REGIONAL ASSESSMENT OF PAST DROUGHT & FLOOD EPISODES AND THEIR MANAGEMENT IN SELECTED SWIM-SM PCS (TUNISIA, JORDAN AND PALESTINE)

Work package (WP1)
Water Governance and Mainstreaming
Activity 1.3.3.1

February 2014

Version	Title of document	Authors	Review and Clearance
V3	**REGIONAL ASSESSMENT OF PAST DROUGHT & FLOOD EPISODES AND THEIR MANAGEMENT IN SELECTED SWIM-SM PCs (TUNISIA, JORDAN AND PALESTINE)**	Regional Assessment: Suzan TAHA Jordan's Case Study: Suzan TAHA Palestine Case Study: Ayman RABI Tunisia Case Study: Sarra TOUZI:	**Hosny Khordagui, and Vangelis Constantianos**

……..Water is too precious to Waste

Acknowledgement:

Special thanks are extended to the countries' officials; for the valuable information they have provided; namely **in the case of Jordan**: Eng. Basem Telfah; the Secretary General (SG) of **the Jordanian Ministry of Water and Irrigation (MWI),** Eng. Ali Subah; MWI Assistant Secretary General (ASG) for Technical Affairs; and SWIM-SM focal point, Eng. Mohammad Momani; Advisor to the Secretary General and Eng. Mohammad Atrash; director of water resources and monitoring, for their valued guidance and/or insights. Also special thanks go to Mr. Zakaria Haj Ali; head of MWI surface water studies and Ayman Jaber; head of information systems at MWI, for all the data they provided. **At the Jordan Valley Authority (JVA),** we would like to acknowledge the time and assistance of Eng. Foad Eijilat; ASG for Technical Affairs and the insightful information provided by both:Eng. Youssef Hassan; the advisor to JVA SG, and Eng. Qais Oweis; ASG for Northern & Middle Ghors. Our thanks also go to Eng. Na'eem Dabbour; Director of Dams Department, Eng. Hisham Al-Hiyasa; director of Mujeb Dam at JVA. At the **Ministry of Agriculture (MOA)**, our appreciation is due to Eng. Abdallah Shishani; ASG for Governorates Affairs, Eng. Amjad Khundakji, Information and Technology (IT) Director, Eng. Jamal Batsh; ASG for Plants Wealth and Dr. Yaser Mohawesh; director of soil-water and Environment at the **National Center for Agriculture and Research Extension (NCARE)**, in addition to Muna Saba; Supervisor of the Drought Monitoring Unit at NCARE, for the time and supporting information provided by them. Finally special thanks are in order to Mr. Waleed Abdullah;Disaster Risk Department, **Aqaba Special Economic Zone Authority (ASEZA)**for the information he provided on disaster related information in Aqaba, and toDr. Faisal Awawdeh; **Regional Coordinator/Consultant of the Arabian Peninsula Regional Program (APRP)-International Centre for Agriculture Research for Dry Land Areas (ICARDA)**, Dubai, previously the Director of NCARE, for making himself available for assistance from Dubai. Also great thanks to Eng. Raed Bani Hani, Director of Nature Protection at the **Ministry of Environment**, Hussein Kisswani, National Climate Change Officer at the **Royal Society for the Conservation of Nature (RSCN)**, Dr Awni Taimeh, Professor at the Department of Land, Water and Environment, **University of Jordan** and Dr. Taleb Abu-Sharar, Professor at the Department of Land, Water and Environment, University of Jordan, for their valuable information they provided.

In Palestine: Special thanks goes to Mr. Yousef Abu Asaad, the Director General of **Palestinian Meteorological Department**, Mr. Ammar Salameh, the Director General of Disaster Department of the **Civil Defense Directorate**, Mr. Deeb Abdel Ghafour of **Palestinian Water Authority**; Mr. Ahmad Abu Thaher, Director General of International Relations and Projects at **Environment Quality Authority (EQA)** and Mr. Nedal Katbeh, Climate Change expert of EQA; Mr. Isam Nofal, director general of water and soil department

of **Ministry of Agriculture (MoA)** as well as Mr. Nazih Abu Fkhaitha, director of disaster department within MoAand Mr. Sae'edEllaham, director of vegetables and flowers department within the extension directorate of MoA for the valuable information they provided.

