Thematic input paper prepared for the Thematic Regional Meeting of
the Swiss Agency for Development and Cooperation on
'Climate Change, Disaster Risks, Migration and Economic Development'
held in Agadir, March 2016

Thematic Input Paper 1:

The climate change, migration and economic development nexus in North Africa: An overview

By Clara Ariza, *Independent Consultant*
and Henri Rueff, *Researcher University of Basel.*

June 2016

Photo: Floods in Guelmim, Morocco in March 2013 by jpdodane (sourced from Flickr.com)

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Swiss Agency for Development and Cooperation SDC

Climate Change & Environment Network

Background

The objective of this Thematic Input Paper (TIP) is to provide an overview and a succinct discussion of climate change and natural hazards in North Africa. The TIP addresses the climate change and migration nexus from the perspective of disaster risks and employment, and focuses on the context of Morocco, Tunisia and Egypt. To this aim, the results of a non-exhaustive analysis of regional and national information and data are presented. The implications of observed climate trends and future projections for development are discussed and complemented with a case study for the Nile Delta, in Egypt.

Section one describes how the geographic context of North Africa determines its exposure to climate change and disaster risks. It also presents observed climate trends and an analysis of past extreme events recorded for the region.

The second section shows the results of climate change projections undertaken for three key climatic variables for short and long-term time horizons (2030 and 2100, respectively). These are complemented with published projections for other variables and analysed along with existing and relevant literature, to offer an overview of potential climate impacts for the region.

Section three analyses the nexus between climate change, disaster risk, migration and economic development.

Section four offers agricultural management responses to climate change and climate hazards in North Africa, and section five lists identified knowledge gaps.

1. Introduction

Independent of the measures taken to mitigate carbon emissions, human---induced climate change is inevitable. Its effects are already felt and projected to intensify in coming decades (IPCC, 2014). This global daunting challenge threatens to disproportionately affect the poor and to jeopardize development achievements of low income countries (Hallegatte et al. 2016).

Currently, serious environmental and socio---economic problems merge in North Africa and affect livelihoods, economies, and the political stability of the region (Drine, 2011; De Sousa Ferreira, 2014). These include, among others, increasing water scarcity and pollution, declining crop yields, soil degradation and desertification, deforestation, population growth, marked rural---urban migration and high levels of unemployment, which particularly affect the youth (Gubert & Nordman, 2008; ILO, 2011; De Sousa Ferreira, 2014). Climate change can act as a “threat multiplier” (Femia & Werrell, 2012) in this context, putting additional burden on people and institutions and diminishing their ability to respond to the mix of existing and inter-related threats.

1.1. Geographic context, climate trends and climate--related disasters

North African countries are characterized by a sharp aridity gradient that stretches from wetter conditions in coastal areas to drier conditions inland. In general, population, economic assets and activities, including agriculture concentrate in the coastal areas. Compared to coastal areas, North African drylands experience lower rainfall amounts and higher rainfall unpredictability, which may express in consecutive years of drought. The winter rainy season is short and used mostly for rain-fed cereal and legume production and low yield arboriculture, as well as to raise livestock on fragile grazing land (Radhouane, 2013). Crop production in the drier southern areas depends on the extraction of groundwater or the Nile waters in Egypt for irrigation (Drine, 2011; Terink et al., 2013; Radhouane, 2013). However, groundwater resources are being depleted faster than the scarce rain can replenish them (FAO, 2011).

In the past decades North Africa has seen an increase in annual temperature and a spatially variable decrease in precipitation (Drine, 2011, Schilling et al. 2012). These trends agree with the climate change projections presented in the next section. Due to weak disaster records, it would be speculative to deduce that a rise in the frequency of climate-related disasters has occurred in the region in recent years, even though this is to be expected as climate change progresses and extreme events become more frequent (IPCC, 2007) and also as demographic pressures increase settlement and use of areas exposed to hazard impacts.

A total of 115 climate-related disasters were recorded for North African countries over the past twenty years (Figure 1). Most often recorded were floods, including riverine and flash floods, and storms (including convective storms). Only five percent of all disasters recorded for the period were droughts. This is not surprising given the existing constraints to drought recording (see knowledge gaps section). All these events have caused major damage and suffering. In Morocco for example, the 1999 drought affected 275,000 people and generated losses of about USD 900 million, while the combined 21 flood events recorded in the country between 1995 and 2016 caused over USD 295 million in damages and affected more than 230,000 people (EM-DAT, 2016). Noteworthy is that with fast growing urban populations (largely from rural migration), flash floods in cities and their outskirts have become a major risk in the region. These occur largely due to the construction of new concrete surfaces that cannot absorb water, inadequate city drainage systems, and increasing underprivileged population settling in low-lying areas. In 2001, flash floods in the densely populated and low-lying neighbourhood of Bab-El-Oued in Algiers, left more than 900 casualties (World Bank, 2014).

