UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION

Adaptation and mitigation in the Egyptian fruit juice industry

Country report

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION

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- **Capital:**

  Cairo

- **Surface:**

  1,001,450 km^2

- **Population:**

  82.5 million

- **Density:**

  1,500 people per km^2

- **Average temp.:**

  17°C to 20°C

Background of the Fruit Juice Industry in Egypt

In 2014, exported food stuffs represented 1.36 billion USD; 4% of all Egyptian exports and 0.5% of GDP. Fruit juice exports made up 2% of the value of food-related exports, 104 million USD, and also, as of 2014, fruit juice production in Egypt has a Revealed Comparative Advantage index (RCA) of +3.66 (Center for International Development at Harvard University, 2016; World Bank, 2016). RCA is a calculation similar to Economic Base Theory, but considers employment rather than exports.

In 2015, Egyptian Company for Advanced Foodstuff Industries (Faragalla) led juice production in Egypt with an off-trade volume share of 18%, Juhayna Food Industries followed with 13% (Euromonitor International, 2016). Although a large portion of agriculture is undertaken by smallholders, (Kristensen, Hussein, & El-Eraky, n.d.) these large fruit juice companies are pursuing vertical integration, primarily through purchasing agricultural land to source raw inputs (Abou-El-Fadl, 2015). The Egyptian food processing sector is a growing, labor-intensive sector, supporting and creating many vital employment opportunities throughout its value chain (Abdallah, Donnaloj, Gregg, Hofmann, & Tumurchudur Klok, 2015; Malec, Gouda, Kuzmenko, & Soleimani, 2016) and playing a critical role in Egypt's economy (International Trade Centre, 2014).

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 are planted in Egypt and consequently there is no need to import such inputs. The sector grew from 713,000 USD to 13.5 million USD from 2007 to 2012 (Selim, 2009).

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 largely dependent upon the River Nile and delta (Figure 1).

The full potential of fruit juice production in Egypt is nonetheless constrained, due to weak relationships between growers and processors, and low skills in post-harvest handling. The sector also experiences deficiencies related to labor productivity, international compliance, and informality (Abdallah et al., 2015). Climate change will pose additional challenges for industry growth.

Figure 1. **Agricultural concentration in Egypt.**

Source: Ramankutty, Evan, Monfreda, & Foley, 2008.

Comment: Key indicates concentration of agriculture (% of each ~100 km² cell that is cultivated).

A Generic Value Chain of Fruit Juice (From Concentrate) in Egypt

Fruit Growing and Collection

Fruit growing requires long-term investment and planning, orchards often taking years to establish. Proper watering and fertilizing are required during the growing process to achieve and maintain healthy soils and moisture. Healthy growth habit is maintained through seasonal pruning as well as disease and pest management. Harvesting is seasonal and takes place when the fruit is mature. Fruit collection peaks from March to May (Desouki, et.al. 2009).

Transportation and Sorting

Handling fruit after harvesting is important as careless or prolonged handling and transport increase post-harvest losses and/or decrease overall fruit juice quality which, in turn, raise cost. Fresh fruits are delivered in boxes which are emptied on a long conveyor belt where manual sorting takes place. Rejected fruits are discarded as solid waste.

Washing and Juice Extraction

After sorting, fruits are washed then peeled and pitted, either manually or automatically. Some fruits with a high juice content and tomatoes need to be preheated for easier pip and seed removal. They are then subjected to a type of mechanical compression appropriate to the fruit concerned. Although there are general fruit presses that can be used for more

Figure 1. Fruit juice production chain

than one fruit type, citrus and stone fruits are usually processed in specially designed equipment. Some fruit types require mechanical milling coupled with a biochemical process involving enzymes to obtain best juice yields.

