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مبادرة أبوظبي العالمية للبيانات البيئية
Abu Dhabi Global Environmental Data Initiative

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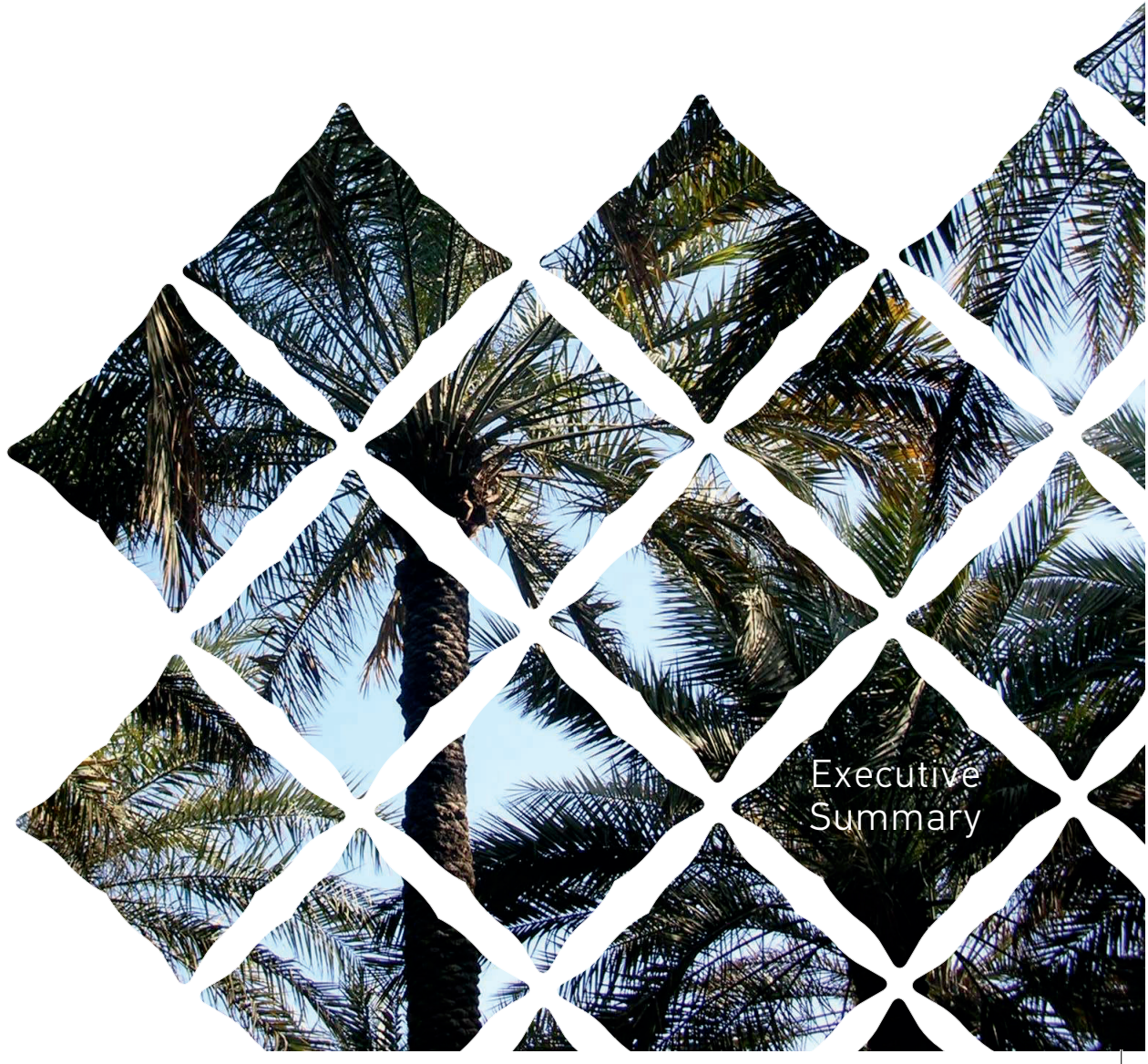
هيئة البيئة - أبوظبي
Environment Agency - ABU DHABI

LOCAL, NATIONAL, REGIONAL CLIMATE CHANGE PROGRAMME

FOOD SECURITY AND CLIMATE CHANGE

- Atmospheric Modelling
- Arabian Gulf Modelling
- Terrestrial Ecosystems
- Marine Ecosystems
- Transboundary Groundwater
- Water Resource Management
- Al Ain Water Resources
- Coastal Vulnerability Index
- Desalinated Water Supply
- **Food Security & Climate change**
- Public Health Benefits of GHG Mitigation
- Sea Level Rise

Climate Change Research Group



The authors of this report are Bill Dougherty (Principal Investigator) from the Climate Change Research Group and Patrick Keys from Colorado State University. The authors would like to acknowledge the significant contributions of several colleagues: Clemens Breisinger, Siwa Msangi, and Daniel Mason-D'Croz from the International Food Policy Research Institute (IFPRI), Eckart Woertz from the Barcelona Centre for International Affairs (CIDOB), and Ian Tellam from Adaptify.

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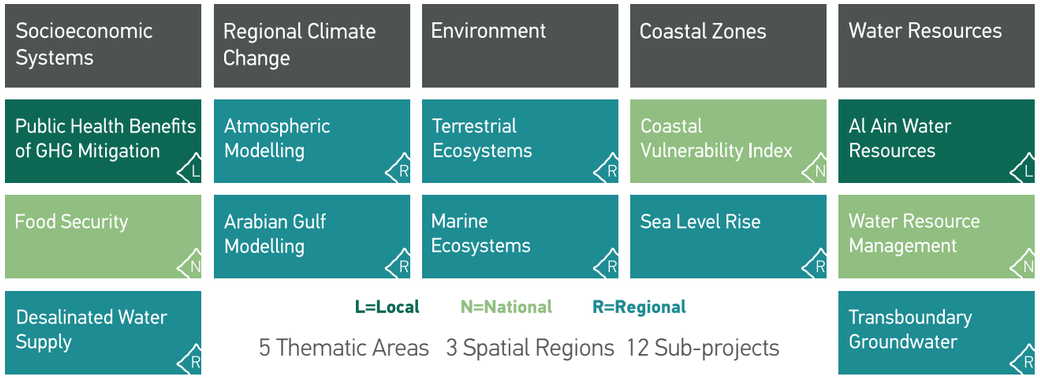