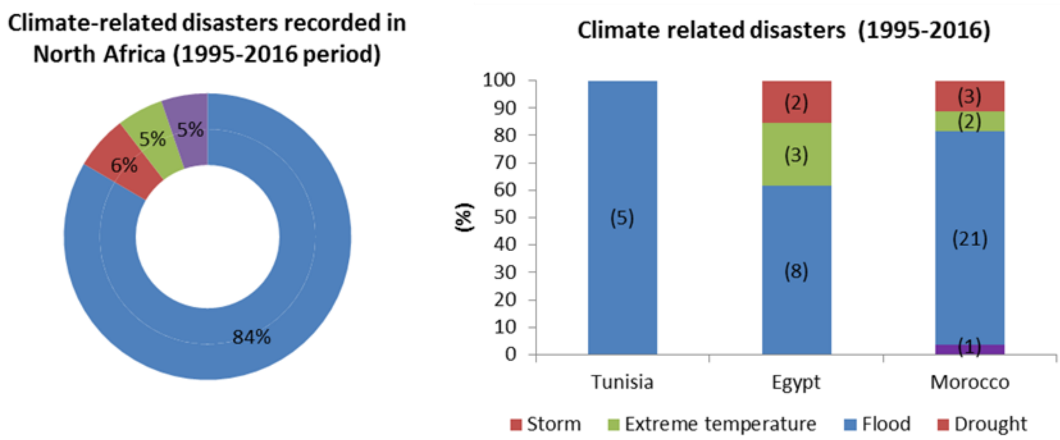


Figure 1. Climate-related disasters recorded in North African countries in the past 20 years. The left figure presents the relative frequency of disaster types during this period in the region (the analysis included Morocco, Egypt, Tunisia, Libya, Egypt, Sudan and Algeria) while the figure at the right shows the frequency of climate-related disasters for the three focal countries. In parenthesis is the absolute recorded number of disasters per type. Source: EM-DAT database accessed on 5 February 2016.

2. *Future climate*

Climate projections for precipitation, temperature and dry spells for the Mediterranean region were generated using data available on the KNMI Climate Explorer (climexp.knmi.nl; van Oldenborgh et al. 2009) for a short-term horizon (2030), to contribute to strategic planning purposes -see Annex 1- and for 2100, to establish long-term trends. These, summarized in Table 1, show that the region will experience increased average temperatures, a long-term increase in the length of dry spells and a decline in mean annual precipitation, all denoting drier conditions. The signal of these changes is particularly clear in the end-of-century projections. However, this region is characterized by high spatial variability in precipitation, therefore, significant sub-regional and sub-national differences in future patterns of rainfall change are likely, and the results shown should be used cautiously. This also applies to changes in the length of dry spells.

Table I. Current climate and climate projections for the North Africa/Mediterranean region for the RCP8.5 scenario, representing a conservative "business-as-usual" greenhouse gases concentration pathway. The range of changes is shown, with the median value in brackets. The changes indicated are projected against the 1986-2005 period. All analyses were conducted using data and processes available on the KNMI Climate Explorer (climexp.knmi.nl; van Oldenborgh et al., 2009).

North Africa and Mediterranean region	2030	Signal	2100	Signal
Mean annual temperature.[1]	0.5 to 1.4°C (0.9°C)	↑	3.3 to 6.8°C (4.5°C)	↑
Dry spells	-2 to 8.4% (4%)	-	11.1 to 44.8% (29.5%)	↑
Annual Precipitation	-5.6 to 3.8% (-1.9%)	-	-32.6 to -5.7% (-17.7%)	↓
Morocco				
Mean annual temperature	0.5 to 1.4°C (0.9°C)	↑	3.5 to 6.6°C (4.3°C)	↑
Dry spells	-7.7 to 16.8% (3.7%)	-	13 to 32.8% (24.1%)	↑
Annual Precipitation	-23.1 to 10.3% (-6.1%)	-	-54.8 to -7.8% (-34.7%)	↓
Tunisia				
Mean annual temperature	0.4 to 1.5°C (0.9°C)	↑	3.1 to 6.3°C (4.4°C)	↑
Dry spells	-7.5 to 21.9% (4.1%)	-	5.4 to 52.9% (34.6%)	↑
Annual Precipitation	-17.7 to 12.8% (-2.8%)	-	-60.3 to -6.4% (-25.2%)	↓
Egypt				
Mean annual temperature	0.6 to 1.4°C (0.9°C)	↑	3.5 to 6.6°C (4.5°C)	↑
Dry spells	-7.3 to 9.8% (-0.8%)	-	-11.3 to 15.1% (5.9%)	-
Annual Precipitation	-25.2 to 52% (-2.5%)	-	-63.7 to 86.8% (-17.4%)	-

[1] Ranges of change shown consider values at the 5th and 95th percentiles. Projected extreme events values (i.e. dry spells) should be taken cautiously because of substantial spatial variability not being reflected in national level projections.

These results, averaging over 20 Global circulation models, offer clearer signals (directions) of change in Morocco and Tunisia, and a wider range of precipitation scenarios in Egypt (Table I). In the case of Egypt, upstream water supply of the Nile is a central element in understanding the availability of water for agriculture in the country (Agrawala et al. 2004). Projections show increasing precipitation in East Africa (TREE, 2014) and higher stream flows in the Upper Blue Nile (Aich et al. 2014) supplying more water. However, higher temperatures and higher evaporation and evapotranspiration levels (Terink et al. 2013), may reduce the latter benefits.