Evaporation and Fiber Removal

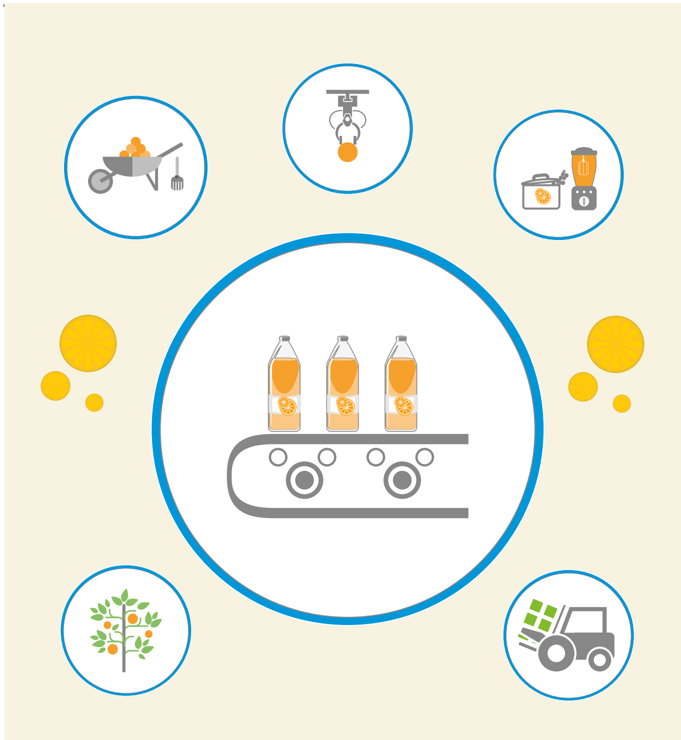
The juice undergoes a single- or multi-stage evaporation process to remove most of the water and other volatile material. The juice is cooked and fed into a centrifugal to separate pulp and cellular debris. After concentration, juices can be stored until they are reconstituted. Some concentrated juices, particularly orange, require freezing at below 10˚C for effective preservation.

Reconstitution, Homogenization & Pasteurization

For consistency the juice is then reconstituted and blended in steam-jacketed mixers: water, and sometimes multiple concentrate sources, are homogenized and sweetened as desired. The juice is heated to 85˚C-95˚C for 15-60 seconds to pasteurize, then instantly cooled with water.

Packing and Distribution

Juice is packed in glass bottles (sterilized prior to filling), tin cans or Dowepack. The filled containers are then sealed and placed on a conveyor belt that passes through a loosely covered trough filled with water. After that, drying, labelling and packaging proceeds. Juice can be warehoused until distribution. Dispatch of packed juice is contracted commercially (Sossna, 2009).



Stakeholders' Perceptions of the Impacts of Climate Hazards on Exposed Industry Processes

In 2015, as part of the vulnerability assessment, a vulnerability matrix was compiled to capture the extent to which fruit and vegetable processing sector stakeholders perceive various climate hazards as impacting industry production processes (Figure 3). Representatives from EEAA (Egyptian Environmental Affairs Agency), UNIDO (United Nations Industrial Development Organization), Food Technology Centre, EMA (Egyptian Meteorological Authority) and national experts from ENCPC (Egyptian National Cleaner Production Center) were involved. These stakeholders' perceptions of current and past climate vulnerability can offer insights into, and inform priorities for, climate change adaptation (Stockholm Environment Institute, 2007).

The vulnerability matrix shows the climate hazards identified by stakeholders as threats to the juice industry (top row), each evaluated on a scale 0-3.

The rating depended on the perceived degree of impact the climate hazard would have on components of the production process (first column). Being subject to climate hazards, the production process components are referred to as *exposure units* (see methodology report for detail).

The scale was delineated as: 0 = no impact on the exposure unit, 1 = low impact on the exposure unit, 2 = medium impact on the exposure unit, 3= significant impact on the exposure unit[1]

[1] 'Significant impact' was explicitly defined as 'impact the exposure unit has not coped historically or is not able to cope without an external support'.

