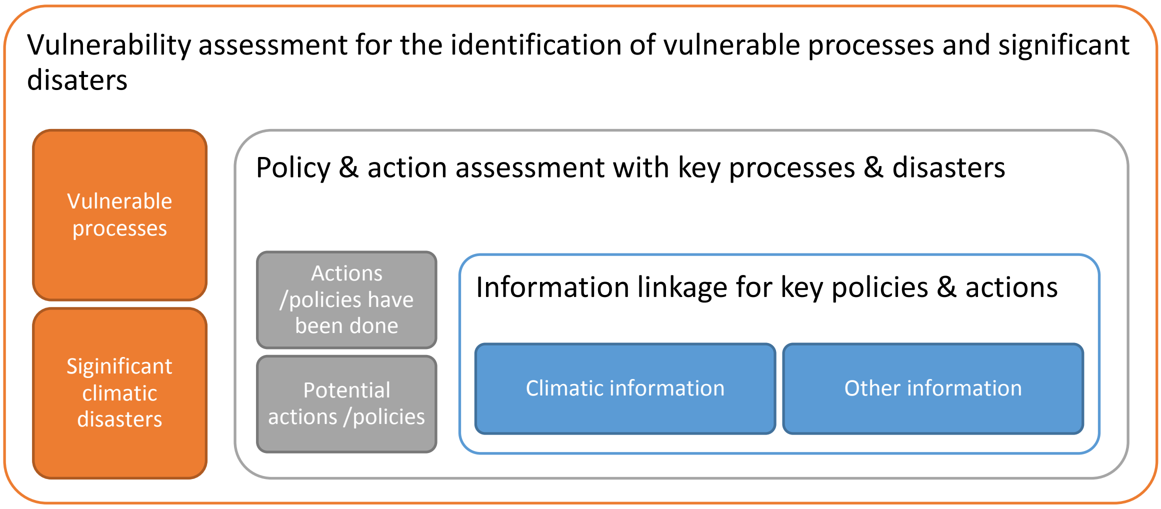

Figure 1. Framework of a stakeholder exercise. A vulnerability assessment including a matrix identifies the most vulnerable process and disasters. A policy and action assessment discuss the policies and actions have been conducted and should be carried out. Information required to design key policies and actions is investigated.

Two types of vulnerability concepts associated with climate change adaptation have been widely accepted. The vulnerabilities of climate change have been defined differently, but it is categorised between outcome and contextual vulnerabilities (Adger et al. 2005; IPCC 2007; O'Brien et al. 2007; Takama et al. 2016). Outcome vulnerability defines vulnerability as the overall effect of climate change, once climate impacts, and adaptive capacity have been considered (Figure 2). Contextual vulnerability assumes that vulnerability is determined by the potential characteristics of issues, context, purpose, and system. In the vulnerability matrix exercise, the assessment with stakeholders are based on the contextual vulnerability and with climate information, this assessment is considered as outcome vulnerability.

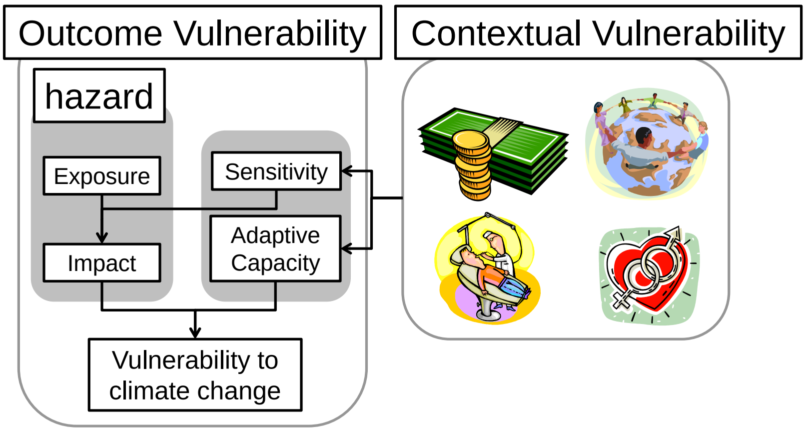

Figure 2: Vulnerability concepts and importance of finding issues, context, purpose, system, etc. Outcome vulnerability defines vulnerability as the compound result of impact assessments and adaptive capacity. Contextual vulnerability assumes that vulnerability is determined by the potential characteristics of issues, context, purpose, and system
(Takama et al. 2016)

The vulnerability matrix focused on assessing production processes or supply chain in a targeted industry and their exposure to climatic disasters including frost, floods, cyclones, etc. Participants were asked to list all production processes as ‘exposure units’. The potential climatic threats were listed and ranked through a rapid, scoping exercise, the matrix is filled by ranking each cell according to a four-point scale:

3 = significant impact on the exposure unit

2 = medium impact on the exposure unit

1 = low impact on the exposure unit

0 = no impact on the exposure unit

The rating of sensitivities depends on the outcome of exposures and hazards, and is used to identify the relative significance amongst exposure units and hazards. “3” is interpreted as “the impact on the exposure unit was not coped with historically or is unable to cope without an external support”. The number of “3s” is summed by rows and columns to show the overall vulnerability of the exposure unit. After the matrices are completed, the assessment identified policies and actions to cope with the vulnerabilities. Lastly, this assessment used Climate Information Portal (CIP)[1] developed by Climate System Analysis Group, University of Cape Town to explore the climate situation in the target areas.

4. Result: Egypt

4.1 Vulnerability Assessment for the Identification of Vulnerable Processes and Significant Disasters

The vulnerability matrix for vegetables and fruits processing was developed with representatives from EEAA (Egyptian Environmental Affairs Agency), UNIDO, Food Technology Centre, EMA (Egyptian Meteorological Authority) and national experts from ENCPC (Egyptian National Cleaner Production Center). The matrix focused on production processes in a targeted business and industry, namely Fruit and Vegetables Processing against climatic disasters including frost, floods, cyclones, etc.

The fruit and vegetables value chain in Egypt includes several segments: inputs, production, packing and storage, processing and distribution and marketing. The important inputs for production in this industry are seeds, fertilizers, agrochemicals (herbicides, fungicides and pesticides), farm equipment and irrigation equipment.

Logistics and transportation fulfils key supporting functions, while government regulatory bodies are required to approve the sanitary and phytosanitary conditions of outbound products. Due to the fragile and perishable nature of the product, a high degree of coordination between the different participants along the chain is required. This ensures that the perishable product reaches its destination in good condition (Fernandez-Stark, Bamber, and Gereffi 2011). Cold storage units are used throughout the chain to keep the produce fresh, and both air and sea freighting supported by the cold chain are key elements to ensure timely delivery.

[1] http://cip.csag.uct.ac.za/webclient2/app/

Fernandez-Stark et al. stated the main stages of the value chain are as follows (Fernandez-Stark, Bamber, and Gereffi 2011):

Inputs: Elements needed for production, such as seeds, fertilizers, agrochemicals (herbicides, fungicides and pesticides), farm equipment and irrigation equipment.

Production for Export: Includes the production of fruit and vegetables and all processes related to the growth and harvesting of the produce, such as planting, weeding, spraying and picking.

Packing and Cold Storage: Grading, washing, trimming, chopping, mixing, packing and labelling are all processes that may occur in this packing stage of the value chain. Once the produce is ready for transport, it is blast chilled and placed in cold storage units ready for export.

Processed Fruit and Vegetables include dried, frozen, preserved, juices and pulps. Many of these processes add value to the raw product by increasing the shelf life of the fruit and vegetables.

Distribution and Marketing: The product is distributed to different channels; including supermarkets, small scale retailers, wholesalers and food services.

The matrices (**Table 1**) started from the collection process and not from the agriculture process. There are many types of fruits and vegetables that are used as raw materials for collection process and many parameters vary according to the type of the product (Seasons of agriculture, location of agriculture, agriculture in greenhouses or open-field, etc). The matrices cover different areas in Egypt.

Table 1: Climate change vulnerability matrix for Fruit Juice

	Heavy Rain	Flood	Frost Bite	Strong wind	Rise in Sea Level	Drought	Rise in Temperature	**Number of 3s**
Frequency	—	—	—	—	+	+	+	
Collection	1	0	0	0	0	0	0	**0**
Transportation	1	2	0	2	0	0	2	**0**
Storage	3	0	1	2	0	0	3	**2**
Washing	0	0	0	0	0	3	0	**1**
Preparation	0	0	0	0	0	0	1	**0**
Cooking	0	0	1	0	0	3	2	**1**

	Heavy Rain	Flood	Frost Bite	Strong wind	Rise in Sea Level	Drought	Rise in Temperature	**Number of 3s**
Dilution and sugar addition	0	0	0	0	0	3	2	**1**
Pasteurisation	0	0	0	0	0	3	3	**2**
Packing	0	0	0	0	0	0	1	**0**
Sterilisation	0	0	0	0	0	3	3	**2**
Storage	0	0	0	0	0	0	0	**0**
Transportation	1	3	0	2	0	0	3	**2**
Number of 3s	**1**	**1**	**0**	**0**	**0**	**5**	**4**	

After a brainstorming session with different stakeholders to identify the potential climate change disasters that might affect fruit and vegetables processing sector, we agreed on discussing these following factors. In fruit juice industry, transportation and storage are the most affected processes, alongside pasteurisation and sterilisation processes. These four processes are highly affected by rise in temperature. Temperature affects water availability and water is a key raw material crucial for production of juice. Water is used in the pasteurisation and sterilisation processes for the juice (Mohamed et al. 2010). Drought affects the most number of processes including washing, cooking, dilution and sugar addition, pasteurisation and sterilisation. Historical climate data shows that for the 1979–2000 period, the rainfall pattern in the agriculture region was characterised by drought suggesting that drought is a manageable climate condition in Egypt to a certain extent (Ezz and Arafat 2015). On contrary, unexpected heavy rain is more likely to impact on storage and flood poses a threat for transportation process. Rise in temperature also affects the storage of fruits (Wilson, Boyette, and Estes 1999). It is proven by the matrix that, in addition to storage, it also affects the transportation of the products significantly as the energy required to reach the cooling temperature will be substantially larger.