Other climate projections for the same region under the RCP8.5 (business as usual scenario) extracted from the IPCC (AR5) by TREE (2014) indicate:

- An increase in the number of 24-hour days above 20°C, particularly in Morocco, Algeria, Tunisia, Libya and Egypt,
- A long-term (2081-2100) decrease in winter precipitation (Dec-Feb) from 20 to 50% (Morocco, Algeria, Tunisia) and 10 to 50% increase in summer precipitation (June – August) in Egypt and Sudan.
- A decrease in cloudiness and humidity in the Mediterranean and very north portion of Africa.

Flooding in cities of North Africa

Cities in North Africa are hotspots for the combined effects of climate change and disasters, migration and population growth, socio-political, economic and other development-related problems. Sixty percent of the population in the region is currently urbanized, and the number of urban dwellers is likely to double over the next 3 decades.

With a growing young population, the demand for low-income housing and urban services will increase. However, current housing programs will be insufficient to prevent the spread of informal settlements at the cities' outskirts, over high risk areas. Under these conditions, flooding could threaten the lives of millions of urban residents in the region. In fact, informal settlements are today home to 25 to 50% of the total populations of Alexandria, Casablanca and Tripoli. As seen in Algiers in 2001, flash floods also threaten lives and property of urban dwellers in high risk lowland areas.

Climate-resilient urban planning, improved city-wide basic infrastructure (e.g. drainage systems), containing settlement in flood and landslide prone areas and operational and functioning integrated disaster risk management systems (i.e. structural protection and early warning systems) are necessary measures to prevent human and economic losses to recurrent flood events in the future.

Source*: World Bank, 2014*

2.1. Potential climate change impacts

While a comprehensive list of potential climate change impacts in the Mediterranean and North Africa has been compiled by TREE (2014), here **average drier conditions, drought and sea level rise** are discussed as the **key climate change-related threats to development in the region** and in particular in Morocco, Tunisia and Egypt.

Through land losses to the sea, increased coastal erosion, saltwater intrusion into aquifers and surface waters, sea level rise (SLR) will directly impact agricultural fields, infrastructure, and other capital assets in coastal areas, where most of the population live and economic activities occur, with negative repercussions on food security, freshwater supply, tourism services and employment.

Comparative analyses of potential sea level rise impacts indicate that Egypt is one of the four most vulnerable countries to SLR in the world, and that the consequences of a SLR of 1m or more could be devastating (Dasgupta et al. 2007). It has been estimated that an increase of 1m in sea level[2] would decrease the country's agricultural land extent by 12.5% and directly affect 10% of the population, mainly in the Nile delta (Dasgupta et al. 2007; Link et al. 2012, see case study). A 1m SLR would also impact approximately 5% of Tunisia's population and 5% of its urban land (Dasgupta et al. 2007).

Decreased rainfall, rising temperatures and longer and more frequent dry spells are expected to affect rain-fed agricultural production by decreasing the extent of land areas suitable for agriculture, shortening the length of the growing seasons and reducing crop yields (Ringius et al. 1996; Radhouane, 2013). These effects are also predicted for arid and semiarid lands (IPCC, 2007), hence increasing demand for water and likely exacerbating existing cycles of natural resource degradation (Turral et al. 2011). This situation complicates food security in North Africa, particularly because between 30 and 80% of the poor population, including some of the most marginalized and vulnerable (landless, single women) live in rural areas (Christensen et al. 2007) and depend on their harvests for sustenance and because about half of the food currently consumed is imported (Harrigan et al. 2012) and the region is short in additional productive land, with agricultural intensification being the only option countries can resort to for increasing production (but see Schilling et al. 2012).

Less but heavier rain events are to be expected in North African drylands, triggering runoff, increasing the risk of flash floods, landslides, infrastructure damages, and higher soil erosion. Warmer and drier conditions and drought will also affect aquifer recharge and add to the existing high water stress of the region. By 2025, North African countries will surpass their maximum economically usable land-based water resources (Ashton, 2002) and, with the growth in population expected by 2050, an increase of 3°C could cause water stress to 155-600 million North Africans (FAO, 2008). Studies suggest that Morocco's water resources will be reduced between 10 and 15% by 2020; Tunisia's water resources will decline 28% by 2030 and in Egypt, more than 74.8% of the population will have less than adequate fresh water supply by 2030 (review in National Intelligence Council, 2009). Policy-supported water intensive developments such as irrigation schemes, construction of dams, tourism, and the cultivation of fruits and vegetables for export, increase the vulnerability of North African countries to climate change. These are nevertheless important economic alternatives for these countries, since Tunisia and Morocco have managed to strategically position themselves on European markets to attract tourists and supply Europe with fresh vegetables and fruits. These are key areas for future economic development which should be scrutinized through a climate change lens.

Increases in soil salinization and erosion rates, both related to desertification (Baumhauer, 2007) are also to be expected with climate change. Higher temperatures and reduced precipitation can lead to higher evaporation rates and soil salinization problems. These already affect large parts of Egypt and have also been observed in Morocco and Tunisia (FAO and ITPS, 2015). Soil salinization processes will be exacerbated in irrigated areas, particularly if irrigation uses fossil water. Soil salinization and erosion compromise land use and natural vegetation cover and add to overgrazing, deforestation and unsustainable land management practices in enhancing desertification.

Clearly, the combined effect of the presented climate change impacts, interacting with demographic pressures and other socio-economic and political issues will substantially affect North African communities, livelihoods and national economies in the medium and longer-term.