12 Sub-projects
Assess the Impacts, Vulnerability & Adaptation to Climate Change in the Arabian Peninsula

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About the Food Security & Climate Change sub-project

In October 2013, The Abu Dhabi Global Environmental Data Initiative (AGEDI) launched the Local, National, and Regional Climate Change Programme (LNRCCP) to build upon, expand, and deepen understanding of vulnerability to the impacts of climate change as well as to identify practical adaptive responses at local (Abu Dhabi), national (UAE), and regional (Arabian Peninsula) levels. The design of the Programme was stakeholder-driven, incorporating the perspectives of over 100 local, national, and regional stakeholders in shaping 12 research sub-projects across 5 strategic themes. The "Food Security & Climate Change" sub-project within this Programme aims to assess the impact of climate change on the long-term food security of the UAE, while also seeking to identify and evaluate potential adaptation measures that can reduce future climate change-related risks such as declining agricultural productivity in food-exporting countries, tightening world food markets, and recurrent food price spikes.

1. Food security and climate change context

The UAE is a country that is heavily dependent on food imports and may be vulnerable to food supply constraints and price shocks associated with climate change impacts in food-exporting countries.

Of the three major sources of food supply: imports, local production and food stocks, UAE food supply relies overwhelmingly, nearly 90%, on international food trade (FAO, 2015). This is due to the UAE's location in a hyper-arid environment where local agricultural production is limited. The UAE is also a major regional trade hub, significant food quantities are exported/re-exported, primarily to other GCC countries.

The combination of climate change-induced declining agricultural productivity in food- exporting countries, tightening of world food markets, and price speculation pressures could lead to several adverse circumstances in the UAE.

These may include recurrent retail food price spikes and/or a need for substantial food subsidies. Households throughout the seven emirates that have annual incomes at the lower end of the national range could find themselves in a position where they would be subject to spending a growing share of household budgets for food.

The lack of viable local production options implies that any disruption to international food markets impacts the UAE more acutely than countries where local food production alternatives are available.

This is particularly true for cereals, vegetables, and meat for which import levels are very high. Moreover, the UAE's combined resident and expatriate populations have been increasing rapidly, rising nearly three-fold over the period 2000-2011, or about 10.3% per year and qualifying the UAE as having one of the highest population growth rates in the world. Cereal import rates have increased an average of 10% per year to keep pace.

Food trade flows for the UAE tend to be dominated by core groups of food exporting countries.

The actual set of countries varies depending on the particular food item imported. For example, most cereal imports such as wheat, rice, barley, maize, oats, millet, and sorghum are typically imported from a handful of countries, namely India, Pakistan, Australia, Argentina, Canada, and Thailand, From year to year cereal imports from these countries can show large swings. Cereal re-exports from the UAE are also primarily focused on handful of countries, namely GCC and Eastern Africa countries. Maintaining food security for the UAE depends, at least in part, on understanding the impact that climate change poses on the very countries upon which the UAE has historically come to rely upon for its food supply.

The food price crisis of 2008 also highlights the linkages between food supply and international financial markets.

(Heady, et al. 2010; Wiggins and Levy, 2008; World Bank, 2012). In 2008, the financial crisis that began in the United States and Europe, led global markets to become much more volatile and caused commodity prices to rise significantly (IPCC, 2014). This volatility in commodity prices was in large part due to a decreasing trend in food supplies available for purchase on the global market. Moreover, since the dirham is pegged to the US dollar, the UAE was strongly affected by the simultaneous rise in food prices on the world market and the weakness of the US currency (Kumetat, 2009).

Numerous studies argue that climate change will contribute to increased food prices by 2050, with estimated increases ranging from 3 to 84%.

(Hertel et al. 2010; Lobell et al. 2013). The Intergovernmental Panel on Climate Change (IPCC) has characterized negative impacts of climate change on crop production to be more prevalent than positive impacts (IPCC, 2013). For example, recent climate trends on wheat productivity show a strong negative trend with yields decreasing roughly between 1% and 3.5% per decade. In other words, an already volatile global food price situation may be expected to worsen with climate change. The increased instability of agricultural yields of cereals and other crops under climate change may aggravate food price volatility.

Today, the UAE is considered a food secure country, by most international measures.

For example, the International Food Policy Research Institute (IFPRI) developed a food security index specifically for the MENA region which shows the UAE as having a "Low Risk of Food Insecurity" within this classification system (see Figure 1). This is due to the UAE's capacity to ensure access, affordability, and quality of its food supplies. However, while this finding may be true relative to aggregate comparisons across countries, it may mask important information across segments of the population since food insecurity is not experienced in a homogeneous way by the residents of a country.

In the future, food security in the UAE under climate change will likely revolve around several key factors.

First, potential food insecurity may be experienced at both the household and government levels. This is evident from a review of food security indicators – some indicators are appropriate at a national scale (e.g. food availability, food access) while others are more appropriate to consider at a household scale (e.g. food affordability, food utilization). Second, food exports from other countries are far more integral to the UAE's future food security than local agricultural productivity. Third, national policies that are currently in place to address food security (e.g. tariff levels, subsidies to reduce impacts of price increases, strategic food reserves) may need ongoing assessment and evaluation to cope with future climate change.

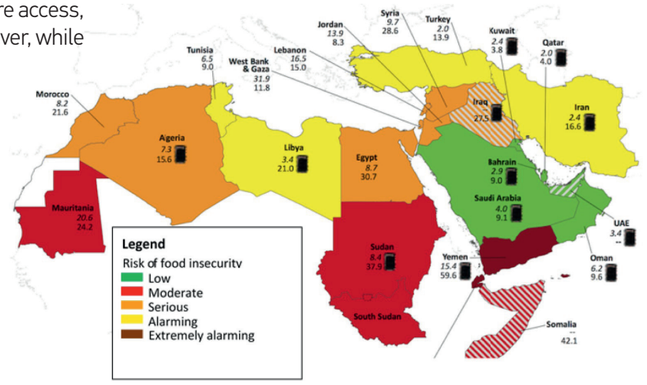


Figure 1: IFPRI's food security index for the MENA region (IFPRI, 2013)

2. Approach

The overall goal of the sub-project is to better understand the future impact of climate change on the food security of the UAE.