Table 1. **Vulnerability matrix of fruit juice industry in Egypt**

	Heavy Rain	Flood	Frost	Strong wind	Sea Level Rise	Drought	Temperature Rise	**Number of 3s**
Frequency	-	-	-	-	+	+	+	
Growing & Collection	1	0	0	0	0	0	0	**0**
Transportation & Sorting	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**
Evaporation	0	0	1	0	0	3	2	**1**
Dilution and sugar addition	0	0	0	0	0	3	2	**1**
Pasteurization	0	0	0	0	0	3	3	**2**
Packing	0	0	0	0	0	0	1	**0**
Sterilization	0	0	0	0	0	3	3	**2**
Storage	0	0	0	0	0	0	0	**0**
Distribution	1	3	0	2	0	0	3	**2**
Number of 3s	**1**	**1**	**0**	**0**	**0**	**5**	**4**	**11**

The aggregated frequency of significant impact (Number of 3s) reveals stakeholders' perception of the impact of climate hazards on exposure units.

Stakeholders perceived a threat of significant impact on the following exposure units: storage (2), pasteurisation (2), sterilization (2), pre-process storage (2), washing/cooking/dilution and sugar addition. Those units are considered to be vulnerable due to the probability and prevalence of the hazards occurring. It should be considered in order to determine their adaptation priority. Collection, transportation, preparation, packing and post-process storage, however, were perceived to be invulnerable to climate hazards. Impacts to on-farm exposure units were not assessed.

Stakeholders assessment of the impact

Storage

Pasteurisation

Sterilization

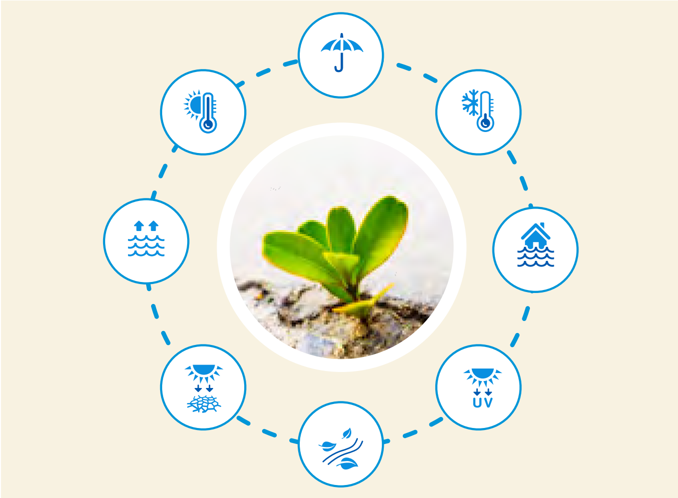
Pre-process storage

Washing, cooking, dilution and sugar addition

Projected Implications of Climate Hazards

Drought

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. The largest precipitation decreases in North Africa will be in parts of Egypt (Terink, Immerzeel, & Droogers, 2013) whilst ground water availability and surface water evaporation are predicted to increase as a result of climate change (Abdel-Shafy & El-Saharty, 2007; Agrawala et al., 2004; Bakri & Abou-Shleel, 2013; Frihy & El-Sayed, 2013; Ministry of Water Resources and Irrigation, Egypt, 2014; Radhouane, 2013; Schilling, Freier, Hertig, & Scheffran, 2012). The Nile River is understood to be very sensitive to temperature and precipitation changes, mainly because of its low runoff/rainfall ratio which is 4% (McCarl et al., 2013; Ministry of Water Resources and Irrigation, Egypt, 2014; Smith et al., 2013). Results from analysis on two extensive data sets describing sea surface temperature of the Pacific Ocean, and the flow of water in the Nile River suggests that 25% of the natural variability in the annual flow of the Nile is associated with El Niño oscillations (Eltahir, 1996). The prolonged 1979-1987 drought forced Egypt to reduce its water use despite the inter-annual storage in Lake Nasser behind the High Aswan Dam. This clearly shows Egypt's vulnerability is brought by climate variability that cause the changes in Nile River (Ministry of Water Resources and Irrigation, Egypt, 2014). A climate change prediction model identified water resources as one of the three