---

[2] The likely range of SLR increase for the RCP 8.5 by 2100 is of (+0.52 -- +0.98m) but most studies consider projections based on 1 to 5m SLR (see Church et al. 2013)

Climate change and surface water resources in Morocco

By 2020, projected climate change---related rainfall changes will reduce Morocco's dam capacity (by rapid siltation exacerbated by erosion and concentrated rainfalls); alter river flow rates; and decrease water levels, decreasing natural outlets for water tables and increasing salinity in coastline areas; and deteriorate water quality (National Intelligence Council, 2009). Under these conditions, Morocco will see a 10---15% reduction of its water resources. Additionally, and without assuming changes in precipitation, a 1°C rise in temperature could lead to a 10% reduction of runoff in the watershed of the Ouergha River, which is the main water source for the Al Wahda Dam, the second---largest dam in Africa. The aggregated estimated reduction of runoff in this and other watersheds could be compared to the loss of one large dam per year in the region (Boko et al. 2007).

Sea level rise threatens the Nile delta

The Nile delta has been Egypt's breadbasket for thousands of years. Today, it produces about one third of the country's crops and the delta region is home to about 39 million people, including the population of the city of Alexandria. However, the Nile delta is threatened by sea level rise, subsidence and unsustainable environmental management practices (Dasgupta et al. 2009; Link et al. 2012; Hassaan & Abdrabo, 2013). In recent years land reclamation projects have added large expanses of agricultural land and unproductive land has been converted to fish farms, considerably increasing the delta's economic output but reducing natural protective barriers to SLR (Link et al. 2012). Decreased sedimentation since the construction of the Aswan dam, increasing seawater intrusion, soil salinization and coastal erosion also affect the delta (Agrawala et al. 2004; El---Nahry. & Doluschitz, 2010; El Raey, 2010). In addition, the delta's wetlands are drying up (Link et al. 2012). A study commissioned by the city of Alexandria projects that a 30cm SLR, could occur as soon as 2030 and flood approximately 200 square kilometres. This would displace over half a million inhabitants and erase around 70,000 jobs (El Raey, 1999; Agrawala et al. 2004; but see El Sayed Frihy et.al. 2010).

Addressing environmental and climate change related risks in the Nile Delta is not yet one of Egypt's top priorities. However, if no measures are taken, the impacts of a 1m SLR on the delta could trigger massive food shortages and drive the migration of eight million people by the end of the century, as has been widely reported (IPCC 1997).

3. The climate change, migration and economic development nexus

North Africa is a centre of international and internal migration. Traditionally, countries in the region have been destinations and transit areas for labour migrants from Sub-Saharan countries trying to reach Europe (Werz and Conley, 2012; De Sousa Ferreira, 2014; Tangermann and Traore Chazalnoel, 2016). However, migrations from rural areas to urban centers within countries of the region have been common. Likewise, the migration of North Africans from their own countries of origin or through neighbouring countries to destinations in Europe and beyond have also been occurring (Gubert and Nordman, 2008; De Sousa Ferreira, 2014).

This situation presents a good opportunity to analyse various aspects of climate change-induced migration. For example, it is evident that **climate change-related drivers of migration in North Africa need to be understood not only at the level of the region and its countries but also at the level of the regions and countries of origin of the migrants who reach North Africa, either to stay or on their way to cross the Mediterranean.** It also becomes evident, that except for internal or cross-border climate disaster displacement, climate change cannot be singled out as the cause of migration. Rather, it is an important contributing factor that may directly or indirectly interact with or influence many others (for example conflict, poverty and weak institutional support to cope with change) which are considered in migration decisions (Fritz, 2010).

In North Africa, the impacts of climate change already converge with existing development and political challenges (Schilling et al. 2012; Githeko et al. 2013; De Sousa Ferreira, 2014; Sternberg, 2011). Declining agricultural yields, desertification and increasing poverty in rural areas drive people to migrate to urban centers in search of economic and livelihood alternatives. However, these are scarce and likely to be impacted by climate change, as key economic sectors in these zones, such as tourism, are threatened by sea level rise and water scarcity (Gubert and Nordman, 2008). With climate change, shrinking land suitable for agriculture, and cropping increasingly dedicated to exports, reliance on food imports for local consumption will likely increase, exposing North African people to high and volatile food prices, which in turn may be influenced by climate impacts on agriculture elsewhere. A major drought in China or the USA can have substantial impact on bread prices in North Africa (e.g. Sternberg, 2011). Adding to this situation is the rapidly growing population in the region and the likely increase of immigration from other African countries, which could also be driven by processes related to climate change and environmental degradation (Werz and Conley, 2012).

Coastal cities in the region have seen a large rural population influx in the past 50 years (Gubert and Nordman, 2008). Shall sea level rise projections materialize and impact key economic sectors, it is likely that people in urban centers will seek better living conditions by migrating towards third countries, and will not return to the county side where they originally come from. However, the effects of climate change and disasters will compound existing and new development challenges in the region's coastal cities.

The climate change, migration, and economic development nexus hence centers on limited rural development potentially due to climatic and environmental degradation/desertification factors fostering migrations within countries towards coastal cities. The second nexus is the exposure of coastal cities to sea level rise, affecting economic hubs and hence exacerbating urban unemployment and triggering a second wave of migration towards third countries across the Mediterranean Sea.