Several core research questions were addressed:

1) To what extent will agricultural productivity in food exporting countries on which the UAE has traditionally relied be affected by climate change?

2) Will UAE households, both resident and expatriate, face rising shares of their household budgets devoted to food purchases? and

3) What types of policy options and measures could be considered to strengthen UAE food security under climate change?

Conceptual framework

The conceptual framework for the assessment of food security under climate change in the UAE addresses both the "macro" (i.e. food trade) and "micro" (i.e. household food expenditure) scales.

At the macro scale, a key indicator to explore is the degree to which food exporting countries on which the UAE has historically relied upon are projected to experience constraints in agricultural productivity due to climate change. Such constraints could lead to a decrease in the availability of and access to imported food items by the UAE, or at least adverse perturbations in availability and access. At the micro scale, a key indicator is the degree to which food at retail outlets throughout the UAE remains affordable under climate change. Affordability, a relative term, needs to be considered within the overall context of household expenditures and how household incomes are projected to change over time.

Data availability

Several kinds of data were obtained to conduct the analysis.

First, the UAE's historical food import trends were obtained from FAO trade matrices and cross-checked against available foreign trade statistics from the UAE's National Statistical Bureau (NBS) where possible. Second, data on the agricultural productivity under climate change of food exporting countries was obtained by accessing outputs of the of the International Model for Policy Analysis of Agricultural Commodities and Trade (IMPACT) model runs, which were used as the basis to estimate the impacts of climate change on the agricultural productivity of the UAE's major trading partners (IFPRI, 2015). Third, the characterization of the profile of UAE households was based on data obtained from the NBS and country market research studies (Euromonitor, 2015). From these resources, a detailed database on household income and expenditure characteristics was constructed.

Modelling framework

At the macro-level, an econometric modelling approach was used to estimate food supply and trade risks under climate change.

Such a modelling approach was able to integrate a wide range of pertinent country-level and global information into a single analytical platform to support food security risk assessments. The International Model for Policy Analysis of Agricultural Commodities and Trade (IMPACT) which consists of a network of linked economic, water, and crop models, and was used to estimate the impacts of climate change on food exporting countries (see Figure 2).

At the micro-level, a spreadsheet modelling approach was used to estimate the share of household expenditures on food, with and without climate change.

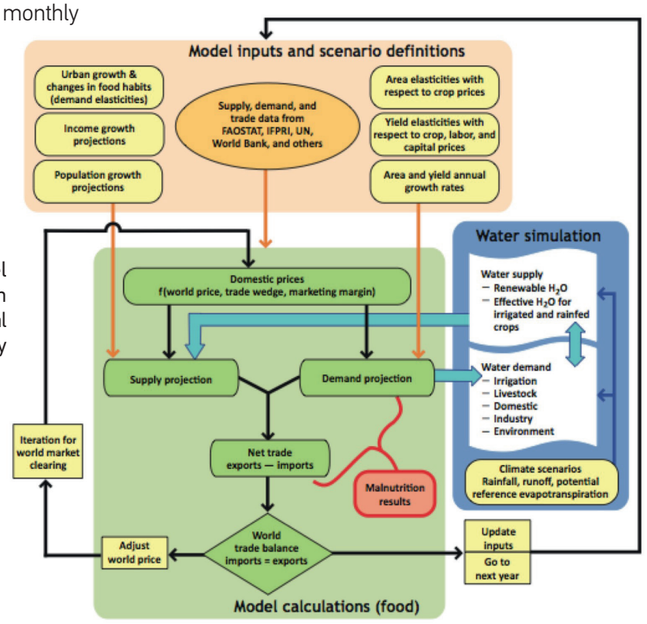
This involved the development of an analytical system capable of estimating of the share of current and future household income that is spent on food items while integrating a number of key assumptions regarding disaggregated consumer price indices, household income growth rates, and climate change impacts on local food prices. For the purpose of the analysis, vulnerable groups within the UAE were defined as any household located within any emirate whose share of food expenditures in monthly household budgets exceeds a certain level.

These modelling approaches were incorporated within a scenario framework to address issues of uncertainty.

Several scenarios were considered; a "Baseline Scenario" (or Business-as-Usual scenario), corresponding to a future where the climate of food exporting remains consistent with historical trends and a number of "Climate Impact Scenarios" corresponding to a future climate in food exporting countries consistent with the emissions scenarios proposed by the IPCC.

Figure 2: IMPACT modelling framework (Nelson, et al, 2010)

IMPACT is a computable global equilibrium model developed by the International Food Policy Research Institute (IFPRI) to examine alternative futures for global food supply, demand, trade, prices, and food security under climate change.



Methodology

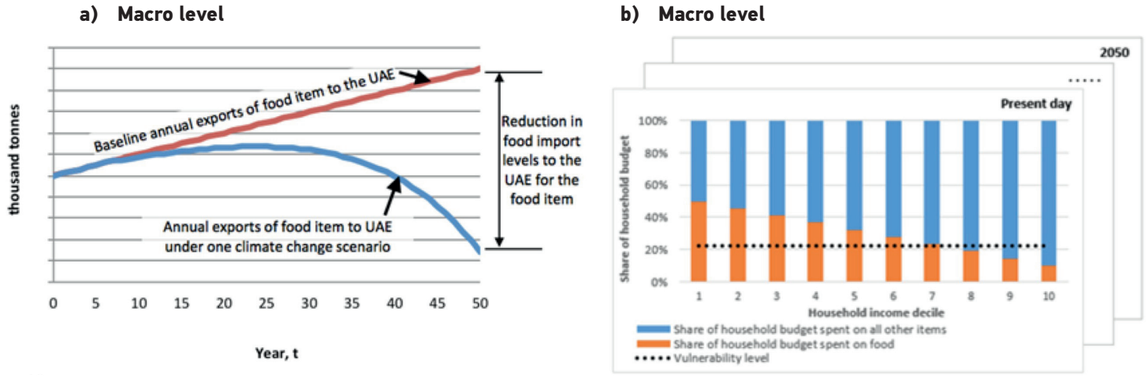
For the macro-level assessment, an idealized representation of the analytical approach is provided in Figure 3a.