most vulnerable sectors to climate change in Egypt (Ministry of Water Resources and Irrigation, Egypt, 2014). While the variability in models prevents a conclusive determination of whether climate change will mean more or less rain at the Nile's source waters, it is clear that the increased evaporation, due to rising temperatures and heatwaves,will result in greater water stress (Agrawala et al., 2004) and increased salinity (Agoumi, 2003). With higher drought frequency and less water availability, all crops are predicted to have an increase in irrigation needs and a decrease in yields (Brauman, Siebert, & Foley, 2013; Mohamed, Mohamed, Ahmed, & Abdrabbo, 2015; Ouda & Zohry, 2016; Smith et al., 2013). It contributes significant impacts to the fruit juice value chain. For example, the yield of citrus grown in Egypt is predicted to decrease by 15.2% by 2060, mainly as a result of insufficient water (Smith et al., 2013).

Temperature Rise

Rises in annual temperatures would bring hazard for the region in addition to more numerous, longer and intense heat-waves (Radhouane, 2013). Rising temperatures and more extreme weather events will lead to significant post-harvest losses, on top of those already being experienced. Furthermore, the increase of temperature also has implications for any instances during processing where cooling or chilling to specific temperatures is required (James & James, 2010). An increased temperature will also increase the overall energy in such processes and potentially lead to power overloads. Moreover, due to the energy insecurity wrought by temperature heat extremes, any powered production process will be at higher risk of disruption (Kingsley, 2014).

On the other hand, due to poor packaging, lack of cold chain facilities, rough transport, and multiple handling, the Egyptian perishable products sector (mainly the fruit, vegetables, and dairy) 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 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, & 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 & James, 2010).

On-farm, yield quantity and quality could decrease in both sub-tropical and tropical trees. Research continues into how climate change will influence potential yield, but it is known that potential fruit yield is affected by both temperature and radiation (Radhouane, 2013). Insufficient cool days during winter (winter chill) will result in poorer flowering and therefore lower production of subtropical fruit; timing changes in seasonal shifts will also impact pollination and character/quality of the fruit and too many hot days and heat extremes will cause damage and spoilage to both fruits and the trees, with implications for yield (Darbyshire, 2016; El Yaacoubi, Malagi, Oukabli, Hafidi, & Legave, 2014; Khalil & Hassanein, 2010). Due to marginal climate conditions in some fruit growing areas already, even slight increases in temperatures could have severe impacts (Khalil & Hassanein, 2010).

Flood

In the past, Egypt, especially Upper Egypt, has been subjected to damaging floods (Khater, 2015) and extreme weather, such as floods and tidal surges, which are predicted to become more frequent and damaging in the following 10-25 years due to climate change (Crane, 2015; Radhouane, 2013). Floods cause major damage to any agricultural areas they submerge, and will also interrupt transportation processes, causing spoilage and waste. In 2014, heavy rain for two consecutive days in Egypt caused strong floods and damage in different governorates In Egypt. The rains in two days flooded 35 acres of agricultural land in 15 different villages in Asyut and displaced hundreds of citizens since the floods destroyed the dams previously built by the army forces in Wady Al-Sheikh (Cairo Post, 2014).

Heavy Rain

Heavy rain is associated both to intensity and frequency. In 2015, severe weather including strong winds, heavy rainfall and flooding, affected northern Egypt in November. The heavy rainfall has been reported in the Governorates of Beheira, Kafr El-Sheikh, North Sinai, Monufia, Matrouh and Alexandria. The worst affected areas are thought to be Alexandria and Beheira. According to WMO figures, 52 mm of rain fell in the city of Alexandria over a 24 hour period to 04 November. The increasing periods of heavy rain predicted (Radhouane, 2013) will have a notable effect on the fruit juice industry. Heavy rain has a significant effect on storage, especially on open storage areas at some facilities. This will lead to damage of some raw materials, like vegetables, fruits and chemicals, used in the production process. The possibility of heavy rain occurrence is increased in the delta region and coastal areas which are agriculture and industrial areas. Heavy rain on-farm, at flowering particularly, can wipe out or severely damage entire crops (El Yaacoubi et al., 2014; Sthapit et al., 2012). Furthermore, heavy rain may delay transportation and distribution processes.