Egypt is subjected during some periods of the year to heavy rain, greatly affecting the roads and increased periods of heavy rain have remarkable effects on the storage in the industry. Flooding during January 2010 is highlighted here as an example of a recent extreme precipitation event affecting Egypt. In January 2010, heavy rain exceeding 80 mm/day, led to the worst flash-floods in Egypt since 1994. The floods affected the Sinai Peninsula, the Red Sea coast and the Aswan

Governorate in southern Egypt, and led to 15 deaths and hundreds of homes destroyed (Medany et al. 2011). This kind of flooding lead to transportation disruption and the damage of some raw materials, for example some vegetables, fruits and chemicals used in the production process. Possibility of heavy rain occurrence increases in the delta region and coastal areas, which are our target areas.

In the past, Egypt was subjected to floods, especially in Upper Egypt, that caused damages and so might be subjected to floods again with the changes in the climate. (Frihy 2001) indicated that the dam was successful in controlling floodwaters and ensuring continuous water supplies, but water consumption became excessive and would have to be controlled. Some valuable land was lost below the dam because the flow of Nile silt was stopped, and increased salinity remains a problem. Furthermore, the drought in the Ethiopian highlands — the source of the Nile River's water — caused the water level of Lake Nasser, the Aswan High Dam's reservoir, to drop to the lowest recorded level in 1987. In 1996, however, the level of water behind the High Dam and in Lake Nasser reached the highest level since the completion of the dam (White 1988; Wolters et al. 2016). Controlling the floodwater is important for reducing threat to transportation process in the industry.

Another climate variable is frost bite. It can occur in the early winter mornings, and affects the fruits as raw materials (Paul 2016). In fruit juice industry, it impacts on cooking process. Frost bite affects the value chain in small scale. In medium scale, there is strong wind which occurs in Egypt’s spring season with limited effects but increased intensity and frequency may affect agriculture and related industries as well as storage (Yizhaq, Y., and H. 2007)(Youssef et al. 2011).

In conclusion, for Fruit Juice, drought is the most significant disaster as it affects five production processes, namely washing, sterilisation, cooking, dilution and sugar addition and pasteurisation; so, the industry must make an adaptation plan for this kind of disasters. A rise in temperature affects four key industrial processes as the second most significant disaster and the industry must prepare to adapt to it. The industrial processes most affected by the climate related disasters are storage, pasteurisation, sterilisation and transportation as they are exposed twice.

4.2 Policy & Action Assessment with Key Processes & Disasters

In case of fruit juice industrial value chain, many processes except collection, transportation, preparation, packing and post-process storage, were perceived to be vulnerable to climate hazards such as temperature rise, drought, heavy rain and flood. Due to poor packaging, lack of cold chain facilities, rough transport, and multiple handling, the Egyptian perishable products sector like the fruit is constrained by a transportation and storage system that is very damaging to product quality. It is estimated that up to 40% of total production of highly perishable products are damaged or lost in transit and handling (Ecorys 2005; Selim 2009), although this probably varies with the perishability of the product. Agricultural raw material losses could be as much as 60% (Selim 2009). With high rates of spoilage, these transport and handling issues mean that supply to the food processing industry is often unreliable and inconsistent in terms of both quality and quantity, and therefore result in reduced productivity (Koscielski, Lotfi, and Butterfield 2012). Furthermore, usually due to inadequate temperature control, the final products of food processing are at higher risk of suffering quality defects or being destroyed; especially those that require freezing or chilling (James and James 2010).

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 (Sowers, Vengosh, and Weinthal 2011). 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.

Furthermore, through implementation of the 2005 National Water Resources Plan, Egypt could reduce its vulnerability to future water shortages. Measures in this plan include: the improvement of irrigation systems, redesigning canal cross sections to reduce evaporation loss, improving drainage, and resolving conflicts between users more quickly (Hamouda, Nour El-Din, and Moursy 2009). Requirements for water in Egypt, which is predominately drawn from the Nile River, are continuously increasing due to population increase and improving standards of living, as well as the governmental policy to encourage industrialization and agriculture.

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 (Klein et al. 2007).

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 (Brooks, Grist, and Brown 2009). 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 action plan with key climate vulnerability. Cooperation between the government and other local and internationally funded projects 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 independently identify and describe the roles and responsibilities of each industry (ENCPC 2014).

4.3 Climate Information Linkage for Key Policies and Actions

4.3.1 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 3 clearly shows that for the 1979–2000 period, the rainfall in the Giza region was characterised by seasonal pattern over the years. The climate monthly average shows that November to March have more than 3 mm of rainfall. In April to October, the rainfall is 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, which is still a very dry condition. The minimum average temperature was 9°C in January, while the maximum average temperature was 34°C from June to August.

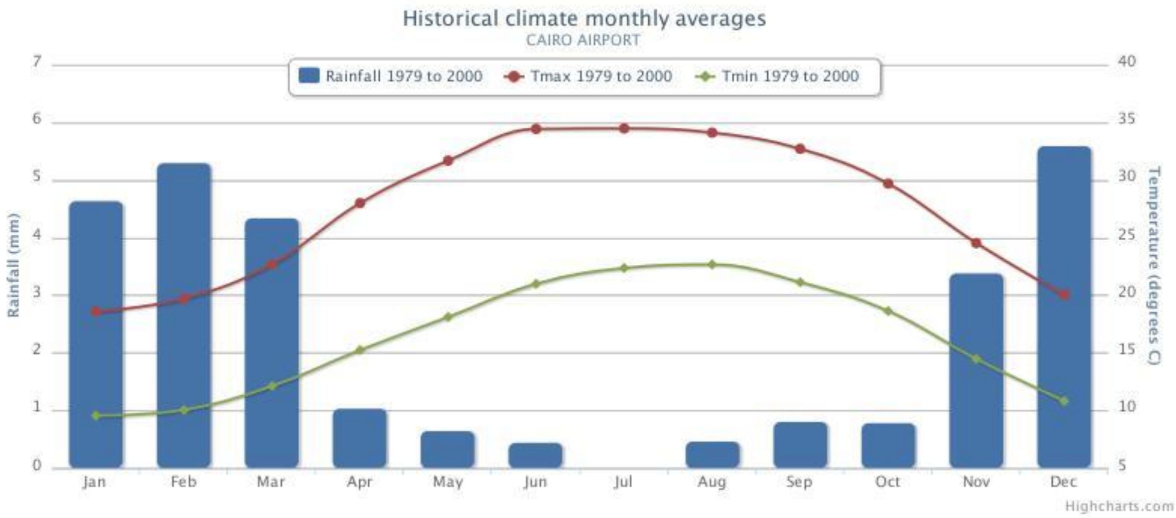

Figure 3. Historical Climate Monthly Average in Giza from 1979 to 2000. The temperature changes significantly throughout the year. There is clear mild winter and hot summer in Cairo Airport Station, Giza.

The total monthly rainfall data for the period of 1979–2000, as shown in Figure 4, indicates that the highest total monthly rainfall occurred in March 1989, namely 26 mm. This condition had implication to irrigation water for wheat cultivation. The decrease of rainfall since 1990 had been affecting water shortage along irrigation system.

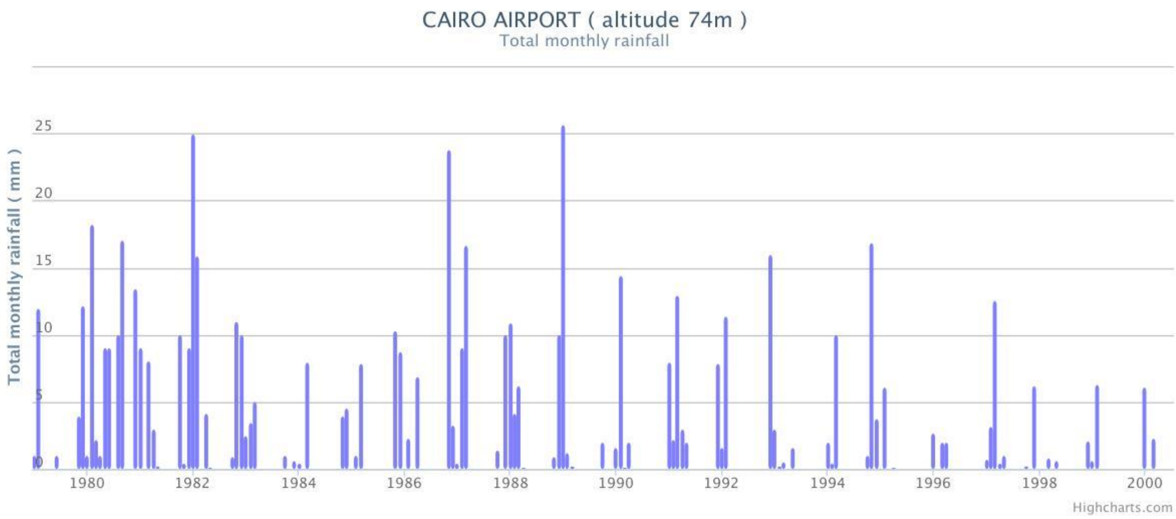

Figure 4. Total Monthly Rainfall in Giza

4.3.2 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 5, 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. This projection will have impact on future condition of irrigation water in Egypt. Decrease of rainfall will reduce support for water resources management.