Food insecurity risks at the national level were directly compared to the projected decline in food imports from countries on which the UAE has historically relied. Under a Baseline scenario, annual exports of food to the UAE for all major food-country combinations was projected based on future demand and production characteristics (i.e. red line in Figure 3a). Under the Climate Change scenarios, available food exports to the UAE for the same food-country combinations were assumed to decrease proportionally to the decline of agricultural productivity under climate change (i.e. blue line in Figure 3a). Upon estimating the import gaps for all country-food combinations, the results were standardized into a scale from 1 to 10, with 1 indicating the lowest risks to future imports under climate change and 10 indicating the highest risks to future imports under climate change.

For the micro-level assessment, an idealized representation of the approach is provided in Figure 3b.

As an analytical construct, food insecurity risks at the household level were equated to the share in household budgets taken up by food purchases. UAE households were disaggregated according to income deciles. In the present day, household vulnerability was characterized relative to the share of food purchases above a UAE-specific standard for UAE households (i.e. percentage points in the brown bars above the dashed black line in Figure 3b for the Present day). Under the Climate Impact scenarios, household vulnerability was characterized relative to the projected change in household food expenditure shares, based on consumer food prices derived from the IMPACT model results and subject to assumptions regarding the consumer price index and household income growth levels.

Figure 3: Conceptualization of assessment of UAE food security under climate change



Annual and cumulative deviations from the household food expenditure standard were then estimated for each household income decile for each Climate Impact scenario through 2050. Upon estimating the real (i.e. discounted) deviations, the results were standardized into a scale from 1 to 10, with 1 indicating the lowest household vulnerability to future food price increases under climate change and 10 indicating the highest household vulnerability to future food price increases under climate change.

Accessibility

A "Food Security Inspector" was developed to make accessible input data and results to interested stakeholders to conduct subsequent analyses.

The UAE Food Security Inspector is a macro-driven Graphical User Interface (GUI) built in Excel software that codifies all data assumptions, modelling techniques, and vulnerability index calculations that have been used to assess the UAE's food security under climate change. It provides a flexible way to explore food import assumptions, agricultural productivity in food exporting countries under climate change, future consumer food prices, UAE income growth trends, food consumption characteristics, and many other factors and assumptions. It is available at www.ccr-group.org/food-security.

3. Food security under climate change – Macro level

The UAE's historical food import trends represent the point of departure for assessing macro-level food security under climate change.

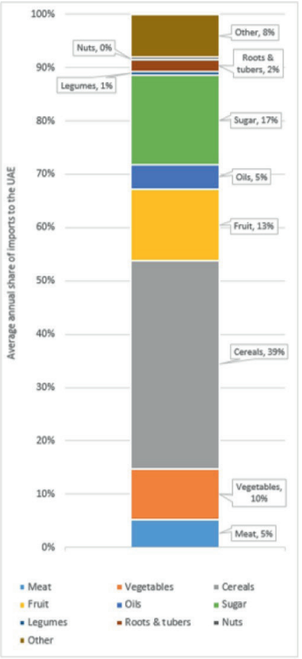
Nearly 6 million tonnes of food are imported every year into the UAE (see Figure 4a). Cereals in the form of wheat, rice, and others accounted for the largest share of annual imports, 39%, followed by sugar at 17%, fruit from temperature and sub-tropical regions at 13%, vegetables at 10% and assorted meat products at 5% (see Figure 4b).

Figure 4: Summary of average annual food imports to the UAE (FAO, 2015)

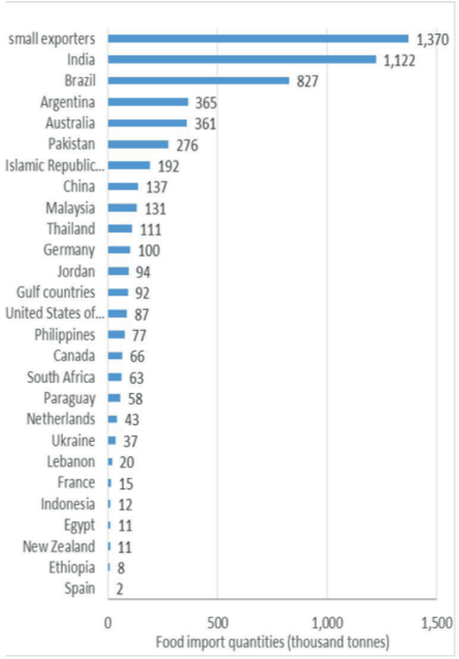
a) Import level breakdown

Category	#	Sub-category Name	Average annual imports to UAE, 2002-2008 (000 tonnes/year)
Cereals	1	Wheat and products	1,185
	2	Maize and products	147
	3	Millet and products	12
	4	Barley and products	169
	5	Rice (Milled Equivalent)	744
		Subtotal	**2,257**
Fruit	6	Fruit - Temperate	309
	7	Fruit - Subtropical	467
		Subtotal	**776**
Legumes	8	Pulses, and products	**43**
Meat	9	Bovine Meat	57
	10	Mutton & Goat Meat	41
	11	Pigmeat	7
	12	Poultry Meat	197
		Subtotal	**302**
Nuts	13	Groundnuts (Shelled Eq)	**23**
Oils	14	Oil - Palm and Palm kernel	152
	15	Rape and Mustard Oil	2
	16	Soyabean Oil	36
	17	Sunflowerseed Oil	35
	18	Oil - Other	42
		Subtotal	**268**
Other	19	Rape and Mustardseed	72
	20	Sunflower seed	10
	21	Soybeans	215
	22	Eggs	31
	23	Milk - Excluding Butter	139
		Subtotal	**468**
Roots & tubers	24	Cassava and products	12
	25	Sweet potatoes	1
	26	Potatoes and products	118
		Subtotal	**130**
Sugar	27	Sugar (raw)	640
	28	Sugar (Refined)	327
		Subtotal	**967**
Vegetables	29	All	**553**
Total			**5,788**

b) Food level breakdown



c) Exporting country breakdown



IMPACT model run results were used as the basis to project agricultural productivity of the UAE's major trading partners.