In the case of Tunisia, special acknowledgment is due to Mme Sondes Kamoun; SWIM-SM focal point in Tunisia and General Director of the "Office of Planning and Hydraulic Balance" at the **Tunisian Ministry of Agriculture**, for dedicating her own time to facilitate the contacts and access to the different sources of information and whose support was essential for the realisation of the Tunisian case study. Also special thanks go to the new SWIM-SM focal point; M. Slah Nasri; presently the acting director general of the "Office of Planning and Hydraulic Balance" in the same Ministry. The case study was produced with the support and collaboration of several managers and executives of the Tunisian administration whom we thank for receiving the SWIM-SM consultant and providing the documentation that they have: M Lotfi and Mrs. Frigui Hayet Ben Mansour of the General Directorate of Water Resources, Mr. Yousef Saadani at the General Directorate of Forests, Ms. Sahla Mezghanni; the General Directorate of Agricultural Production, Mr. Lazhar El Echi; the General Directorate for Research and Agricultural Development, MM. Taoufik Gaied

Taoufik Abdelhedi and Khalil Jemmali from the General Directorate for Dams and Large Hydraulic Works at the Ministry of Agriculture, Colonel Adel Slimani from the National Office of Civil Protection of the **Ministry of Interior**, Ms. Wafa Ben Amor and Jouda Nasri at the Directorate of Urban Hydraulics, at the **Ministry of Infrastructure and the Environment.**

Disclaimer:

TABLE OF CONTENTS

LIST OF TABLES:

LIST OF FIGURES:

LIST OF BOXES:

LIST OF ACRONYMS

AFED	Arab Forum for Environment and Development
ARIJ	Applied Research Institute - Jerusalem
ARMF	Agricultural Risk Management Fund
ASEZA	Aqaba Special Economic Zone Authority
BCM	Billion Cubic Meters
BCT	Banque Centrale de Tunisie
BV	Bassin Versant
CBOs	Community Based Organizations
CC	Climate Change
CCA	Climate Change Adaptation
CCNUCC	Convention-Cadre des Nations Unies sur les Changements Climatiques
CDD	Civil Defence Directorate
CDM	Clean development mechanism
CEHA	Centre of Environmental Health Activities
CEIGRAM	Centro de Estudios e Investigación para la Gestión de Riesgos Agrarios y Medioambientales (Studies and Research Center for the Management of Agricultural and Environmental Risks)
CEPF	Critical Ecosystems Partnership Fund
CIHEAM	International Centre for Advanced Mediterranean Agronomic Studies
CNEA	Centre National d’Etudes Agricoles
CRDA	Commissariat Régional au Développement Agricole
DFO	Dartmouth Flood Observatory
DG/BGTH	Direction Générale des Barrages et des Grands Travaux Hydrauliques
DG/F	Direction Générale des Forêts
DG/FIOP	Direction Générale du Financement, des Investissements et des Organismes Professionnels
DG/GREE	Direction Générale de Génie Rural et de l’Exploitation des Eaux
DG/PA	Direction Générale de la Production Agricole
DG/SA	Direction Générale de la Santé Animale
DGRE	Direction Générale des Ressources en Eau
DMU	Drought Monitoring Unit
DRM	Disaster Risk Management
DRR	Disaster Risk Reduction
DT	Dinars Tunisiens
DZ	Algeria
EEAA	Egyptian Environmental Affairs Agency
EG	Egypt
EM-DAT	Emergency Events Database
EMG	Experts Group Meeting
ENNP	European Network of National Platforms
EQA	Environment Quality Authority
ESCWA	Economic and Social Commission for Western Asia
ESIP	Environmental Strategy Implementation Plan
EU	the European Union
EUWI Med	the European Union Water Initiative -the Mediterranean Component
FAO	Food and Agriculture Organisation