Strong Wind

Despite stakeholders,Table 1 stated that strong wind doesn't affect growing process. However, strong wind which occurs in Egypt in spring season causing dust storms and erosion, is also set to increase in frequency and severity as a result of climate change (El Ashmawy, 2013). Currently its effects are mainly felt by agriculture; wind and dust delay plant growth and cause damage to trees and fruit (Swain, 2016). Strong wind, and particularly the dust storms it causes, can also affect industry, including: structural damage from dust deposition; waste and damage from dust infiltration; and costs incurred from dust removal or, in severe cases, excavation. Dust storms also affect transportation, causing road closures, accidents, delays, and material loss or damage (Swain, 2016).

Frost

Currently, occasional radiation frost events occur in winter in the early morning and have effect on the fruits as raw materials. Seasonal temperature changes will expose the fruit to higher risk of frost damage on-farm (Darbyshire, 2016). Frost bite affects the quality of raw materials in storage, especially in open storage areas. Lower temperatures affect the blanching process as more energy is necessary to reach the required temperature of blanching. Average low temperatures vary from 9.5 °C (49.1 °F) during winter to 23 °C (73.4 °F) in summer (Geisler, et. al. 2003).

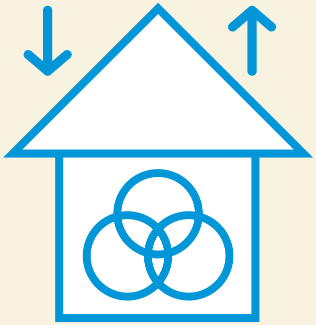
Sea Level Rise

The Nile Delta is already subsiding at a rate of 3-5 mm per year (Agrawala et al., 2004). The northern and eastern borders of Egypt lie low to the Mediterranean and Red Sea so any rise in sea level will threaten industrial facilities nearby the shore, with disastrous consequences (Abdelaty, Abd-Elhamid, Fahmy, & Abdelaal, 2014; Sterman, 2009). During high tides, tidal flooding is affecting coastal areas. The extent and magnitude of subsidence related to flooding will worsen with the likely continuation of sea level rise (Janin, Mandia, 2012). Up to half of the agricultural land in the northeast Nile Delta is threatened by a high rate of sea level rise (Smith et al., 2013). Transportation and distribution networks will likely be affected due to sea level rise.

Adaptation Options for the Egyptian Fruit Juice Industry

Adaptation at Farm-Level

Recent scientific research has been conducted related to climate change adaptation relevant to the fruit growing sector in Egypt (McCarl et al., 2013; Paciello, 2015; Sthapit et al., 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 proved as an effective way (Darbyshire, 2016; Refaie, Esmail, & Madany, 2012; Sthapit et al., 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 et al., 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 et al., 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, & 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).

In implementing climate adaptation interventions at farm-level, understanding future climate change impacts across growing regions and different varieties is particularly important for the fruit tree industry.

Unlike annual crop growers, fruit growers are limited in how quickly they can adapt to a changing climate; e.g. oranges are typically planted only once every 25 or more years. Therefore, adoption of new varieties occurs much more slowly than for annual crops, and planting configurations are difficult to modify. Changing trees is a substantial and long-term investment for an orchard owner so fruit growers need to be thinking in advance about likely climate changes and how best to prepare for them. Growers can implement some of the most effective climate adaptation strategies at the point at which orchard blocks are developed and re-developed; these decisions will affect production for the next few decades (Darbyshire, 2016; Lobell et al., 2006; Sthapit et al., 2012).

Adaptation at Factory-Level

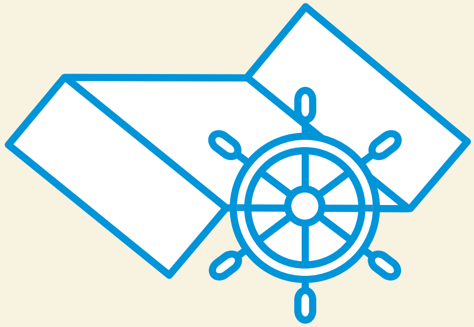
As previously mentioned, fruit agriculture is concentrated in coastal areas (North Egypt), therefore, it is likely that the government constructs barriers that could protect industry from sea level rise (Smith et al., 2013). Agricultural and land management practices can reduce the severity of dust storms, thereby the practices are important to mitigating dust storms' impacts on industry.