A comprehensive set of model outputs was produced by colleagues at IFPRI, using the latest version of the model as of summer of 2014 (Nelson et al. 2010). IMPACT model run results correspond to a "Baseline Scenario" that corresponds to business-as-usual agricultural productivity under a stable climate and a twelve (12) "Climate Impact Scenarios" that correspond to alternative agricultural productivity after accounting for global climate change as projected by General Circulation Models (GCMs). These climate change scenarios span the possible range of climatic futures, from low rainfall-high temperature to high temperatures-low rainfall, hence bracketing uncertainty regarding yields, national supply, and trade prices. The IMPACT results show that there can be large differences in productivity across food items and countries, relative to time and climate change scenario. Total food imports were assumed to be driven by the UAE's growing population. Three population projections were assumed – low, mid, and high – in an effort to bracket uncertainty.

Detailed available export projections were developed for each major food-country combination for the UAE.

From this, annual and cumulative food shortfall/surplus metrics were developed that indicated whether a historical food trading partner would be constrained or unconstrained relative to future exports to the UAE. For unconstrained food trade, the range in required UAE imports of a food commodity across all population growth variants is less than available exports of that food commodity across all major exporters and across all scenarios. For constrained food trade, the range in required UAE imports of a food commodity across all population growth variants is greater than available exports of that food commodity across all major exporters and across all scenarios.

Cumulative food import shortfall/surplus metrics provide a way to capture temporal effects of climate change on projected available exports to the UAE.

When summed across all years and accounting for each of the 12 climate change scenarios, the cumulative gap between required imports and available exports denotes a situation where cumulative food export supply under climate change is not consistent with UAE cumulative food import demand. As such it is directly related to the vulnerability of the UAE to future food import constraints due to climate change. The use of cumulative food import gaps results in a more robust metric than annual food gaps to capture temporal effects and is used as an input to quantify the macro-level vulnerability of the UAE.

A macro-level Food Insecurity Index has been calculated for each modelled food item imported into the UAE.

The basis for constructing the food insecurity index, by food item as well as by country, is the cumulative food import gap (whether it be a shortfall or a surplus). The Index - by food item - ranges from 1 to 10. A value of 1 represents a strongly food-secure item and 10 representing strongly food-insecure item. The Macro Index - by country – also ranges from 1 to 10. A value of 1 represents a strongly food export-secure country and 10 represents strongly food export-insecure country.

Table 1a and 1b provides a summary of results, by food item and country.

Green-shaded rows indicate high food import security under climate change (Index =1 to 2). Light red-shaded rows indicate increasing levels of food import insecurity under climate change countries (Index = 5 to 10, where 10 indicates the highest level of food import insecurity). Light brown-shaded rows indicate the middle range of food import insecurity (Index =3 to 4). Major conclusions are summarized in the bullets below.

- **Macro food security, by food item:** Table 1a indicates that most food imports will be constrained under climate change. Rice and wheat are strongly insecure food items for the UAE under climate change. Both cereals show a Food Insecurity Index of 10 which indicates that future food import gaps are large and adaptation strategies should be considered to reduce the potential constraints in import supplies. On the other hand, beef, lamb meat, and maize are strongly food secure items suggesting that current food trade flows will not be adversely affected in the future.
- **Macro food security, by country:** Table 1b indicates that there are several countries where food exports will be constrained. These countries include Brazil, India, Iran, and South Africa. Each of these countries has an Index of at least 5. On the other hand, traditional exporting partners such as Pakistan, Germany, and Thailand are strongly food secure countries suggesting that current food trade flows from these countries will not be adversely affected in the future in comparison to the countries with higher index values.

Table 1: Food Insecurity Index results – Macro level

a) By Food item

Food item	Food import status	Food Security index
BEEF (i.e., Bovine Meat)	UNCONSTRAINED	1
CASS (i.e., Cassava and	CONSTRAINED	6
CHKP (i.e., Pulses, and	PARTIALLY CONSTRAINED	3
EGGS (i.e., Eggs)	PARTIALLY CONSTRAINED	2
GRND (i.e., Groundnuts	CONSTRAINED	6
LAMB (i.e., Mutton & Goat	UNCONSTRAINED	1
MAIZ (i.e., Maize and	UNCONSTRAINED	1
MILK (i.e., Milk - Excluding	PARTIALLY CONSTRAINED	3
MILL (i.e., Millet and	CONSTRAINED	6
OGRN (i.e., Barley and	CONSTRAINED	6
PKOL (i.e., Oil - Palm and	PARTIALLY CONSTRAINED	3
PORK (i.e., Pigmeat)	CONSTRAINED	6
POTA (i.e., Potatoes and	PARTIALLY CONSTRAINED	5
POUL (i.e., Poultry Meat)	PARTIALLY CONSTRAINED	3
RICE (i.e., Rice (Milled	CONSTRAINED	10
RPOL (i.e., Rape and	CONSTRAINED	6
RPSD (i.e., Rape and	CONSTRAINED	6
SBOL (i.e., Soyabean Oil)	CONSTRAINED	6
SFOL (i.e., Sunflowerseed	CONSTRAINED	6
SNFL (i.e., Sunflower seed)	CONSTRAINED	6
SOYB (i.e., Soybeans)	CONSTRAINED	7
SUBF (i.e., Fruit -	CONSTRAINED	8
SUGC (i.e., Sugar (raw))	PARTIALLY CONSTRAINED	2
SUGR (i.e., Sugar (Refined))	CONSTRAINED	7
SWPY (i.e., Sweet potatoes)	CONSTRAINED	6
TEMF (i.e., Fruit -	CONSTRAINED	7
TOOL (i.e., Oil - Other)	CONSTRAINED	4
VEGE (i.e., Vegetables - All)	CONSTRAINED	8
WHEA (i.e., Wheat and	CONSTRAINED	10

b) By Country

Country name	Criterion		Food Security index
	Share of Imports	Climate change impact	
Argentina	4	2	3
Australia	4	2	3
Brazil	7	3	5
Canada	2	1	2
China	2	3	3
Egypt	1	3	2
Ethiopia	1	2	2
France	1	3	2
Germany	2	5	4
Gulf countries	2	2	2
India	9	3	6
Indonesia	1	4	3
Iran (Islamic Republic of)	3	8	6
Jordan	2	2	2
Lebanon	1	2	2
Malaysia	2	4	3
Netherlands	2	2	2
New Zealand	1	2	2
Pakistan	3	4	4
Paraguay	2	3	3
Philippines	2	5	4
South Africa	2	10	6
Spain	1	2	2
Thailand	2	4	3
Ukraine	2	2	2
United States of America	2	4	3
All other countries	10	3	7

4. Food security under climate change – Micro level

The UAE's household expenditure and food price trends represent the point of departure for assessing micro-level food security under climate change.