FMIDACN	Fonds de Mutualité pour l'Indemnisation des Dommages Agricoles dus aux Calamités Naturelles
FNCR	First National Communication Report
FNG	Fonds National de Garantie
FWP	Food World Program
GCM	Global Climate Model
GDA	Groupement de Développement Agricole
GDCD	General Directorate of Civil Defence
GDP	Gross Domestic Production
GEF	Global Environment Facility
GIZ	Coopération Internationale Allemande
GS	Gaza Strip
GTZ	Coopération Technique Allemande (actuellement GIZ)
GVC	Gruppo Di Volontariato Civile (Civil Volunteer Group)
HCCD	Higher Council for the Civil Defence
HCDC	Higher Civil Defence Council
HFA	Hyogo Framework for Action
IAMB	Mediterranean Agronomic Institute of Bari
IBPs	Indigenous best practices
ICARDA	International Center for Agricultural Research in the Dry Areas
IFAD	International Fund for Agricultural Development
IFM	Integrated Flood Management
IL	Israel
INM	Institut National de Météorologie
INS	Institut National des Statistiques
IPCC	Intergovernmental Panel for Climate Change
IUCN	International Union for Nature Conservation
IWMI	International Water Management Institute
IWRM	Integrated Water Resources Management
JD	Jordanian Dinars
JICA	Japan International Cooperation Agency
JO	Jordan
JRV	Jordan Rift Valley
JVA	Jordan Valley Authority
KW/h	Kilo Watt par Heure
l/c/d	Litres per Capita per Day
LB	Lebanon
M	Flood Magnitude
MA	Ministère de l'Agriculture
MAEWR	Ministry of Agriculture and Water Resources
MATE	Ministère de l'Aménagement du Territoire et de l'environnement (Algérie)
MCD	Ministry of Civil Defence
MCM	Million Cubic Meter
MDG	Millennium Development Goals
MDG-F	MDG Achievement Fund
MDT	Millions Dinars Tunisiens
MEDA Water	Mediterranean Regional Programme for Local Water Management
MEDROPLAN	Mediterranean Drought Preparedness and Mitigation Planning
MEMEE	Ministère de l'Aménagement du Territoire, de l'Urbanisme, de l'Habitat, et de

	l'Environnement (le Maroc)
MEP	Ministry of Environmental Protection (Israel)
MICL	Ministère de L'intérieure et des Collectivités Locales (Algérie)
MO	Morocco
MOA	Ministry of Agriculture
MOE-JO	Ministry of Environment - Jordan
MOE-LB	Ministry of Environment - Lebanon
MOT	Ministry of Transport
MWI	Ministry of Water and Irrigation
MWO	Mediterranean Wetlands Observatory
MWSDWG	Mediterranean Water Scarcity and Drought Working Group
NCARE	National Centre for Agricultural Research and Extension
NCPED	National Comprehensive Plan for Emergencies and Disasters
NCRD	National Center for Research and Development
NCSA	National Capacity Self-Assessment
NCSCM	National Centre for Security and Crisis Management
NDVI	Normalized Difference Vegetation Index
NEAP	National Environmental Action Plan
NGOs	Non-Governmental Organizations
NIS	New Israeli Shekel
OC	Office des Céréales
OEP	Office de l'Elevage et du Pâturage
ONAS	Office National de l'Assainissement
OSS	Observatoire du Sahara et du Sahel
OTEDD	Observatoire Tunisien de l'Environnement et du Développement Durable
PA	Palestine
PCs	Partner Countries
PHG	Palestinian Hydrology Group
PIB	Produit Intérieur Brut
PMD	Palestinian Meteorology Department
PNUD	Programme des Nations Unies pour le Développement
PPRD	Prevention, Preparedness and Response to Natural and Man-made Disasters
PWA	Palestinian Water Authority
RN	Route Nationale
S1	Flood Severity Class 1
S2	Flood Severity Class 2
S3	Flood Severity Class 3
SEARCH	Social, Ecological and Agricultural Resilience in the Face of Climate Change
SNCR	Second National Communication Report
SONEDE	Société Nationale d'Exploitation et de Distribution des Eaux
SPI	Standard Precipitation Index
STEG	Société Nationale d'Electricité et de Gaz
SWIM	Sustainable Water Integrated Management
SWIM-SM	Sustainable Water Integrated Management - Support Mechanism
TeWaRON	Telemetric Water Resources Observation Network
TN	Tunisia
UAWC	Union of Agricultural Work Committees
UN	United Nations
UNDP	United Nations Development Program

UNDP - PAPP	United Nations Development Program - Program of Assistance to the Palestinian People
UNEP	United Nations Environment Program
UNESCO	United Nations Educational Scientific and Cultural Organization
UNFCC	United Nation Frame work for Climate Change
UNISDR	United Nation Office for Disaster Risk Reduction
UNPFA	United Nations Population Fund Agency
USAID	United States Agency for International Development
UTAP	Union Tunisienne de l'Agriculture et de la Pêche
UTICA	Union Tunisienne de l'Industrie, du Commerce et de l'Artisanat
W.	Wadi
WAJ	Water Authority of Jordan
WB	West Bank
WEAP	Water Evaluation and Planning
WHO	World Health Organisation
WMO	World Meteorological Organisation
WWF	World Wide Fund
WWTP	Wastewater Treatment Plant