In addition to the rainfall projection, the average maximum temperature scenario projection (Figure 6) 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 increase in average maximum temperature up to 35°C, especially in May and October. June to August are projected to be the hottest months.

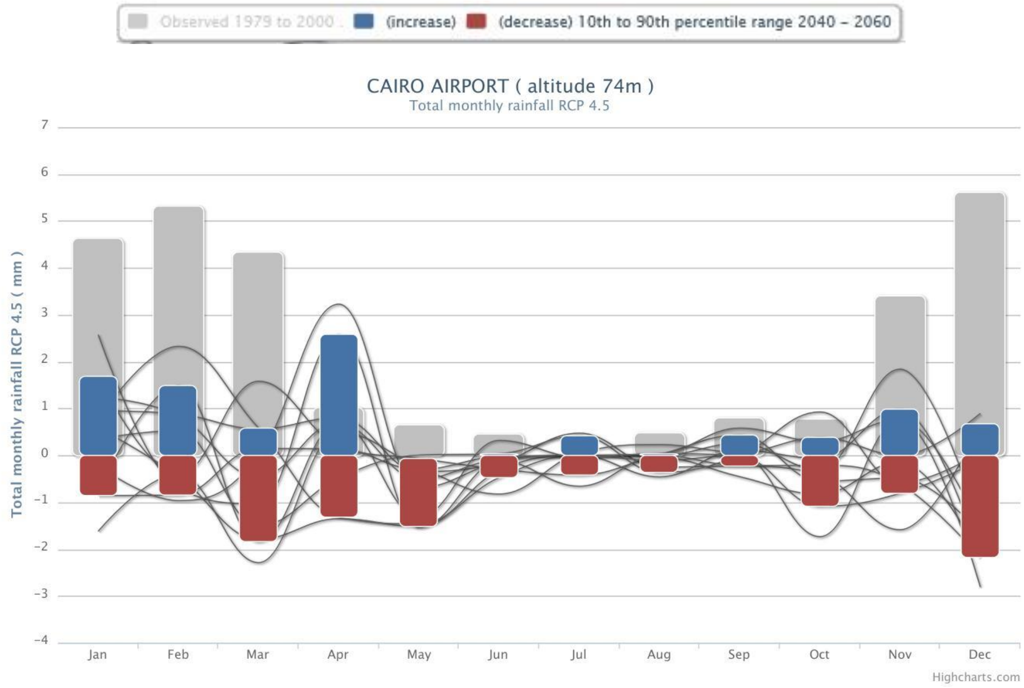

Figure 5. Total Monthly Rainfall Projection for Period of 2040–2060 Based on RCP 4.5 in Giza. The lines show the results for each of 7 climate models.

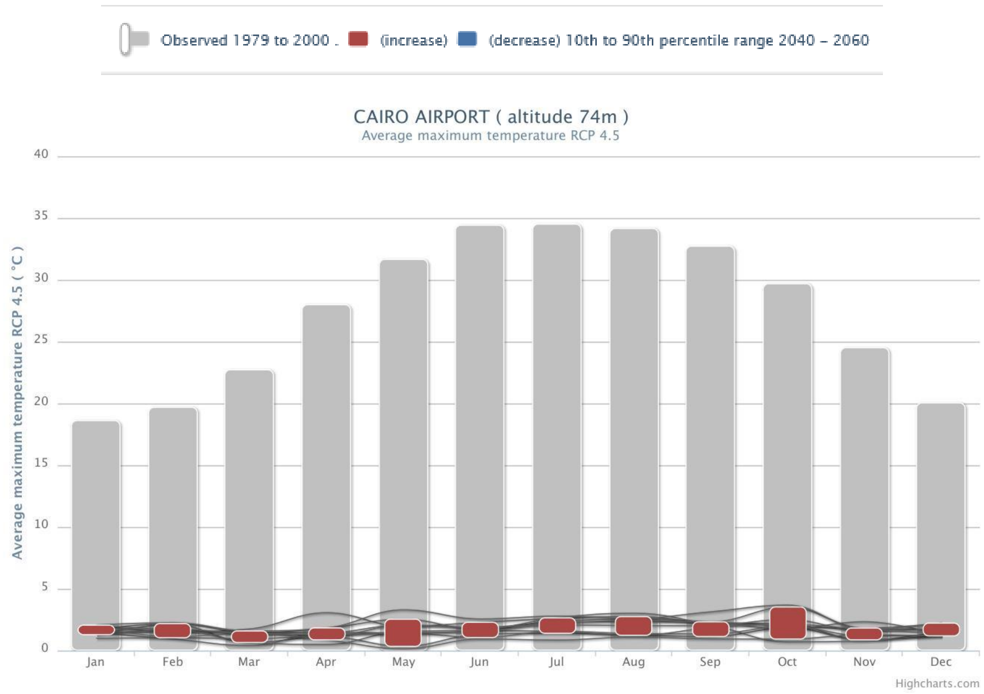

Figure 6. Average Maximum Temperature for Period of 2040–2060 based on RCP 4.5 in Giza. The lines show the results for each of 7 climate models.

5. Results: Kenya

5.1 Vulnerability Assessment for the Identification of Vulnerable Processes and Significant Disasters

Tea production in Kenya continues all year around with two main peak seasons of high crop between March and June, and October and December which coincide with the rainy seasons. Kenyan tea is grown free of agrochemicals because the ideal environment in which the tea is grown acts as a natural deterrent to pests' infestation and crop diseases. This natural condition guarantees the consumer the safest and most refreshing health drink.

Value chain includes tea production processes. The main raw material in the tea production is the green tea leaves. The green leaves from the farm undergo the following processes of tea production (Gesimba et al. 2005), and hence the value chain are as follows;

Farm level: This is where land preparation, planting, crop husbandry and plucking takes place.

Weighbridge: The weighbridge clerk weighs and records the gross weight of transported green leaf on arrival from the estates. After offloading the green leaf in the reception bay, the tare weight of transport medium is taken off to determine the net weight of green leaf purchased.

Withering: This takes between 14-20 hours to allow biochemical reaction to take place. It is done to ensure that the green tea leaves attain moisture content of approximately 71% (Gupta, Dey, and Sinha 2012).

CTC (Crush, Tear and Curl): The withered leaf is macerated through a rotor vane and subjected to four stages of CTC in 3 lines A, B, and C. Metals of the rotor are controlled by use of magnets through a pre-programmed protocol. The product of CTC is referred to as dhool (Kerio 2012).

Fermenting: This is done to allow the oxidation of chemicals, transforming the dhool into black tea with quality parameters set at low temperatures of 22°C-30°C by use of continuous fermenting units (CFUs) for duration of 110-150 minutes. The target moisture content here is 67-69% (Karori 2007).

Drying: This is to rapidly reduce the moisture content to 2.8-3.2% within 15-20 minutes, achieved through use of fluidized bed dryers and this is critical control point 1. Inlet temperatures for hot and main chambers are used as critical limiters (Temple, van Boxtel, and van Straten 2000).

Dispatching: Dispatching of packed teas is done by using contracted lorry transporters. All containers are inspected to conform to C-TPAT (Customs-Trade Partnership Against Terrorism) policy prior to loading.

The identified processes that are sensitive to climatic disasters in a targeted chain above were developed with the vulnerability matrix below.

Table 1 Vulnerability matrix for tea sector in Kenya

	Hail storm	Frost	Inadequate rainfall	Cold condition	No. of 3s
Frequency	+	-		-	
Land preparation	2	1	3	0	1
Planting	2	2	3	1	1
Plant husbandry	3	2	3	3	3
Plucking	3	3	3	3	**4**
Transportation	1	1	0	1	0
Withering	1	2	2	3	**1**
Cut, Tear, & Curl	0	0	1	2	0
Fermentation	2	2	2	3	**1**
Drying	3	2	0	3	**2**
Sorting	0	0	0	0	0
Packaging	0	0	0	0	0
Distribution	1	0	0	0	0
No. of 3s	**3**	1	**4**	**5**	

There are several climate change disasters in the tea sector. First of these is cold condition. It occurs when the temperatures are low in the absence of rain, snow and frost (Meteorological Department of Kenya). This inhibits the application of fertilizers, plant husbandry and plucking process, ultimately leading to low yields. While this discourages the farmers from planting more seedlings, the more devastating the effects of cold conditions are fermentation and drying as well as Cut, Tear and Curl (per. com). The gap between average maximum temperature and minimum temperature is significant. The average minimum temperature recorded was 10.53°C in September, while the forecast minimum temperature is to reach 9.3°C (See Synthesis Report). Withering and drying are affected by low temperatures as the air is more humid during the rainy season, requiring more energy while less energy is used when the air is drier.