On a per capita basis, residents and citizens of the UAE enjoy some of the highest gross incomes in the world. The UAE population is also characterized by large income differences between groups. In 2014, the UAE was home to about 7.5 million foreign citizens, many of whom are low paid migrant workers, many from the Indian subcontinent, who hold jobs in construction or domestic service and remit most of their wages to families back home. Most of these individuals tend to fall in the lowest income category and make up about 31% of the population of individuals over 15 years of age. On the other hand, roughly 40% of the population were those pursuing careers or starting families, between 27 and 38, and having high annual incomes. This group consists mainly of Emirati professionals and expatriate specialists.

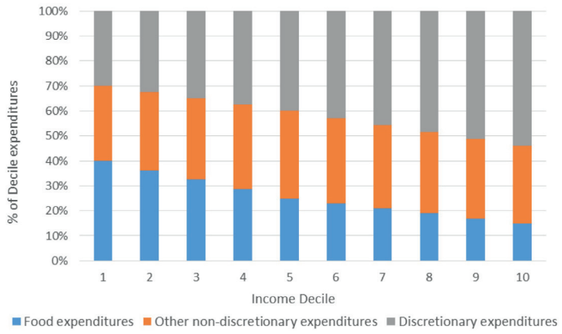
To assess UAE households relative to the potential future impact of high food prices, households were broken out into 10 income groups ("deciles") relative to household disposable income levels.

The poorest households are included in Decile 1 and the most affluent in Decile 10. Household spending was divided into discretionary and non-discretionary categories, both of which are relative to disposable income. A discretionary household expense is a cost which is not essential for the operation of a home such as purchases for recreational/cultural activities, alcoholic beverages, tobacco products, restaurants/cafes, etc. On the other hand, non-discretionary household expenses are those that are essential for the operation of a home, namely food, housing, and healthcare. Typically, these items are considered the highest priorities in a household budget and are purchased at the expense of the range of non-discretionary items.

Across the UAE, household food expenditures are about 14% of disposable income, like the 11% share in the Europe and North America (USDA, 2015).

At the decile level, there are large variations across income groups that are similarly evident, as illustrated in Figure 5 for the year 2015. The least affluent households throughout the UAE's seven emirates (i.e. Decile 1) typically devoted nearly 40% of their overall 2015 expenditures to food, with only about 30% available for discretionary spending. For middle-income households (Decile 5), food expenditures accounted for about 25% of total spending, with about 40% available for discretionary purchases. For the most affluent households (i.e. Decile 10), only about 15% of their disposable income was spent on non-discretionary food items, leaving over 50% available for discretionary purchases.

Figure 5: Household expenditure share levels by income group in the UAE (EI, 2015)



Food prices have been rising steadily over the past several years across the seven emirates (NBS, 2015).

This is shown in Figure 6a for the Consumer Price Index (CPI) for food and for all items at the national level. The gold-shaded area represents the range in CPI for food at the emirate level, with the blue line representing the UAE average of the food CPI. The orange area represents the range in CPI for all items at the emirate level, with the green line representing the UAE average of all items in the CPI. The curves show that there is both a larger variation in the food CPI than there is for the overall CPI, as well as steeper increases in the food CPI compared to the overall CPI. Similar trends for CPI are evident at the emirate level, as shown in Figure 6b. For the UAE, food prices have been increasing about an average of 2.19 times the rate of overall prices (dashed green line). Four of the emirates are at or below this level (i.e. Abu Dhabi, Dubai, Ajman, and Fujairah), while for Umm Al-Quwain, Ras Al-Khaimah, and Sharjah, food prices have been increasing at a higher rate than the national average.

A micro-level Food Insecurity Index has been calculated for each household decile.

The basis for constructing the micro-level food insecurity index is the extent to which the share of household food expenditures exceeds a certain level considered to be a plausible characterization of a food secure situation at the household level. A default level of 17% was assumed. Several scenarios (i.e. "Low stress", "Chronic stress", and "Mounting stress") were constructed, with and without climate change, regarding the way the household income, inflation levels, and real food prices would change over time through 2050. The Micro Index ranges from 1 to 5. A value of 1 represents a strongly food-secure household and 5 representing highly food-insecure household (i.e. most vulnerable to food price shocks under climate change). In 2014, there were no households in the UAE considered to be very highly food insecure.

Figure 6: Consumer Price Index trends at the emirate level, 2008-2014 (NBS, 2015)

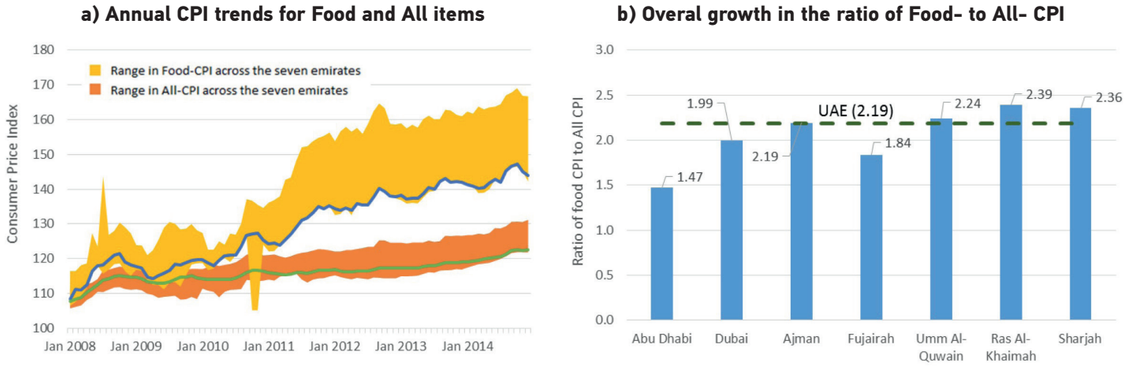


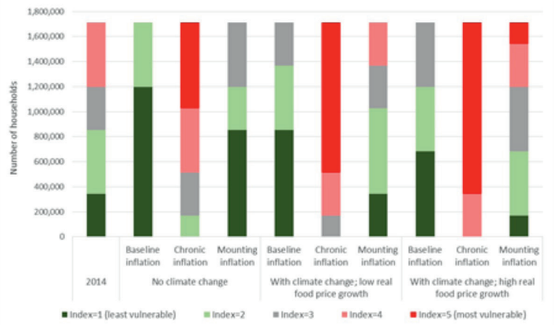
Figure 7a and 7b provides a summary of results for the year 2050 in both absolute terms and changes relative to 2014.