EXECUTIVE SUMMARY

Despite the lack of consistent data in terms of temporal and spatial resolution and extent, the regional assessment shows that most of the drought episodes occurred during the last three decades and are becoming more persistent involving multiple years of consecutive droughts. Available studies of the standardized precipitation index (SPI) over the last century for **the east Mediterranean** indicates that the entire region**,** has **negative trends of annual SPI and precipitation**, while **countries like Jordan, Lebanon and Palestine; happen to be most affected by the decrease**. Likewise, **review of national reports for the southern Mediterranean** countries point to the same conclusion. All countries also report increased incidences of flood events with dramatic economic, social and environmental consequences, especially in the Western PCs. However lack of sufficiently long records on floods in addition to their incompleteness, does not allow depicting any discernable trends. On the other hand, the national communication reports to the United Nations Framework for Climate Change (UNFCC) confirm that climate change is one of the drivers for the extreme phenomena in the PCs including increased intensity and severity of droughts. **Table 1** presents the highlights of the review of drought and flood episodes for each country; Algeria (DZ), Egypt (EG), Israel (IL), Jordan (JO), Lebanon (LB), Morocco (MO), Palestine (PA) and Tunisia (TN). **Although Libya is among the Partner Countries, however no information is readily available on-line to enable assessing drought and flood characteristics in the country.**

Table 1: Summary of the review of the drought and flood episodes in the PCs and potential linkage to Climate Change

	Drought	Flood	Potential Linkage to CC
DZ	Intense and persistent drought during the past 25 years (rainfall deficit around 30% across the country. Western Part most hit by drought (rainfall deficit >50%)	Most of the floods occur in the north (195-2009), particularly in the centre and north east regions. The most frequent flood events are of S1[1], M [2] >4. Floods of higher severity and/or magnitude have also been observed during the past decade	Increased temperature by 0.5°C during the period 1961-1990 compared to the preceding 30 years, including decreased precipitation by 10% and marked increase in floods
EG	Egypt's vulnerability to drought is confined where rain-fed agriculture is practiced in the north west, for which drought frequency has been increasing (after 1957)	Most of the floods recorded between 1990 and 2009 occurred in the south particularly in the southeast areas and the southern part of Sinai. The Most frequent flood events are of S1, M>4	Increased severity of extreme events and increased rainfall trend over the Mediterranean coast with a mean trend of +0.76 mm/year when considering the period 1973-2002, However, the long term precipitation analysis for the period 1901-2007shows increased drought frequency.

[1] S1 = Class 1; representing large flood events with significant damage to structures or agriculture; fatalities; and/or with a return period of 10-20 years..

[2] Magnitude is expressed in the logarithm of the "Duration X Severity X the Affected Area (in square km)"