Second disaster is unpredictable rain patterns, including uneven spread of rainfall across the tea growing areas, longer dry periods, destructive rainfall which can damage tea bushes and erode tops soils, and these occurrences are on the rise (Cracknell 2013). Historical climate data indicated that the highest total monthly rainfall during May 1987 was 450 mm. The midterm projection for the period of 2040-2060 shows that the total monthly rainfall is predicted to increase throughout the year (See Synthesis Report). This will have negative impact on tea production at farm level as well as the withering and drying stages. For the same reason as described above for cold condition, the higher humidity in the air requires more energy for the withering and drying processes. Heavy rains make all-weather-purpose roads impassable hence delay in delivery of green leaves (Miriti, Bundi, and Jeremy 2003). Sustainable land use management practices such as mulching, minimum tillage, agroforestry and soil conservation methods mitigate against this problem at the local level.

Hail storm also affects the foreign trade earnings. For a country like Kenya which already suffers adaptation deficit, this scenario aggravates the socio-economic conditions of the country hence the need for strategies on low carbon and climate resilient industrial development. Hailstone is a form of precipitation that falls from the sky as pellets of ice. The pellets can range from small pea size to hailstones as large as grapes. It is damaging for the tea crop and can completely strip the branches of all the leaves thereby reducing the yields, and the crop takes a long time to regenerate (Ng'etich and Stephens 2001). Factories are closed and workers laid off for an extended period. It also affects plant husbandry, plucking and drying process significantly.

Next is drought which has effects not only at the farm level like land preparation, planting, plant husbandry and plucking process, but also spread across the entire value chain especially withering, cut-tear-curl and fermentation. Drought results in reduced production of green leaf, stunted growth, low leaf quality and susceptibility to fire hazards (Cheruiyot et al. 2007). The totality of these outcomes exposes the tea sector to reduced productivity by undermining the change competitiveness and the communities' ability to withstand climate change effects.

Lastly, frost occurs when temperatures fall below freezing point causing formation of small white ice crystals. It causes withering of the tea leaves therefore reducing productivity hence less tea export which reduces foreign trade for the country (DW 2015). It is prevalent in hilly areas such as Nandi, Kericho, Bomet and Kisii. During such times, the tea plantations lay off workers. The practice of agroforestry alleviates the situation as livelihood diversifying income. Looking at the entire value chain, this problem is more accentuated at the farm level. Kenya suffered the worst frost in the period of late 2011 and early 2012 (OCHA 2011). The frost effect is expected to extend into the future following the adverse effects of climate change and this justifies the need for low carbon and climate change resilient industrial development in Kenya.

5.2 Policy & Action Assessment with Key Processes & Disasters

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. 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.

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 and EMCA 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 (Adams 2009).

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 which establishes the National Climate Change Council (Kasperson and Berberian 2011). It will be a corporate body whose function will be to advise national and county governments on legislation and other measures for climate change mitigation and adaptation, coordinate and prepare reports, and undertake negotiations on climate change matters.

In case of tea industry, there is a lack of earnestness and commitment in regards to making the appropriate investments in low carbon and climate change resilient industrial development. Information related to climate change has been relegated to the periphery of the management decisions and policy actions. Adaptation and mitigation measures might be better communicated in terms of tailored cost-benefit outlooks and strategies for the value chains of individual operations. Disseminating and championing success stories of climate-innovators in the sector and practical ‘climate-smart’ (See Kenya’s country report).

5.3 Climate Information Linkage for Key Policies & Actions

5.3.1 Historical climate data

The long-term monthly climatology of total rainfall and monthly average maximum and minimum temperatures are showed in 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. The minimum temperature recorded was 10.53°C in September and the maximum was 25.60°C in February. The wide gap between average maximum 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 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.

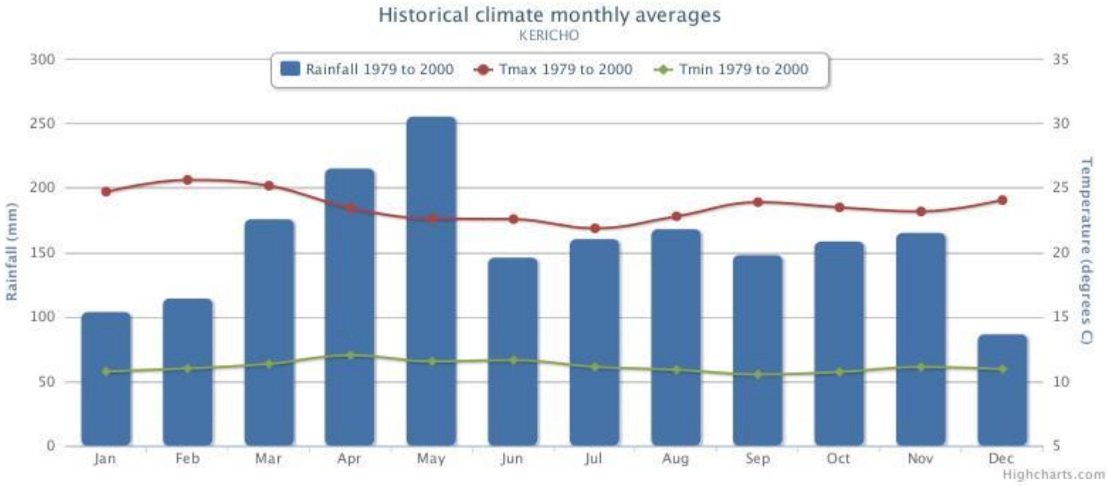

Figure 7. Historical Climate Monthly Average in Kericho, 1979–2000

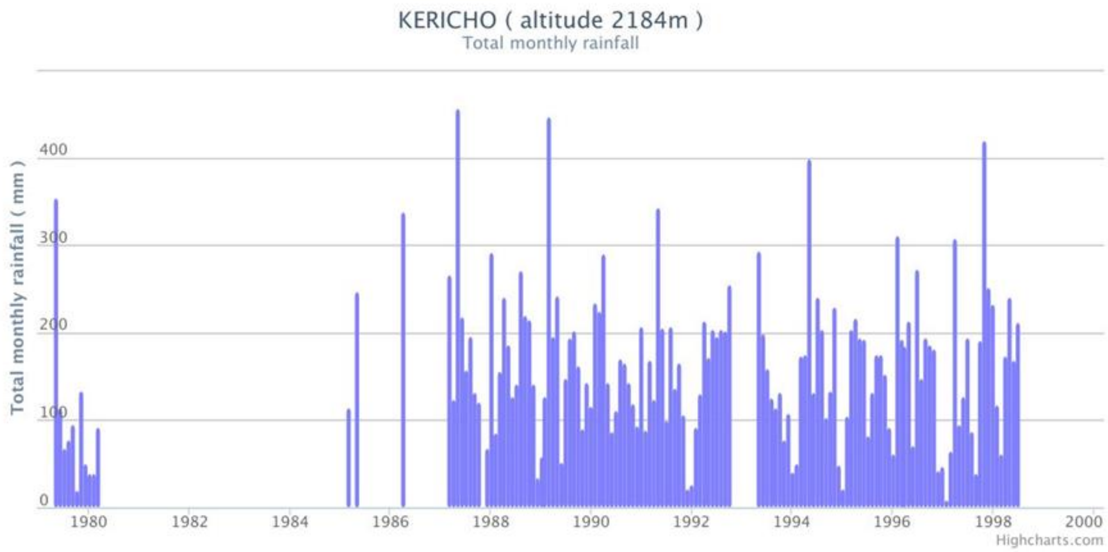

Figure 8. Total monthly rainfall in Kericho, 1979–2000

There is also rise in temperature. The impact of increasing temperature potentially can increase tea yields. However, a positive correlation exists between air temperatures and tea yields only when soil moisture is adequate (Cheserek 2013). Furthermore, the incidences of extreme temperature, either cold or hot, suppress tea yields: daytime maximum temperature in excess of 30˚C leads to a reduction in the rate and desired habit of growth for processing, and whilst heat can improve tea quality, heat extremes potentially damage leaves (Carr and Stephens 1992; Cheserek, Elbehri, and Bore 2015). Warmer temperatures, combined with increased humidity, will potentially proliferate new pests and diseases (Chang and Brattlof 2015; Cheserek, Elbehri, and Bore 2015; Ethical Tea

Partnership 2011; Schepp 2009) whilst destabilizing existing habitat and ecosystems unable to adapt (Cracknell 2015). New pests and disease will incur additional costs and will require new techniques to be appropriately managed.

5.3.2 Future Climate Projections

The projected future changes for the location across 10 different statistically downscaled CMIP5 GCMs for RCP 4.5 because RCP 4.5 assumes that global annual GHG emissions (measured in CO2-equivalents) peak around 2040, with emissions declining substantially thereafter. According to midterm projected changes for the period of 2040-2060 shown in 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 throughout almost 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 approximately 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 receive total monthly rainfall in sufficient quantities still.