Migration is an important response to all, extreme weather events, climate variability and longer term climate change (Heimann, 2015; Warner et al. 2009). Thus, the interaction between climate change and other factors will likely increase displacement in future years. However, projections of the number of people to be displaced by climate change and inter-related factors vary widely and are difficult to make, as to date, there are no consistent global or regional systems to account internal or cross-border climate and environment-related migrants (Warner et al. 2009; Fritz, 2010; McAdam and Limon, 2015). There is also no international framework in place to offer them protection and assistance under a recognized official status. However, efforts such as the Nansen Initiative, have brought to the attention of governments the need to recognize and tackle these issues (The Nansen Initiative, 2015). This is complicated in practical terms, particularly for migrations triggered by the effects of slow-onset climate processes, such as sea level rise, glacial melting or drought, as it may be extremely difficult to relate migrations to these serious climate and environmental processes before they turn into recognizable disasters (Kolmannskog, 2009).

Migrants in urban areas can greatly contribute as man power to economic growth and sustain relatives with remittances. Hence, migratory flows can also generate opportunities through financial transfers and economic growth. Remittances provide also a substantial adaptive capacity tool for relatives who remained in rural areas and whose livelihoods are affected by diminished or uncertain agricultural production exacerbated by climate change.

Increasing drought intensity and frequency is a driver for migrations (see Science for Environmental Policy, 2015). With growing challenges to rural livelihoods posed by water scarcity, weather extremes and environmental degradation, migrations in the region first occur from rural areas to coastal cities. Rising population pressures in coastal cities and higher exposure to SLR are likely to further incite migrations towards Europe and beyond. However, migrations back to the country side are unlikely. Furthermore, migrations from Sub-Saharan Africa to North African cities Rabat, Algiers, Tunis, Tripoli and Cairo, are likely to amplify the exposure of these cities to hazard impacts (e.g. the Bab el Oued floods in Algiers).

With the prospect of drought and sea level rise looming over North Africa, investing on sustainable environmental management, water resource efficiency, coastal zone protection, disaster risk reduction and protection and assistance to climate-related migrants should be prioritized by governments and donor agencies.

4. Best practices in agriculture to improve adaptive capacity in North Africa[3]

- Improved irrigation techniques and/or desalinization to reduce groundwater extraction and prevent seawater intrusion in aquifers
- Prevention of sand encroachment over crop fields by fixating sand dunes through mechanical and biological means (e.g. tree plantations)
- Income source diversification in rural areas (i.e. tourism)
- Implementation of climate-smart, low-water demanding technologies in agriculture
- Implementing urban wastewater treatment for re-use in agriculture
- Awareness raising programs on water scarcity and efficient water use options
- Improvement of meteorological facilities to strengthen prediction models and mapping.
- Implementation of early warning systems for drought
- Implementation of systems to protect crops from hail.
- Adoption of crop varieties and livestock breeds resistant to water scarcity. This should be complemented by the creation of germplasm banks. i.e. Indigenous livestock genetic resources have important adaptive traits for harsher environments.
- Promotion of conservation agriculture techniques such as intercropping and mulching with multi-level , multi-function shading systems.

Examples of agricultural practices used in North Africa to cope with climate hazards and change:

Egypt

"Egyptian farmers who observed change (85% of 900 households interviewed) in rainfall and temperature patterns adjusted their irrigation management (more often, more quantity, or timely irrigation when evaporation is lower). They also adjusted sowing dates and used heat-resistant and early maturing varieties. They adjusted also their pesticide and fertilizer management". (*National Intelligence Council, 2009).*

3 (Taken from Morocco's Second National Communication on GHG, 2013)

Examples of agricultural practices used in North Africa to cope with climate hazards and change:

Morocco

"The National Institute for Agricultural Research in Morocco introduced wheat and barley varieties resistant to water scarcity. As a result, crop yields have increased by over 35%". (*Morocco's 2nd National Communication on GHG, 2013*)

5. Identified knowledge gaps

- Large gaps in regional and national climate data collection and monitoring.
- Low capacity to analyse existing climate and environmental data and make predictions that incorporate complexities (global / local processes).
- High levels of uncertainty for key variables and processes, including precipitation, dust storms, and desertification leave important gaps in knowledge needed for climate and environment-migration projections.
- Scarce medium-term climate projections for planning purposes at local level.
- Limited understanding of resilience, adaptive capacity and successful coping strategies for environmental degradation and climate processes at national and local level.
- Need for improved understanding of behaviour and choice of people facing climate change.
- Need for improved understanding of population dynamics intersected to SRL models to identify critical hotspots, and develop a spatial vulnerability index.
- Need for improved drought recording. Insufficient systems are in place for drought monitoring, given this hazard's slow onset nature and lack of solid definition.
- Need for improved understanding of technologies to protect coastal cities in drylands against SLR.
- Very limited understanding of the effect of climate change and related processes (i.e. land degradation, resource scarcity) on migrations.