Red bars indicate a Micro Index level of 5 (highly food insecure); dark green bars indicate a Micro Index level of 1 (highly food secure). with already challenging food security situation for low-income households in the UAE which worsen with climate change. Major conclusions are summarized in the bullets below.

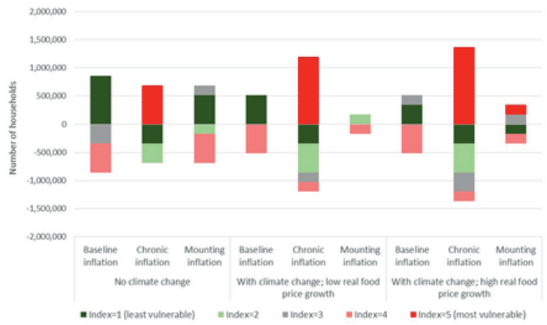
- **Micro food security, absolute level:** The number of households that are highly vulnerable to food price increases (i.e. red bars; Micro Index = 5) is expected to rise in the future. In the most pessimistic scenario where there is chronic inflation combined with high levels of food price increases under climate change, the food security situation for all the households in the UAE declines significantly and all 171,126 households across the UAE that are projected to be highly food insecure (i.e. second column from right). This contrasts with the most optimistic scenario (i.e. where inflation continues at current levels and there are no climate change impacts), which shows the food security situation for all the households in the UAE improve significantly. In this scenario, there are no households across the UAE that are food insecure (i.e. second column from left). Figure 7b shows that climate change introduces serious shifts in food spending patterns.
- **Micro food security, relative change:** Without considering the impact of climate change, chronic inflation leads to a change in households that are highly food insecure, from zero households in 2014, to 685 thousand by 2015. The combination of climate change and chronic inflation would further increase the number of the most vulnerable households by another 515 thousand, given low real food price increases, and 715 thousand, given high real food price increases. This reflects a shift to greater spending on food as a percentage of annual household spending.

Figure 7: Food Insecurity Index results – Micro level

a) Number of households, by Micro Index



b) Change in number of households, by Micro Index



5. Options to enhance food security under climate change

The results of study the pose significant implications for food security policies and measures in the UAE.

As a country that is heavily dependent on food imports. The UAE may be vulnerable to food supply constraints and associated price volatility associated with climate change impacts in food-exporting countries. The study found that the combination of climate change-induced declining agricultural productivity in food-exporting countries, tightening of world food markets, and limits to local agricultural production could lead to several adverse circumstances for the UAE. These may include constraints in future food trade flows of key items likes cereals and vegetables that could lead to recurrent food price increases and a need for substantial food subsidies. Moreover, households throughout the seven emirates with annual incomes at the lower end of the national range could find themselves in a position where they would be subject to spending a growing share of household budgets for food.

The identification and analysis of specific strategies that could improve UAE's future food security under climate change were beyond the scope of the study. However, there are numerous options and measures that could potentially reduce risks associated with volatile international food markets (Abbot, 2010; Porter, et al. 2014; Dawe, 2010; World Bank, 2012; FAO, 2011a, 2011b, 2014; and Prakash, 2011). Risk-hedging food procurement strategies, such as virtual food stockpiles, early warning systems, and alternative food acquisition strategies are some of the options that may be most effective under conditions of future climate change. A brief overview of some potential options that may be valuable to consider in future UAE food security policymaking is provided in the bullets below.

- **Assess and address any procurement barriers to food imports:** Large international food trades may represent high risks in a future climate-changed world where supplies may become more limited and procurement may become more competitive. Any barriers in the UAE to efficient and market-based international procurement systems - whether in existing legislation or in food control regulatory procedures – should be reviewed and removed as appropriate to take advantage of cost-effective procurement strategies such as electronic tendering and transaction-risk mitigation (i.e. risk hedging).
- **Exploit any regional economies of scale for food imports:** Alone, the UAE is not a large importer of any food commodity by quantity. On the other hand, the GCC countries as a bloc of countries represent a major importer of certain food commodities that will likely be constrained under climate change, as the study has shown. For example, in 2013 about 1 billion tonnes of refined sugar was imported by GCC countries, about 40 times the level of china and 6 times the level of US (the two highest importing countries in the world), respectively. Similar - though not as large - food import patterns are evident for other potentially constrained food imports like cooking oil, fruit, wheat, and rice, when compared to China and the USA. With such evident economies of scale at the GCC bloc level, there could be substantial market leverage that would allow the UAE/GCC to take advantage of formal risk markets and push for better prices – provided the UAE and GCC countries establish and/or build upon food procurement collaboration mechanisms.

- **Develop an early warning system to monitor international food trade developments:** Putting in place an agency/department in the UAE with the sole responsibility of monitoring world and regional supply and demand for major food items that are projected to be export-constrained to the UAE under climate change (e.g. wheat, rice, vegetables, fruit, cooking oil, groundnuts) could provide a valuable information system to help identify potential supply/demand warning signs and potentially foresee looming price shocks. Such an early warning system could enable advance action to adjust import levels and/or apply risk hedging strategies that would lessen the UAE's vulnerability to circumstances in food exporting countries beyond its control.

- **Complement physical food stockpiling with virtual stockpiling strategies:** Physical stockpiling strategies would involve buying and stockpiling potentially constrained food items during good years (i.e. agricultural productivity is high in major exporters and international food trade prices are low). The location could be within the UAE or even elsewhere within the GCC as part of a GCC-wide stockpiling strategy. Virtual stockpiling strategies would involve the use of financial instruments such as futures contracts and options. These would help to ensure procurement of a constrained food item at a certain price without the costs of the physical infrastructure for perishable items.

- **Invest in agricultural research and development in traditional priority trading partners:** Many countries upon which the UAE relies for substantial quantities of food imports (e.g. India) are also countries where the resources and systems needed to effectively adapt its agricultural systems to climate change are lacking. As a complement to its overseas development assistance strategies, the UAE could consider investing in rehabilitating irrigation infrastructure, distribution networks, or other stages of the food supply chain in these countries. Such investments could increase the agricultural productivity of the land and could be combined with price-competitive bilateral agreements on future imports.