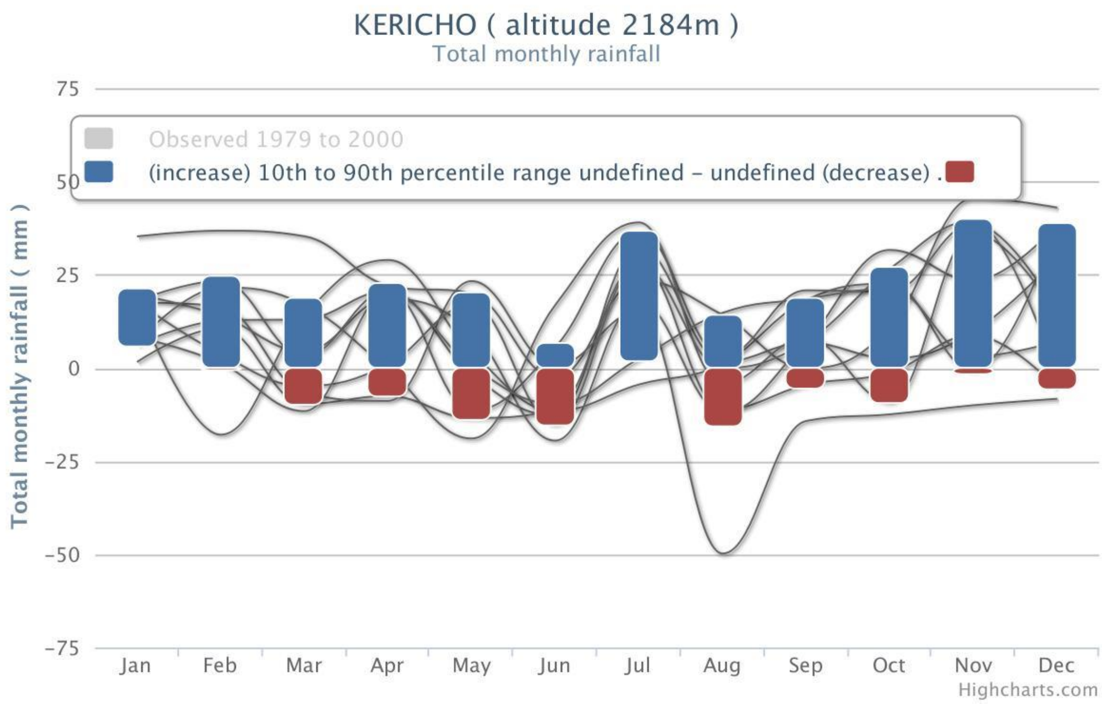

Figure 9. Projected Changes in Total Monthly Rainfall RCP 4.5 in Kericho Station, 2040–2060 *(CIP. 2001)*

For the long-term projection, as shown in Figure 10, total monthly rainfall decrease is less than those for the midterm projection. The decrease of total monthly rainfall is predicted to occur in only a few months, namely, April, May and June; 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. There’s a likely increase from July to February and March is uncertain.

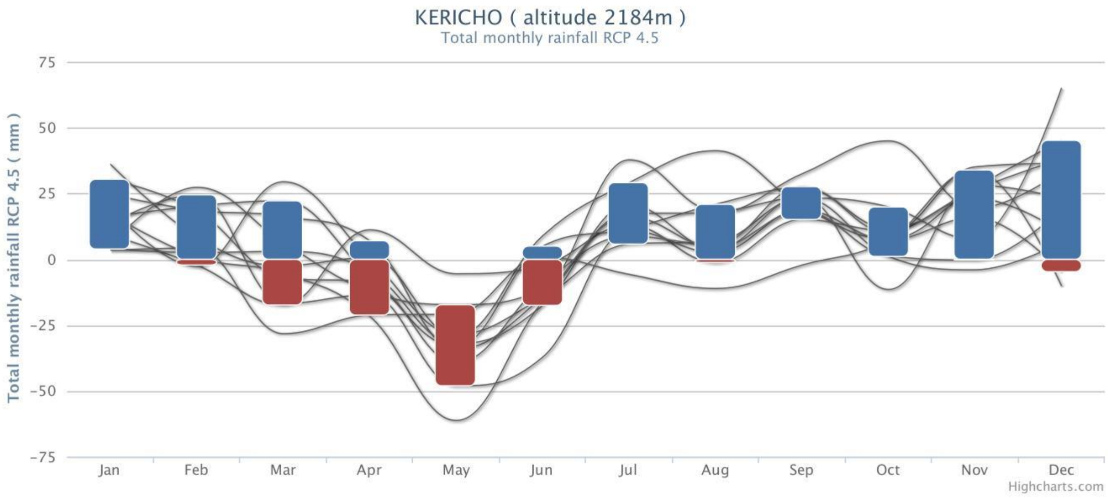

Figure 10. Projected Changes in Total Monthly Rainfall RCP 4.5 in Kericho Station, 2070–2090 *(CIP, 2001)*

The average maximum temperature in the period of 2040–2060 (Figure 11) indicates a rise in average maximum temperature throughout the year by a range of 0.4°C to 2°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 2.2°C, as shown in 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 forecasted to reach 9.3°C.

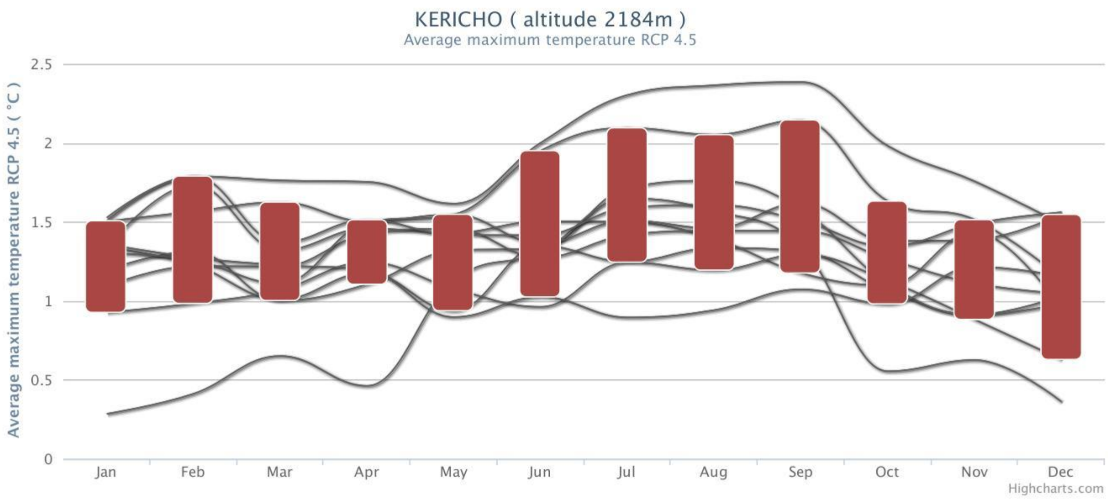

Figure 11. Projected Changes in Average Maximum Temperature RCP 4.5 in Kericho Station, 2040–2060 *(CIP, 2001)*

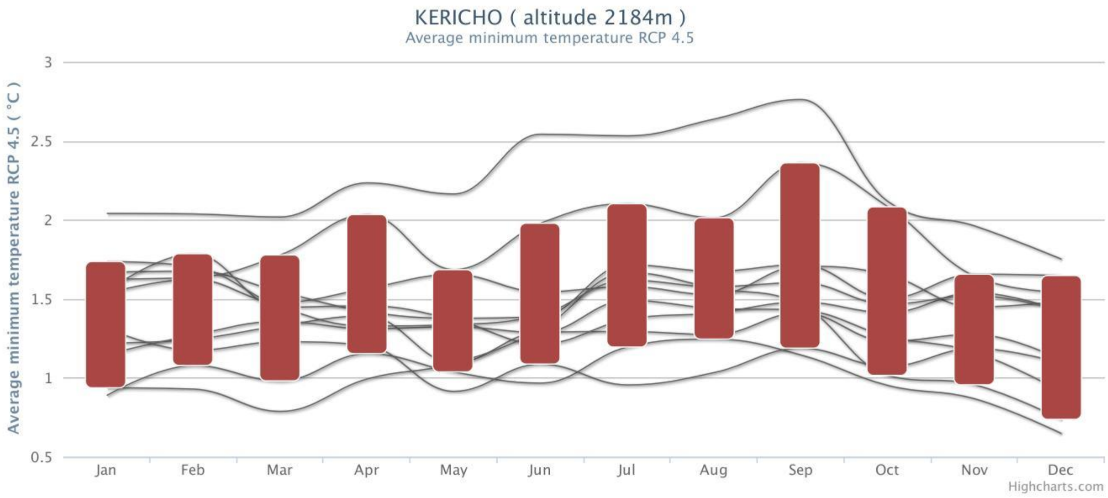

Figure 12. Projected Changes in Average Minimum Temperature RCP 4.5 in Kericho Station, 2040–2060 (CIP, 2001)

In the projection for long term period (2070–2090), as shown in Figure 13 and Figure 14 below, both average maximum and minimum temperatures are expected to experience a slight increase compared to the midterm projection. This condition will affect suitability area for tea growing in Kericho. It is expected to reduce suitable area for tea plantation.