A number of the factory processes crucial to optimizing juice quality are sensitive to temperature. Thus, measures and control are required to enable better temperature regulation at critical processing stages. The latter mitigation options listed in the latter part of this document, are the major adaptations that will increase the fruit juice sector's resilience to climate change; simply by increasing process and machinery efficiency, reducing heat/cold leakage. Temperature regulation should account for factory microclimates created or exacerbated by external climate conditions and thermal or vapor emissions generated by other machinery and processing. External climatic conditions have a decisive impact upon the climatic conditions inside containers. External climatic conditions are in particular determined by the transport route, season and time of day and the current weather, e.g. rain, sunlight (Thompson, Henke, 2000).

Mitigation Options for the Egyptian Fruit Juice Industry

Mitigation at Farm-Level

At farm level, climate change mitigation can often be achieved as a result of implementing appropriate climate change adaptation strategies that use resources more efficiently or substitute dependence on external inputs. Many of the landscape approaches for adaptation suggested in the previous section; for example soil conservation and management practices, will also sequester carbon and result in fewer greenhouse gas emissions (Aguilera, Lassaletta, Gattinger, & Gimeno, 2013). In addition, water management is also important at-farm level.



Mitigation Options at Factory-Level

Climate change mitigation becomes increasingly important at the point of processing which requires proper technologies that are more efficient and thus reduce energy demand. The following tables include energy efficiency and low carbon energy sources that are key to reducing emissions, and could lead to cost savings, as well as additional benefits such as lowered pollution levels.

1. Cross cutting energy efficiency measures

Steam Systems

Boilers		Steam Distribution Systems	Process Integration
• Boiler process control • Flue gas heat recovery • Reduce flue gas quantities • Condensate return • Reduce excess air • Blow down steam recovery	• Properly sized boiler systems • Boiler replacement • Improve boiler insulation • Direct contact water heating • Boiler maintenance	• Improved distribution system insulation • Steam trap monitoring • Insulation maintenance • Leak repair • Steam trap improvement • Flash steam recovery • Steam trap maintenance	• Process integration • Pinch analysis

Motor Systems and Pumps

Motor Systems	Pumps	
• Motor management plan • Strategic motor selection • Maintenance • Properly sized motors • Adjustable-speed drives • Power factor correction • Minimizing voltage unbalances	• Pump system maintenance • Multiple pumps for variable loads • Pump system monitoring • Impeller trimming • Pump demand reduction • Avoiding throttling valves • Controls	• Replacement of belt drives • High-efficiency pumps • Proper pipe sizing • Properly sized pumps • Adjustable-speed drives

Refrigeration Systems

Refrigeration System Management	Cooling Load Reduction	Reducing building heat loads
• Good housekeeping • Refrigeration system controls • Monitoring system performance • Checking for refrigerant contamination • Ensuring proper refrigerant charge • Efficient piping design	• Piping insulation • Properly sized motors • Minimizing heat sources in cold storage areas • Hydrocooling • Reducing heat infiltration in cold storage areas • Geothermal cooling	• Removal of excess surface water • Free cooling
Compressors	**Condensers and Evaporators**	
• Compressor control systems and scheduling • Adjustable-speed drives • Floating head pressure control • Compressor heat recovery • Indirect lubricant cooling • Dedicating a compressor to defrosting • Raising system suction pressure	• Keeping condensers clean • Adjustable-speed drives on condenser fans • Automatic purging of condensers • Cycling of evaporator fans in cold storage • Reducing condenser fan use • Adjustable-speed drives on evaporator fans • Reducing condensing pressure • Demand defrost • Use of axial condenser fans • Water defrosting	