- **Reassess agricultural land acquisition strategies:** In recent years, the UAE has embarked on a coordinated regional policy to buy or lease agricultural land abroad as way to pursue long-term food security. The objective has been to secure deals, particularly in other Islamic countries, by which capital and oil contracts are exchanged for guarantees that private corporations from the Gulf will have access to farmland and can export the produce back to the region. However, there are potential risks to this strategy, the foremost being that many of the same countries in which land-lease arrangements have been established are also likely to experience adverse impacts of climate change on agricultural productivity. Rather than being shielded from food market volatility, the cost of agricultural production from such lands would likely be volatile as well. Moreover, there is the possibility that during a future national food production crisis in such countries, the government could simply ban food exports temporarily, as was the case during the 2008 global food crisis.

References

Abbot, P., 2010. Stabilisation Policies in developing countries after the 2007-08 food crisis, Global forum on Agriculture, 29-30 November 2010, Paris

Dawe, D. (ed.)., 2010. The Rice Crisis: Markets, Policies and Food Security, Food and Agriculture Organization of the United Nations and Earthscan, Rome, London and Washington, DC. 3–11. http://www.fao.org/3/a-an794e.pdf.

Euromonitor International, 2015. "Passport - Income and Expenditure: UAE" USDA, 2015. Food expenditure tables, available at http://www.ers.usda.gov/data-products/food-expenditures.aspx

FAO, 2011a. Price Volatility in Food and Agricultural Markets: Policy Responses. http://www.fao.org/fileadmin/templates/est/Volatility/Interagency_Report_to_the_G20_on_Food_Price_Volatility.pdf

FAO 2011b. Policy options to address price volatility and high prices, in The State of Food Insecurity in the World 2011: How does international price volatility affect domestic economies and food security? http://www.fao.org/docrep/014/i2330e/i2330e00.htm

FAO, 2014. The State of Food Insecurity in the World 2014: Strengthening the Enabling Environment for Food Security and Nutrition. Food and Agriculture Organization of the United Nations, Rome. http://www.fao.org/publications/sofi/2014/en/.

FAO, 2015. FAOSTAT. Food Balance Database available at http://faostat3.fao.org/faostat-gateway/go/to/home/E

Fischer G., Shah M , van Velthuizen H., 2002. Climate Change and Agricultural Vulnerability, A Special Report Prepared as a Contribution to the World Summit on Sustainable Development (International Institute for Applied Systems Analysis, Laxenburg, Austria)

Headey, D and Fan, S., 2010. Reflections on the Global Food Crisis. How Did It Happen? How Has It Hurt? And How Can We Prevent the Next One? International Food Policy Research Institute. Research Monograph 165. The report can be accessed at: http://www.ifpri.org/sites/default/files/publications/rr165.pdf

Hebebrand, C. and Wedding, X., 2010. The Role of Markets and Trade in Food Security - A Report of the CSIS Global Food Security Project, Center for Strategic and International Studies

Hertel, T. W., Burke, M. B., & Lobell, D. B. (2010). The poverty implications of climate-induced crop yield changes by 2030. Global Environmental Change, 20(4), 577–585. doi:10.1016/j.gloenvcha.2010.07.001

IFPRI, 2013. Arab Spatial – Development and Food security Information Tool. International Food Policy Research Institute. Retrieved June 4, 2014, from http://www.arabspatial.org

IFPRI, 2015. Latest IMPACT outputs. Personal communication.

IPCC, 2014. Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. (C. B. Field, V. R. Barros, D. J. Dokken, K. J. Mach, M. D. Mastrandrea, T. E. Bilir, M. Chatterjee, et al., Eds.). Cambridge: Cambridge University Press. Retrieved from http://ipcc-wg2.gov/AR5/report/

IPCC 2013. Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 1535 pp.

Kenny, M., 1998. International food trade: food quality and safety considerations, Food Quality and Standards Service, FAO Food and Nutrition Division.

Kumetat, D., 2009. "Climate Change in the Persian Gulf – regional security, sustainability strategies, and research needs" Conference on Climate Change, Social Stress, and Violent Conflict, Hamburg, November.

Lobell, D. B., Burke, M. B., Tebaldi, C., Mastrandrea, M. D., Falcon, W. P., & Naylor, R. L. (2008). Prioritizing climate change adaptation needs for food security in 2030. Science, 319(5863), 607–10. doi:10.1126/science.1152339

Lobell, D., Baldos, U., and Hertel, T., 2013, "Climate adaptation as mitigation: the case of agricultural investments", Environmental Research Letters, Volume 8, Number 1.

National Bureau of Statistics (NBS). 2015. Statistical tables for the UAE available at http://www.uaestatistics.gov.ae/EnglishHome/tabid/96/Default.aspx

Nelson, G., Rosegrant, M., Palazzo, A., Gray, I., Ingersoll, C., Robertson, R., Tokgoz, S., Zhu, T., Sulser, T., Ringler, C., Msangi, S., and You, L., 2010. "Food Security, Farming, and Climate Change to 2050: Scenarios, Results, policy options", IFPRI.

Porter, J.R., Xie, L., Challinor, A.J., Cochrane, K., Howden, S.M., et al. (2014). Chapter 7: Food Security and Food Production Systems. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, C.B. Field, V.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastandrea, et al. (eds.). Cambridge University Press, Cambridge, UK, and New York. http://ipcc-wg2.gov/AR5/images/uploads/WGIIAR5-Chap7_FINAL.pdf.

Prakash, A. (ed) (2011). Safeguarding Food Security in Volatile Global Markets, Food and Agriculture Organization of the United Nations, Rome. 175–201. http://www.fao.org/docrep/013/i2107e/i2107e10.pdf.

Taha, M., 2013. United Arab Emirates - Food and Agricultural Import Regulations and Standards - Narrative, USDA Foreign Agricultural Service

USDA, 2015. Food expenditure tables, available at http://www.ers.usda.gov/data-products/food-expenditures.aspx

Wiggins, S. and Levy, S., 2008. "Rising food prices: Cause for concern", Natural Resource Perspectives, 115

World Bank, 2012. Improving Food Security in Arab Countries. The World Bank. Washington, DC

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