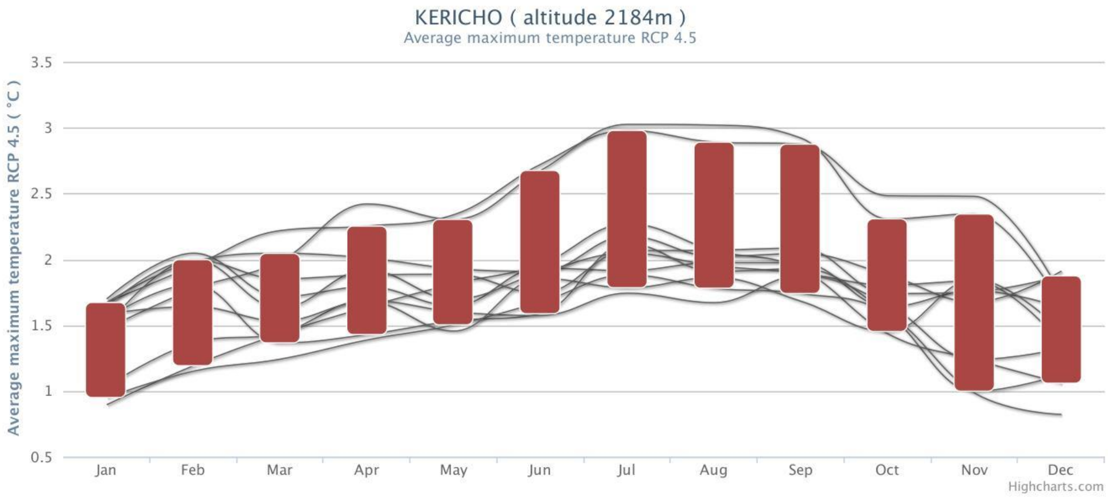

Figure 13. Projected Changes in Average Maximum Temperature RCP 4.5 in Kericho Station, 2070–2090 *(CIP, 2001)*

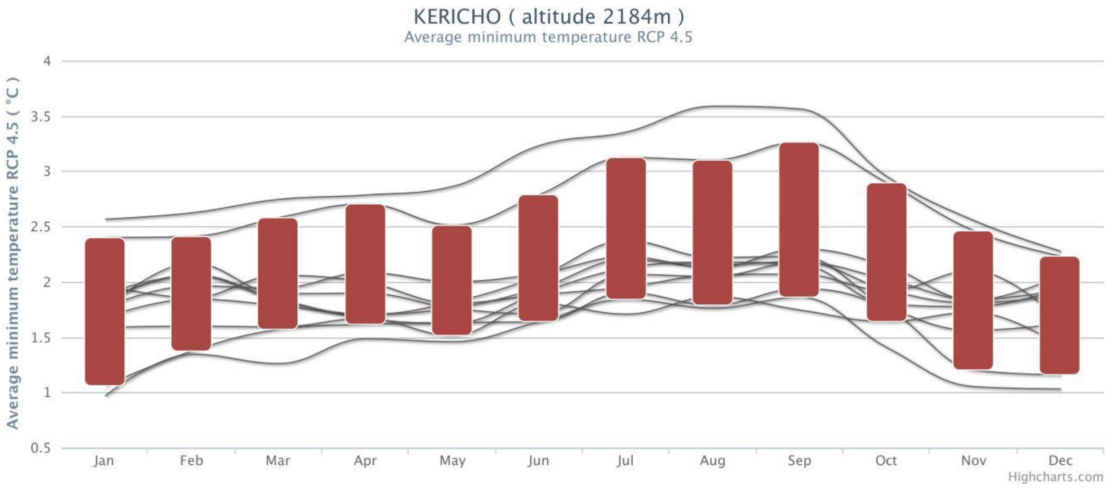

Figure 14. Projected Changes in Average Minimum Temperature RCP 4.5 in Kericho Station, 2070–2090 *(CIP, 2001)*

6. Recommendation for Fruit Juice Industry in Egypt

This study showed that fruit juice industry is vulnerable to rise in temperature and drought. Recent scientific research also shows climate change adaptation relevant to these exposers in the fruit growing sector in Egypt (McCarl et al. 2013; Paciello 2015; Sthapit, Rao, and Sthapit 2012). At farm level, changing management practices is among the most important adaptation measures for the industry to navigate the impacts of climate change. Internationally, systems are being developed that can better predict flowering times for certain fruit trees, calculating pollination confidence and coincidental conditions for damaging weather events like frost or heavy rain (Primary Industries Climate Challenges Centre 2016). Introducing ways to protect against insects, shade, and cool fruit at certain times is proving effective (Darbyshire 2016; Refaie, Esmail, and Madany 2012; Sthapit, Rao, and Sthapit 2012). The agriculture sector in Egypt is dominated by small farms which use traditional practices that do not comply with internationally recognized standards; farmers, for example, tend to overuse and misuse agricultural chemicals and use outdated technologies and tools for land preparation, irrigation, and harvesting (Koscielski, Lotfi, and Butterfield 2012). Improving extension and updating to climate smart farming techniques would improve farm resilience. Simple climate smart interventions such as mulching and preserving ground cover can improve soils and mitigate the extent of dust storms (Sthapit, Rao, and Sthapit 2012; Swain 2016). Using different combinations of different levels of improved surface irrigation system efficiencies and applying deficit irrigation are considered as means of increasing the capacity of surface irrigation systems in old land in order to overcome the negative impacts of climate change (Smith et al. 2013; Sterman 2009). Changing cultivars is often cited as one of the most effective adaptations to climate change (Attaher, Medany, and Abou-Hadid 2009) as new varieties and cultivars can be chosen that cope better with reduced water availability and the increased average temperatures, have increased resiliency to pests and disease, and have increased yields (McCarl et al. 2013; Smith et al. 2013).

For example, good orange production would make the fruit juice industry resilient, which would help the food industry in defending 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. The major challenges for Egyptian oranges are transportation costs, distance between competitors and the destination markets, and seasonality of production. In Egypt, there is a large increase in the internal transport costs, in addition to customs clearance at the port and shipping commissions. These increases represent significant challenges for the Egyptian exporter. The increase in the production equipment costs will also affect the crop prices in the coming years. The projected climate can intensify this condition if there is no effort from stakeholders to solve the problems. Poor transportation can obstruct export of oranges to Saudi Arabia (250,000 tons), Russia (238,000 tons), United Arab Emirates (80,000 tons), Ukraine (75,000 tons), Iraq (70,000 tons), England (68,000 tons) and Netherlands (57,000 tons) (AGQ 2015).

For the small fruit farming and industry, which cannot afford consistently good transportation for its distribution, it is better to consider value added post-harvest production. Whole residuals from the market which may otherwise be wasted, could be suitable for feeding animals (El-Ramady 2015). For a large company, one of its long-term strategy built on three complementary pillars is investment in infrastructure and organic growth market reach. These strategies can be considered as recommended adaptation measures for fruit juice industry in Egypt. Researchers need to demonstrate the benefits of adaptation options, industry needs to promote change amongst growers, and governments must ensure policy encourages change.

7. Recommendation for Tea Industry in Kenya

This study showed that Kenyan tea sector is influenced by hail storm and low precipitation as well as lower temperature. FAO found that a Geographic Information System (GIS) approach was carried out to predict the impact of progressive climate change on tea suitability in Kenya from 2000 to the year 2075 (FAO 2012). The implications are that the distribution of suitability's within the current tea-growing areas in Kenya would decrease not because of rainfall amounts but its distribution and rise in mean air temperatures beyond the threshold of 23.5 ºC. Preliminary results suggest that the suitability of tea growing areas is expected to increase of 8% by 2025, but drop by 22.5% by the year 2075. The key issue for tea in Kenya is rising temperatures, which will push the areas suitable for cultivation to higher altitudes and in some areas, mean it can't be grown. This condition will change tea suitability across different regions in Kenya.

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 the minimum temperature is too low and 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 farmers may have to support the adaptation actions. Renewable energy technologies may help to improve the storage and the transportation system efficiency and sustainability; allowing the tea production industry to allocate its budget for assisting the production stage adaptation to climate change. The industries need to connect energy-agriculture nexus to produce sustainable energy for supporting tea value chain. It is also important to consider increasing value added post-harvest production for small plantations.

Resource efficient and cleaner technologies are fast emerging and need to be incorporated in tea key processing areas but their uptake in the tea industries is generally low due to primarily low awareness levels and inhibiting costs, especially for small-holder farmers. Their uptake can result in low carbon and reduced climate change and vulnerability. Although some adoption is occurring, there is need for capacity building on climate change issues and funding of the technologies by industries geared towards low carbon and climate resilient industrial development.

8. Conclusion

Fruits cultivation growth requirements for Egypt suggest that it currently has insufficient rainfall. Although efforts to improve water drainage structures and irrigation channels may help to combat projected decreases in rainfall fruits and crops, new varieties that can accommodate increases in temperature to address the spread of fungal diseases and drought will also be needed. In addition to improvements storage facilities and transportation efficiency in fruit juice industry, smaller producers should consider value added post-harvest production.

In the Kericho region, climate change models projections for rainfall and temperature suggest 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 the minimum temperature is too low and will affect the growth and the quality of tea. As tea industries depend on the tea plantations, the farmers may have to support the adaptation actions.