	Drought	Flood	Potential Linkage to CC
IL	Persistent droughts with multiple years of droughts during the 1990's and the past decade, involving varying severity; of which 1998/99 was the worst.	More intense & frequent floods in the more arid part of the country. The most frequent flood events are of S1, M<4, although floods of S2[3], M>4 have also been observed during the past decade	Negative rainfall trends statistically significant during spring over the majority of the country & in the super-arid region (1975-2010). Increased incidence of major flood events during the past years may be attributed to climate change
JO	Persistent droughts with multiple years of droughts during the 1990's and the past decade, involving varying severity; of which 1998/99 was the worst. Increased drought frequency from 46.6% (1937-2011) to 52% during 1962-2011, with a probability of severe drought at 16%.	Period examined was limited to 1991-2000, during which most of the floods occurred in the northwest and to lesser extent in the south. The picture reverses when compiling information on flood events during the past 50 years from more than one source. The most frequent flood events (1991-2000) are of S1, M>4, but floods of S1.5[4], M>4 have also been observed	Decreasing trend in rainfall by 5-20% in the majority of the country. At the same time, larger amounts of rainfall are associated with a decrease in the number of rainy days, suggest increased chance of extreme precipitation and floods (1961-2005)
LB	Mild to moderate drought with a respective return period of 1 in 3 and 1 in 8 years (1967-2005).Increased droughts during the second half of the past century.	Increased frequency and magnitudes of floods with increased landslides. Floods of S1, M<4 are more common, but flood of S2, M<4 was also recorded	Increased absolute extreme of the maximum temperature within a year. Overall decrease in total annual rainfall (1981 - 2000), the extent of which is debated in several studies.
MO	Increased droughts frequency, severity & extent. The north east is the area most hit by drought of with drought frequency of 46%. While the probability of occurrence of severe drought is highest in Marrakesh (1961-2004).	The central stretch of the country is the most exposed to floods. Increased frequency and intensity of floods observed. Floods of S1, M>4 are the most common, although floods of higher severity (S1.5 and S2) and M>6, were recorded during the past decade (1991-2009)	Growth of the semi-arid climate to the northern part of the country (1970-2000). Increased frequency and intensity of droughts and unusually devastating floods.
PA	Frequency of occurrence of drought years does not show any uniform return periods 1999 represents the most extreme drought (32-45% of the average rainfall).	Flood incidences are under reported	Decrease in rainfall is only analysed for the past 10 years within the context of the case study of Palestine. No other information is available.
TN	Consecutive droughts are common. The highest number of droughts occur in central and southern Tunisia	Most of the floods recorded between 1985 and 2009 occurred in Northern and Central Tunisia and show increasing trend during the past decade. The Most frequent flood events is of S1, M>4	No statistically significant indications of upward or downward trend in precipitation indices. However the number of extreme events has increased over the past 10 years.

[3] S2=Class 2; representing extreme events: with an estimated recurrence interval greater than 100 years

[4] S1.5 = Class 1.5; represents very large events: greater than 20 years but less than 100 year recurrence interval, and/or a local recurrence interval of 10-20 years

Review of the status of drought and flood management in selected PCs (Jordan, Tunisia and Palestine) evidences the lack of a methodological approach for addressing drought and flood management in Jordan and Palestine, and much less so in Tunisia, which has in the case of drought, a more mature drought management system. The case studies indicate that decision making in both Jordan and Palestine during drought periods is driven by a reactive short term management approach rather than by pro-active risk-based management measures that consider the good practices recommended by Iglesias (2007). However, struck permanently with imminent water scarcity, the government's attention in Jordan is drawn almost predominantly to planning and implementing additional water resources development interventions and water resources management under severe shortage. Several measures have been taken to protect the country's limited water resources including the adoption of water demand management policies. In addition, water rationing throughout the years have become a practice and the country is increasingly dependent on nonconventional water resources. In this regard, those very measures have contributed to mitigating the impacts of drought, especially in the agricultural sector; in the areas which depend mostly on the reuse of treated waste water.

In Palestine the drought and flood management situation is hindered by a joint governance system with Israel, characterised by asymmetries of power and capacity, that does not facilitate rational planning and development of the Palestinian infrastructure or the integrated management of its water resources. This – together with predictions of decreasing rainfall in the coming decades – could compromise the economic welfare of the country in the future.

On the other hand, the Tunisian drought management system[5] as far as the water and agricultural sectors are concerned is based on three phases: (i) before drought (preparedness and early warning); (ii) drought management (mitigating the impacts of drought based on a drought mitigation guidelines developed in this regard); and (iii) post drought (involving updating the drought mitigation guidelines). However, both the methodology and the guidelines, need to be more thoroughly evaluated and improved to account for lessons learnt during previous droughts with due consideration to recommended frameworks for drought planning.

The drought and flood induced socio-economic and environmental impacts affecting water resources and ecosystems are exacerbated by poor management of water resources - including overexploitation of water resources - and increased vulnerability of natural and human systems to droughts and floods. Several factors contribute to the latter; including the prevailing reactive approaches to drought and flood management, which is separated along sectorial lines and lacks integration with sustainable land management, water resource management, food security, etc. This results in ineffective costly short term solutions when considering all socio-economic and environmental impacts.