6. References

Agrawala, A. et. al. 2004. Development and climate change in Egypt, focus on coastal resources and the Nile, Working Party on Global and Structural Policies. OECD, Paris. 68pp. (http://www.oecd.org/env/cc/33330510.pdf)

Aich, V. et al. 2014. Comparing impacts of climate change on streamflow in four large African river basins. Hydrology and Earth System Sciences 18: 1305–1321 (http://www.hydrol-earth-syst-sci.net/18/1305/2014/hess-18-1305-2014.pdf)

Ashton, P.J. 2002. Avoiding conflicts over Africa's water resources. Ambio 31: 236

Baumhauer, R. 2007. Accelerated desertification. In: Lozán, J. L. et al. (eds). Global change: Enough water for all? Wissenschaftliche Auswertungen, Hamburg. 384pp.

Boko, M. et al. 2007. Africa. Climate change 2007: Impacts, adaptation and vulnerability. Contribution of Working Group II to the Fourth assessment report of the Intergovernmental Panel on Climate Change, M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson (eds.) Cambridge University Press, Cambridge UK, 433-467.

Christensen, I. et al. 2007. The status of rural poverty in the Near East and North Africa. IFAD. Rome. 89pp. (https://www.ifad.org/documents/10180/2d14b097-5569-4a54-9967-c970b5afdb32)

Church, J.A. et al. 2013. Sea level change. In: 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., Qin, D., Plattner, G.-K., Tignor, M., Allen, S.K., Boschung, J., Nauels, A., Xia, Y., Bex, V. & Midgley, P.M. (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA. (https://www.ipcc.ch/pdf/assessment-report/ar5/wg1/WG1AR5_Chapter13_FINAL.pdf)

Dasgupta, S. et al. 2007. The Impact of sea Level rise on developing countries: A comparative analysis. World Bank Policy Research Working Paper 4136. 25pp. (https://openknowledge.worldbank.org/bitstream/handle/10986/7174/wps4136.pdf)

Dasgupta, S. et al. 2009.The impact of sea level rise on developing countries: a comparative analysis. Climatic Change 93: 379- 388

De Sousa Ferreira, S. 2014. Migrations and the Arab spring – a new security nexus? Human Security Perspectives 1: 62-90. (http://www.etc-graz.at/typo3//fileadmin/user_upload/ETC-Hauptseite/human_security/hs-perspectives/pdffiles/issue1_2014/Susana_de_Sousa_Ferreira_-_Migrations_and_the_Arab_Spring_Final.pdf)

Drine, I. 2011. Climate change compounding risks in North Africa. World Institute for Development Economics Research, United Nations University Working Paper 2011/32: 19pp. (https://www.wider.unu.edu/sites/default/files/wp2011-032.pdf)

El-Nahry, A. H. & Doluschitz, R. 2010. Climate change and its impacts on the coastal zone of the Nile Delta, Egypt. Environmental Earth Sciences 59:1497–1506

El-Raey, M. 1999. Impact of climate change on Egypt. Environmental Software and Services. http://www.ess.co.at/GAIA/CASES/EGY/impact.html (accessed February, 2016).

El-Raey, M. 2010. Impacts and implications of climate change for the coastal zones of Egypt. In: Michel, D. and Pandya, A. (eds) Coastal zones and climate change. The Henry L. Stimson Center, Washington. pp.31-50 (http://www.stimson.org/images/uploads/research-pdfs/Mohamed.pdf)

El Sayed Frihy, O. et al. 2010. Alexandria-Nile delta coast, Egypt: update and future projection of relative sea-level rise. Environmental Earth Sciences 61:253–273

EM-DAT, the OFDA/CRED International Disaster Database, Université Catholique de Louvain, Brussels, Belgium. Accessed on February 2016 (www.emdat.net)

FAO. 2008. Agriculture in the Near East likely to suffer from climate change: The hungry and poor will be most affected – FAO meeting debates impact on the region. FAONewsroom March 3, 2008. (http://www.fao.org/newsroom/en/news/2008/1000800/index.html).

FAO. 2011. The state of the world's land and water resources for food and agriculture (SOLAW) – Managing systems at risk. FAO, Rome and Earthscan, London. 285pp. (http://www.fao.org/docrep/017/i1688e/i1688e.pdf)

FAO and ITPS. 2015. Status of the world's soil resources (SWSR). Chapter 13: Regional assessment of soil changes in the Near East and North Africa. FAO and Intergovernmental Technical Panel on Soils, Rome, Italy. (http://www.fao.org/3/a-bc602e.pdf)

Femia, F. & Werrell, C.E. 2012. Mali: Migration, militias, coups and climate change. The Center for Climate and Security Briefer 13: 1-3. (https://climateandsecurity.files.wordpress.com/2012/04/mali-migration-militias-coups-and-climate-change-_briefer-13.pdf)

Fritz, C. 2010. Climate change and migration: Sorting through complex issues without the hype. Migration Policy Institute. Online Article. (http://www.migrationpolicy.org/article/climate-change-and-migration-sorting-through-complex-issues-without-hype)

Githeko, A.K. et al. 2013. Africa Environment Outlook 3: Our environment, our health. UNEP. 242pp. (http://www.unep.org/dewa/portals/67/pdf/AEO-3_Full_Report_low-res.pdf)

Gubert, F. & Nordman, C.J. 2008. The future of international migration to OECD countries Regional Note North Africa. OECD. 37pp. (http://www.oecd.org/futures/43484295.pdf)