Analysis of the current and potential climate conditions to two selected sub-industries reveals a spectrum of situations ranging from lower impact in Kenya, to those that exacerbate current non-optimal conditions in Egypt. In both countries, projected decreases in rainfall and increasing water demands pose a challenge, suggesting that technological, managerial and operational capacities of these 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, tea varieties that are resistant to low temperatures in Kenya, and those that are drought resistant in Egypt, may need to be developed, in addition to the development of adaptation plans for some industries. Further industrial development in the two countries related to processing will require the improvement of post-harvest processing, storage technology, and transportation infrastructure and planning.

There are many opportunities to support climate resilient industrial development could be built upon including:

i. Policy shifts that encourage the use of low-carbon energy production that are not sensitive to high temperatures or 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;

iv. 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 climate resilient industrial development include:

i. Full-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 analysis

Lastly, this paper successfully demonstrated the applicability of continuous vulnerability-policy-climate assessment in developing countries. It is not necessary to wait to develop high resolution climate model and costly-full vulnerability assessment to understand the important issues related to climate change in potential vulnerable industries. It is rather more important to start planning and implementing practical adaptation measures with accessible sets of information. The vulnerability matrix used in this study is practical and applicable without high level climate change expertise and this will a good starting point to understand the bottleneck to adapt to the climate change exposures in a target industry.

9. Acknowledgement

The authors would like to express a great appreciation to the Government of Japan and UNIDO for supporting this assessment. The data was prepared in cooperation with weADAPT (www.weadapt.org) and Climate Information Portal – CIP of the University of Cape Town.

References

Adams, W. M. 2009. *Green Development: Environment and Sustainability in a Developing World*. 3rd ed. London ; New York: Routledge.

Adger, W. N., E. H. Allison, M. C. Badjeck, K Brown, D. Conway, N. K. Dulvy, A. Halls, A. Perry, and J. D. Reynolds. 2005. "Effects Of Climate Change On The Sustainability Of Capture And Enhancement Fisheries Important To The Poor: Analysis Of The Vulnerability And Adaptability Of Fisherfolk Living In Poverty." Final Technical Report Project No. R4778J. London: Fisheries Management Science Programme, MRAG/DFID. www.fmsp.org.

AGQ. 2015. "Egyptian Citrus Exporting Season: Challenges and Opportunities." http://www.agq.com.es/article-en/egyptian-citrus-exporting-season-challenges-and-opportunities.

Amde, Marta, Philip Chan, Mamo Mihretu, and Kaleb Tamiru. 2009. "Microeconomics of Competitiveness. Country: Kenya. Cluster: Tea." Institute for Strategy & Competitiveness, Harvard Business School. http://www.isc.hbs.edu/resources/courses/moc-course-at-harvard/Documents/pdf/student-projects/Kenya_Tea_2009.pdf.

Attaher, S. M., M. A. Medany, and A. F. Abou-Hadid. 2009. "Possible Adaptation Measures of Agriculture Sector in the Nile Delta to Climate Change Impacts." *Advances in Science and Research* 3 (1): 123–126.

Brooks, Nick, Natasha Grist, and Katrina Brown. 2009. "Development Futures in the Context of Climate Change: Challenging the Present and Learning from the Past." *Development Policy Review* 27 (6): 741–65. doi:10.1111/j.1467-7679.2009.00468.x.

CARE International. 2009. *Climate Vulnerability and Capacity Analysis Handbook*.

Carr, M.K.V., and W. Stephens. 1992. "Climate, Weather and the Yield of Tea." In *Tea: Cultivation to Consumption*, edited by Ken C. Willson, 1. ed, 87–135. London: Chapman & Hall.

Chang, Kaison, and Margarita Brattlof. 2015. "Socio-Economic Implications of Climate Change for Tea Producing Countries." Rome, Italy: Food and Agriculture Organization of the United Nations (FAO). http://www.fao.org/3/a-i4482e.pdf.

Cheruiyot, Erick K., Louis M. Mumera, Wilson K. Ng'etich, Ahmed Hassanali, and Francis Wachira. 2007. "Polyphenols as Potential Indicators for Drought Tolerance in Tea (Camellia Sinensis L.)." *Bioscience, Biotechnology and Biochemistry* 71 (9): 2190–97.

Cheserek, Beatrice. 2013. "Analysis of Links Between Climate Variables and Tea Production in the Recent Past and GIS Analysis of Tea Suitability Under Future Climate Change Scenarios." presented at the Climate Change and the Tea Sector in Kenya: Impact Assessment and Policy Action National Multi-stakeholder Workshop, Naivasha, Kenya, April 29.

Cheserek, Beatrice, Aziz Elbehri, and John Bore. 2015. "Analysis of Links between Climate Variables and Tea Production in the Recent Past in Kenya." *Donnish Journal of Research in Environmental Studies* 2 (2): 005-017.

CPDA. 2008. "REPORT ON SMALL-SCALE TEA SECTOR IN KENYA." https://www.somo.nl/wp-content/uploads/2008/03/Report-on-Small-Scale-Tea-Sector-in-Kenya.pdf.

Cracknell, Rachel. 2013. "Adapting to Climate Change in the Tea Sector." http://www.ethicalteapartnership.org/wp-content/uploads/Adapting-to-Climate-Change-Manual.pdf.

———. 2015. "Extension Officer Training Manual: Adapting to Climate Change in the Tea Sector." Ethical Tea Partnership, Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), and

Solidaridad. http://www.ethicalteapartnership.org/wp-content/uploads/Adapting-to-Climate-Change-Manual.pdf.

CSAG. 2016. “Climate Information Portal.” http://cip.csag.uct.ac.za/.

Darbyshire, Rebecca. 2016. “Crossing the Threshold: Adaptation Tipping Points for Australian Fruit Trees.” University of Melbourne.

DW. 2015. “Climate Change Bites Kenyan Tea Farmers | DW Environment | DW.COM | 05.11.2015.” *DW.COM*. http://www.dw.com/en/climate-change-bites-kenyan-tea-farmers/a-18830268.

Ecorys. 2005. “Egyptian Processed Food Sector Review.” s3.amazonaws.com/zanran_storage/www.imc-egypt.org/.../2495700595.pdf.

El Shereif, M. 2016. “Egypt.” Food and Agriculture Organization of the United Nations (FAO). http://www.fao.org/docrep/v9978e/v9978e0e.htm.

El-Ramady, Hassan. 2015. “Postharvest Management of Fruits and Vegetables Storage.” Springer International Publishing.

ENCPC. 2014. “Low Carbon and Climate Resilient Industrial Development in Egypt Project.”

Ethical Tea Partnership. 2011. “Climate Change Adaptation in the Kenyan Tea Sector.” www.ethicalteapartnership.org.

Ezz, Mohamed, and Nada Arafat. 2015. “‘We Woke up in a Desert’ – the Water Crisis Taking Hold across Egypt.” *The Guardian*, August 4, sec. World news. https://www.theguardian.com/world/2015/aug/04/egypt-water-crisis-intensifies-scarcity.

FAO. 2012. “Climate Change and Tea in Kenya: Impact Assessment and Policy Response.” http://www.fao.org/fileadmin/templates/est/Climate_change/kenya/Project_brief_Kenya-EN_FINAL.pdf.

Fernandez-Stark, Karina, Penny Bamber, and Gary Gereffi. 2011. “The Fruit and Vegetables Global Value Chain.” Duke CGGC. http://www.cggc.duke.edu/pdfs/2011-11-10_CGGC_Fruit-and-Vegetables-Global-Value-Chain.pdf.

Frihy, Omran E. 2001. “The Necessity of Environmental Impact Assessment (EIA) in Implementing Coastal Projects: Lessons Learned from the Egyptian Mediterranean Coast.” *Ocean & Coastal Management* 44 (7–8): 489–516. doi:10.1016/S0964-5691(01)00062-X.

GAFI. 2014. “Investment in Egypt. General Authority for Investment.” General Authority for Investment. http://www.gafi.gov.eg/en/InvestEgypt/whyegypt.aspx%202014.

Gesimba, R.M., M.C. Langat, G. Liu, and J.N. Wolukau. 2005. “The Tea Industry in Kenya; The Challenges and Positive Developments.” *Journal of Applied Sciences* 5 (2): 334–36. doi:10.3923/jas.2005.334.336.

Gupta, R., S.K. Dey, and Abhijit Sinha. 2012. “Analysis of Tea Withering Process through Fuzzy Logic Approach.” *Global Advanced Research Journal of Engineering, Technology and Innovation* 1 (1): 8–15.

Hamouda, Mohamed A., Mohamed M. Nour El-Din, and Fawzia I. Moursy. 2009. “Vulnerability Assessment of Water Resources Systems in the Eastern Nile Basin.” *Water Resources Management* 23 (13): 2697–2725. doi:10.1007/s11269-009-9404-7.

IPCC. 2007. “The Regional Impacts of Climate Change.” http://www.ipcc.ch/ipccreports/sres/regional/index.php?idp=30.

James, S.J., and C. James. 2010. “The Food Cold-Chain and Climate Change.” *Food Research International* 43 (7): 1944–56. doi:10.1016/j.foodres.2010.02.001.

Kagira, Elias Kiarie, Sarah Wambui Kimani, and Kagwathi Stephen Githii. 2012. "Sustainable Methods of Addressing Challenges Facing Small Holder Tea Sector in Kenya: A Supply Chain Management Approach." *Journal of Management and Sustainability* 2 (2). doi:10.5539/jms.v2n2p75.