Compressed Air Systems

- System improvements
- Improved load management
- Maintenance
- Pressure drop minimization
- Monitoring
- Inlet air temperature reduction
- Leak reduction
- Controls
- Turning off unnecessary compressed air
- Properly sized pipe diameters
- Modification of system in lieu of increased pressure
- Heat recovery
- Replacement of compressed air by other sources
- Natural gas engine-driven compressors

Self-Generation

- Backpressure turbines
- Tri-generation
- Combined heat and power
- Photovoltaic panels

2. Process-specific energy efficiency measures

Blanching

- Upgrading of steam blanchers
- Heat recovery from blancher water or condensate
- Heat and hold techniques
- Steam recirculation

Pasteurization and Sterilization

- Sterilizer insulation
- Helical heat exchangers
- Compact immersion tube heat exchangers
- Induction heating of liquids

Evaporation

- Maintenance
- Mechanical vapor recompression
- Multiple effect evaporators
- Concentration using membrane filtration
- Thermal vapor recompression
- Freeze concentration

Peeling

- Heat recovery from discharge steam
- Dry caustic peeling
- Multi-stage abrasive peeling

Emerging Energy Efficient Technologies

- Heat pump drying
- Carbon dioxide as a refrigerant
- Ohmic heating
- Geothermal heat pumps for HVAC
- Condition-based motor monitoring
- Pulsed electric field pasteurization
- Advanced rotary burners
- Pulsed fluid-bed drying
- Magnetically-coupled adjustable-speed drives

Conclusion: Opportunities and Challenges

Technology

Egypt's Industrial Development Strategy explicitly identifies a vision in which the technology of the food processing sector is developed. Resource efficient and cleaner technologies are fast emerging and need to be incorporated into sector development (Ministry of Trade and Industry, 2012). The primary resources upon which the Egyptian fruit juice sector relies also require technological investment to cope with the pressures of climate change. Further studies on impacts, vulnerability, mitigation and adaptation to climate change are still needed in the agriculture sector in order to be able to develop a mitigation and adaptation strategy for the sector addressing the barriers to implementing adaptation measures. Domestically, the barriers limiting the reach of technical information need to be addressed, and more regional and international partnerships need to be supported to gain deeper insights into the future of Egypt's fruit juice processing industry under climate change, and to benefit from the forefront of industry innovation.

Financing

Financing is often becoming a bottleneck in value chain development, particularly for fruit agriculture which is managed by small farmers. There may be opportunities to finance mitigation strategies, but it needs to reach small stakeholders. Further to this, more finance information is required to facilitate adaptation.

The number of projects being undertaken exclusively in Egypt is approximately equal to regional participation. The level of adaptation activity in Egypt is moderate, at best, if compared to the degree of adaptation action in countries in eastern, western and southern Africa.

However, it should be recognized that a number of internationally-funded projects underway, that do not specify climate change adaptation, could deliver adaptation benefits. There are opportunities to become involved in many programs related to agriculture, water and economic resilience that do not focus on climate change, but will nonetheless improve adaptive capacity (Global Environment Facility, 2008). Proactive approaches are required and private-public partnerships may provide opportunities.

Information

The specific consequences of climate change on fruit juice production in Egypt need to be better understood by the industry. Likewise, better information and decision support needs to be available to growers and factory owners when considering climate adaptation technologies. Although it is relatively easy for fruit juice industry actors to decide to make short-term, incremental adaptations (like growers installing netting or factory owners trying to make energy savings where possible), researchers, industry and government to have an important role to play in adaptation, particularly for more transformative and costly changes.

Researchers need to demonstrate the benefits of adaptation options, industry needs to promote change amongst growers, and governments must ensure policy encourages change. The risks, costs and benefits of adaptation and mitigation need to be carefully assessed and understood. No one-size-fits-all approach can be taken with the fruit juice industry; the vastness of Egypt's growing regions, and the diversity of fruit species and cultivars planted means successful adaptation will differ depending on timing, location, and crop type. A reliable strategy would call for a coherent vision and comprehensive supply chain coordination.

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This report examines the fruit juice industry of Egypt, identifying the impacts of climate change on the fruit juice value chain and suggesting options for climate change adaptation and mitigation.

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