Hallegate, et al. 2016. Shock waves: Managing the impacts of climate change on poverty. Climate Change and Development Series. World Bank, Washington DC. 207pp. (https://openknowledge.worldbank.org/bitstream/handle/10986/22787/9781464806735.pdf)

Hassaan, M. A. & Abdrabo, M.A. 2013. Vulnerability of the Nile Delta coastal areas to inundation by sea level rise. Environmental Monitoring and Assessment 185: 6607-6616

Heimann, L. 2015. Climate change and natural disasters displace millions, affect migration flows. Migration Policy Institute. Online Article. (http://www.migrationpolicy.org/article/top-10-2015-issue-7-climate-change-and-natural-disasters-displace-millions-affect)

ILO. 2011. Youth unemployment in the Arab world is a major cause for rebellion. Online article available at: http://www.ilo.org/global/about-the-ilo/newsroom/features/WCMS_154078/lang--en/index.htm

IPCC. 1997. The Regional impacts of climate change: An assessment of vulnerability. R.T.Watson, M.C. Zinyowera AND R.H. Moss (eds). Cambridge University Press, New York, NY, USA. (http://www.ipcc.ch/ipccreports/sres/regional/index.php?idp=30)

IPCC. 2007. Climate change 2007: Impacts, adaptation and vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds., Cambridge University Press, Cambridge, UK, 976pp.

IPCC. 2014. Summary for policymakers. In Climate change 2014: Synthesis report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]. IPCC, Geneva, Switzerland, 31 pp.

Kolmannskog, V. 2009. Climate change, disaster, displacement and migration: initial evidence from Africa. New Issues in Refugee Research. Research Paper No. 180. UNHCR. Geneva. 16pp. (http://www.unhcr.org/4b18e3599.pdf)

Link, P.M., Kominek, J. & Scheffran, J. 2012. Impacts of sea level rise on the coastal zones of Egypt. Working Paper CLISEC-25. Research Group Climate Change and Security, University of Hamburg. 13pp. (https://clisec.zmaw.de/fileadmin/user_upload/fks/publications/working-papers/Working_paper_CLISEC-25.pdf)

McAdam, J. & Limon, M. 2015. Human rights, climate change and cross-border displacement: the role of the international human rights community in contributing to effective and just solutions. Policy Report. Universal Rights Group. Versoix, Switzerland. 28pp. (http://www.universal-rights.org/wp-content/uploads/2015/12/CC_HR_Displacement_pge.pdf)

The Nansen Initiative. 2015. Agenda for the protection of cross-border displaced persons in the context of disasters and climate change. TNI, Geneva. 35pp. (https://www.nanseninitiative.org/global-consultations/)

National Intelligence Council. 2009. North Africa: The impact of climate change to 2030 (selected countries). Special Report NIC2009-07D. 55pp. (http://livebettermagazine.com/eng/reports_studies/pdf/nic-climate2030_north_africa.pdf)

Oldenborgh, G.J. et al. 2009. Western Europe is warming much faster than expected. Climate of the Past 5: 1-12

Radhouane, L. 2013. Climate change impacts on North African countries and on some Tunisian economic sectors. Journal of Agriculture and Environment for International Development - JAEID 107: 101 – 113 (http://www.iao.florence.it/ojs/index.php/JAEID/article/view/123/106)

Ringius, L. et al. 1996. Climate change in Africa - Issues and challenges in agriculture and water for sustainable development. Center for International Climate and Environmental Research , Oslo. 177pp. (https://brage.bibsys.no/xmlui/bitstream/handle/11250/192102/CICERO_Report_1996-08.pdf?sequence=1&isAllowed=y)

Royaume du Maroc. 2010. Seconde communication nationale a la Convention Cadre des Nations Unies sur les Changements Climatiques. 218pp. (http://www.undp-alm.org/sites/default/files/downloads/morocco_snc.pdf)

Royaume du Maroc. 2013. Deuxieme communiqué national, Rapport gaz à effet de serre

Harrigan, J. et al. 2012. The political economy of food security in North Africa. AfDB Economic Brief. 32pp. (http://www.afdb.org/fileadmin/uploads/afdb/Documents/Publications/Economic_Brief_-_The_Political_Economy_of_Food_Security_in_North_Africa.pdf)

Schilling, J. et al. 2012. Climate change, vulnerability and adaptation in North Africa with focus on Morocco. Agriculture, Ecosystems and Environment, 156: 12–26.

Science for Environment Policy. 2015. Migration in response to environmental change. Thematic Issue 51. Issue produced for the European Commission DG Environment by the Science Communication Unit, UWE, Bristol. 15pp. (http://ec.europa.eu/environment/integration/research/newsalert/pdf/migration_in_response_to_environmental_change_51si_en.pdf)

Sternberg, T. 2011. Regional drought has a global impact. Nature 472: 169

Tangermann, J. S. & Traore Chazalnoel, M. 2016. Environmental migration in Morocco: stocktaking, challenges and opportunities. Migration, Environment and Climate Change: Policy Brief Series 3: 1-10. IOM, Geneva.