Karori, S.M. 2007. "Antioxidant Capacity of Different Types of Tea Products." *African Journal of Biotechnology* 6: 2287–96.

Kasperson, Roger E., and Mimi Berberian, eds. 2011. *Integrating Science and Policy: Vulnerability and Resilience in Global Environmental Change*. Science in Society Series. London ; Washington, DC: Earthscan.

Kerio, L.C. 2012. "Characterization of Anthocyanins in Kenyan Teas: Extraction and Identification." *Food Chemistry* 131 (1): 31–38.

Klein, Richard J. T., Siri E. H. Eriksen, Lars Otto Næss, Anne Hammill, Thomas M. Tanner, Carmenza Robledo, and Karen L. O'Brien. 2007. "Portfolio Screening to Support the Mainstreaming of Adaptation to Climate Change into Development Assistance." *Climatic Change* 84 (1): 23–44. doi:10.1007/s10584-007-9268-x.

Koscielski, Michelle, Ingi Lotfi, and William Butterfield. 2012. "Assessment of the Agricultural Sector in Egypt." United States Agency of International Development (USAID). http://pdf.usaid.gov/pdf_docs/PA00J2CS.pdf.

McCarl, Bruce A., Mark Musumba, Joel B. Smith, Paul Kirshen, Russell Jones, Akram El-Ganzori, Mohamed A. Ali, et al. 2013. "Climate Change Vulnerability and Adaptation Strategies in Egypt's Agricultural Sector." *Mitigation and Adaptation Strategies for Global Change* 20 (7): 1097–1109. doi:10.1007/s11027-013-9520-9.

Medany, Mahmoud A., Samar M. Attaher, A. El-Gindy, and others. 2011. "Feasibility of Some Adaptation Measures of on Farm Irrigation in Egypt under Water Scarcity Conditions." *Options. Mediterraneennes* 95 (307): 12.

MENR. 2010. "Land Degradation in Kenya."

MENR, and EMCA. 1999. "Environmental Management and Coordination Act." Kenya: National Environment Management Authority.

Miriti, Bundi, and Jeremy. 2003. "Rural Transportation Problems: A Case Study of Tea Roads in the Southern Teagrowing Region of Meru-Kenya."

Mohamed, Gehad G., Azza K. Abd El-Hameed, A. M. M. Nezam El-Din, and Lara A. M. M. N. El-Din. 2010. "High Performance Liquid Chromatography, Thin Layer Chromatography and Spectrophotometric Studies on the Removal of Biogenic Amines from Some Egyptian Foods Using Organic, Inorganic and Natural Compounds." *The Journal of Toxicological Sciences* 35 (2): 175–87.

Ng'etich, W.K., and W. Stephens. 2001. "Responses of Tea to Environment in Kenya. 1. Genotype × Environment Interactions for Total Dry Matter Production and Yield." *Experimental Agriculture* 37 (03).

O'Brien, K., S. Eriksen, L. P. Nygaard, and A. Schjolden. 2007. "Why Different Interpretations Of Vulnerability Matter In Climate Change Discourses." . *Climate Policy* 7 (1): 73–88.

OCHA. 2011. "Eastern Africa: Drought Humanitarian Report." http://reliefweb.int/sites/reliefweb.int/files/resources/OCHA%20Eastern%20Africa%20Humanitarian%20Report%20No.%203%20-%20Drought%20May%202011%20FINAL.pdf.

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

Paciello, Maria Cristina. 2015. *Building Sustainable Agriculture for Food Security in the Euro-Mediterranean Area*. Edizioni Nuova Cultura. http://books.google.com/books?hl=en&lr=&id=bfYaCgAAQBAJ&oi=fnd&pg=PA11&dq=%22GMOs+in+Context:+A+Possible+Solution+to+Feed+the+African+Continent%3F%22+%22EU+Regulation+on+GMOs:+Work+in+Progress%22+%22Longstanding+Attempt+to+Regulate+GMOs%22+%22US-Morocco+Free+Trade+Agreement+(FTA)%22+&ots=LHWPrMzs7W&sig=Jp47303WBEPjfJ4NP1MivdWwZgE.

Paul, Lynn. 2016. “Processing Garden Produce Safely After a Frost.” Accessed December 22. http://www.montana.edu/cpa/news/wwwpb-archives/home/safe.html.

Primary Industries Climate Challenges Centre. 2016. “Research Project: Adaptation Tipping Points for Fruit Trees.” http://www.piccc.org.au/research/project/440.

Refaie, K.M., A. A. M. Esmail, and M.A. Madany. 2012. “The Response Of Banana Production And Fruit Quality To Shading Nets.” *Journal of Applied Sciences Research* 8 (12): 5758–64.

Schepp, K. 2009. “Strategy to Adapt to Climate Change for Michimikuru Tea Farmers in Kenya. Chapter 3, AdapCC Report.” Eschborn, Germany: Deutsche Gesellschaft fur Technische Zusammenarbeit (GTZ) GmbH. http://adapcc.org/en/kenya.htm.

Selim, Tarek H. 2009. “The Egyptian Food Processing Industry- Formalization versus Informalization within the Nation’s Food Security Policy.” In . Chicago, United States.

Smith, Joel, Leland Deck, Bruce McCarl, Paul Kirshen, James Malley, and Mohamed Abdrabo. 2013. “Potential Impacts of Climate Change on the Egyptian Economy.” United Nations Development Programme, Government of Egypt. www.eg.undp.org/content/egypt/en/home/library/.../publication_1.html.

SoftKenya. 2016. “Tea Farming in Kenya.” Accessed March 10. http://softkenya.com/farming/tea-in-kenya/.

Sowers, J., A. Vengosh, and E. Weinthal. 2011. “Climate Change, Water Resources, and the Politics of Adaptation in the Middle East and North Africa.” *Climatic Change* 104 (3–4): 599–627.

Sterman, David. 2009. “Climate Change in Egypt: Rising Sea Level, Dwindling Water Supplies.” *Climate Institute*. http://climate.org/archive/topics/international-action/egypt.html.

Sthapit, Buwon, Ramantha Rao, and Sajal Sthapit. 2012. *Tropical Fruit Tree Species and Climate Change*. New Delhi, India: Bioversity International.

Stockholm Environment Institute. 2007. “Identifying Climate Vulnerability Exposure: Preliminary Guidance for ACCCA Teams.” Advancing Support to Support Climate Change Adaptation. UNITAR ACCCA. http://www.acccaproject.org/UserFiles/File/project%20resources/Climate%20vulnerability%20exposure%201_ACCCA_Final.pdf.

Swain, Sunanda. 2016. “Mitigating the Effects of Sand and Dust Storms.” *EcoMENA*. July 16. http://www.ecomena.org/effects-sand-dust-storms/.

Takama, Takeshi, Edvin Aldrian, Sheila D.A Kusumaningtyas, and Widada Sulistya. 2016. “Identified Vulnerability Contexts for a Paddy Production Assessment with Climate Change in Bali, Indonesia.” *Climate and Development* 9 (2): 110–23.

Temple, S.J, A.J.B van Boxtel, and G. van Straten. 2000. “Control of fluid Bed Tea Dryerscontroller Performance under Varying Operating Conditions.” *Computer and Electronics in Agriculture* 29 (3): 217–31.

UNDP. 2010. “Egypt Second National Communication.” United Nations Convention on Climate Change.

White, Gilbert F. 1988. “The Environmental Effects of the High Dam at Aswan.” *Environment* 30 (7): 5-11; 34-40.

Wilson, L. G., M. D. Boyette, and E. A. Estes. 1999. “Postharvest Handling and Cooling of Fresh Fruit, Vegetables, and Flowers for Small Farms.” North Carolina Cooperative Extension Service.

Wolters, Wouter, Robert Smit, Mohamed Nour El-Din, Eman Sayed Ahmed, Jochen Froebrich, and Henk Ritzema. 2016. “Issues and Challenges in Spatial and Temporal Water Allocation in the Nile Delta.” *Sustainability* 8 (383). www.mdpi.com/2071-1050/8/4/383/pdf.

Yizhaq, H., Ashkenazy Y., and Tsoar H. 2007. “Why Do Active and Stabilized Dunes Coexist under the Same Climatic Conditions?” *Phys. Rev. Lett.* 98.

Youssef, F., S. Visser, D. Karssenberg, A. Bruggeman, and G. Erpul. 2011. “Calibration of Rweq in a Patchy Landscape; a First Step towards a Regional Scale Wind Erosion Model.” *Aeolian Research*.

Zaki, M. 1992. “Production Trends for Fruit and Vegetable Crops in Egypt.” Edited by F. Lauret. *Les Fruits et Légumes Dans Les Économies Méditerranéennes : Actes Du Colloque de Chania*, Montpellier : CIHEAM Options Méditerranéennes : Série A. Séminaires Méditerranéens; n. 19, , 147–50.

TIPS is a research organisation that facilitates policy development and dialogue across three focus areas: trade and industrial policy; inequality and economic inclusion; and sustainable growth. The Annual Forum is platform for researchers, policymakers and other stakeholders to present research and engage in dialogue on policy-relevant issues. The Forums have overarching themes and have been running since 1997.

For details of past Forums and copies of research presented go to Forum Papers

info@tips.org.za +27 12 433 9340 www.tips.org.za

TIPS TRADE & INDUSTRIAL POLICY STRATEGIES