Terink, W. et al. 2013. Climate change projections of precipitation and reference evapotranspiration for the Middle East and Northern Africa until 2050. International Journal of Climatology. DOI: 10.1002/joc.3650 (http://www.futurewater.eu/wp-content/uploads/2013/05/Terink_MENA_JOC.pdf)

The Tree, content for climate change communicators. 2014. Region by region: The science of AR5 WG1 and the consequences. TREE Report 85pp. (http://treealerts.org/wp-content/uploads/2013/09/IPCC_Region_by_Region_Final.pdf)

Turral, H. et al. 2011. Climate change, water and food security. FAO Water Reports 36. FAO, Rome. 174pp. (http://www.fao.org/docrep/014/i2096e/i2096e.pdf)

Warner, K. et al. 2009. In search of shelter: mapping the effects of climate change on human migration and displacement. United Nations University, CARE, CIESIN - Columbia University, UNHCR, and the World Bank. 26pp. (http://www.ciesin.columbia.edu/documents/clim-migr-report-june09_media.pdf)

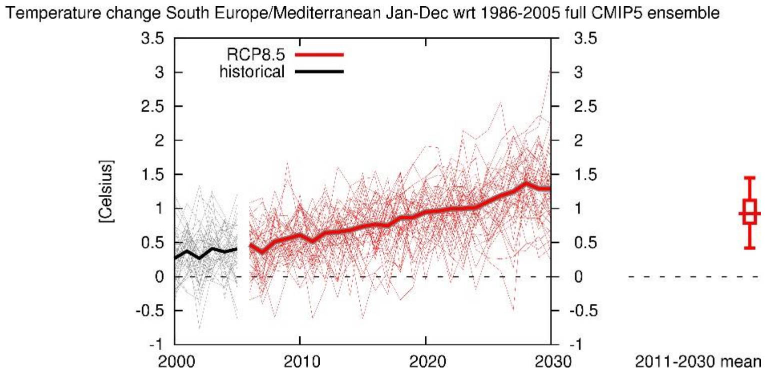
Werz, M. & Conley, L. 2012. Climate change, migration, and conflict in Northwest Africa, rising dangers and policy options across the arc of tension. Center for American Progress and Heinrich Boll Stiftung publication, 75pp. (http://cdn.americanprogress.org/wp-content/uploads/issues/2012/04/pdf/climate_migration_nwafrica.pdf)

World Bank. 2014. Natural disasters in the Middle East and North Africa: A regional overview. The World Bank, Washington, 113pp. (http://www-wds.worldbank.org/external/default/WDSContentServer/WDSP/IB/2014/03/06/000442464_20140306122711/Rendered/PDF/816580WP0REPLA0140same0box00PUBLIC0.pdf)

Annex 1. Future climate projections for selected variables

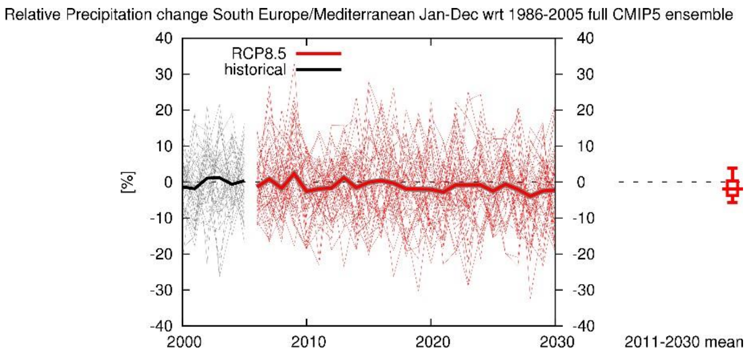
We used RCP8.5 precautionary pathways under "business-as-usual" greenhouse gases concentration scenarios. The changes indicated below are projected against the 1986-2005 period. These projections cover the region South Europe/Mediterranean (climexp.knmi.nl; van Oldenborgh et al. 2009).

-***Mean annual temperature***.[4] Mean annual temperature is projected to increase by 0.9°C by 2030 (very likely in the range of 0.4°C to 1.5°C).

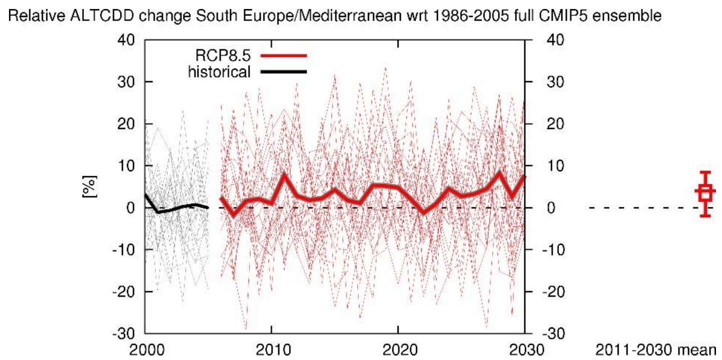


.

-***Precipitation.*** By 2030, the mean annual precipitation is projected to decrease by 4% by 2030 (very likely in the range of -7.2% to +4.8%).



-***Dry spells.***[5] The duration of long-lasting dry spells is predicted to increase by 4% in the Mediterranean region by 2030 (very likely in the range of -2% to +8.4%).



[4] Ranges of change shown below consider values at the 5th and 95th percentiles. Projected extreme events values (i.e. heat waves, cold spells, heavy rains and dry spells) should be taken cautiously because of substantial spatial variability not being reflected in national level projections.

[5] The dry spells are considered as the annual maximum length of spells in days where daily precipitation is less than 1mm per day.