It is increasingly admitted by the scientific community that CC will bring more extreme phenomena, intensify droughts and floods risk patterns and make it harder for meteorologists to predict them, bringing along considerable degree of uncertainty. This necessitates **a shift in paradigm from reactive crisis management into proactive risk based planning**. In this context, planning tools and guidance are already available and can be used for coping with both risk and uncertainty by bringing frameworks to limit the impact of both predictable and unpredictable events**. These are broadly presented in** **ANNEX 2: EXISTING DROUGHT AND FLOOD MANAGEMENT FRAMEWORKS** **of this**

[5]The drought management system has already been tested during the drought events of 1987-1989, 1993-1995 and later during 1999-2002

report. Accordingly, a framework for drought and flood management policy recommendations are presented that embrace the concept of drought and flood risk management **(Chapter 6: Policy Recommendations)**.

INTRODUCTION

In **2012**, the EC funded "Sustainable Water Integrated Management Support Mechanism (**SWIM-SM**) project **undertook an assessment of no-regret actions activities to adapt the water sector in the Partner Countries (PCs) to Climate Change (CC)**. Based on the outcomes of this assessment and the views and recommendations of the water officials during field visits and contacts with stakeholders; it was evident that there is an urgent need to endeavour on no-regret actions designed to improve drought and flood preparedness of SWIM-SM PCs through i- increased knowledge and awareness; ii- better drought and flood integrated management policies based on risk rather than crisis management and iii- contingency plans with the view to reduce community's vulnerability and enhancing their resilience towards future drought and flood episodes.

SWIM-SM has accordingly refocused its CC no-regret scope of work during 2013 and 2014; with the overall objective of supporting SWIM-SM PCs in developing specific drought and flood policies and plans within their long-term sustainable management of water resources with the view of reducing vulnerability and enhancing communities' resilience.

The **specific objectives of the present SWIM-SM CC no regret activity are** to support the PCs in assessing drought and flood episodes (in terms of frequency occurrence, severity/magnitude, and geographic extent) with the aim to enhance the understanding and awareness of the following:

(a) droughts and floods in the SWIM-SM PCs as an increasing hazard that is potentially linked to CC as a main driver, and its potential environmental and socio-economic impacts.

(b) Prevailing drought and flood management practices and responses in the PCs.

In order to materialize the above-mentioned objectives, **SWIM-SM undertook the following:**

(a) A regional assessment **involving** (a) **a desktop** review and inventory of past drought and flood episodes during the past 50 years in the PCS and their potential linkage with climate change, and (b) review of the socioeconomic impacts of both events **based on available on-line literature**

(b) **Focused studies in three PCs (Jordan, Palestine and Tunisia)** involving data collection in the focus countries, with the aim to:

  i. assess drought and flood in the selected PCs during the past ten years

  ii. review and analyse the official water sector reactions including systems and mechanisms in place, and traditional community's response to past drought and flood episodes

  iii. identify lessons learnt and potential indigenous best practices in drought and flood management in the selected countries

  iv. assess the socio-economic and environmental impacts of drought and flood in the selected countries including the identification of the most vulnerable socio-economic sectors and sensitive ecological systems

1 REGIONAL ASSESSMENT OF PAST DROUGHT & FLOOD EPISODES

1.1 REVIEW AND INVENTORY OF PAST DROUGHT AND FLOOD EPISODES IN THE PCS AND POTENTIAL LINKAGE WITH CLIMATE CHANGE

The **precipitation regime** over the SWIM partner countries (PCs) is characterized by strong seasonal behaviour, with the rainy season mostly concentrated between November and March and a strong inter-annual and decadal variability. Accordingly, all major droughts in this region are characterized by the lack of rainfall during several months of winter during one year or consecutive years; resulting in widespread devastating socio-economic and environmental impacts. While flood events tend to occur almost during the same period (between October and May; especially in the west PCs), reflecting the relevant patterns in the synoptic conditions leading to the intense precipitation events, their impact is more of local nature and is influenced by the vulnerability of the affected areas created by various human activities. This has serious implications on data and information availability. Compared to drought, information on flood episodes are scarce, and when found, are at best "limited in temporal coverage" and "inhomogeneous" in terms of observed periods and applicable thresholds. On the other hand, a wealth of information exists for drought, but these were scattered throughout many institutions, which necessitated integration between national, regional and scientific works. The result of this extensive search is documented in the chapters below **for all the Partner Countries; except Libya; for which no information was available on-line**.

1.1.1 ALGERIA

Drought Episodes[6]: According to the country's second national communication on climate change to the United Nations Framework Convention on Climate Change (UNFCC), 2010) Algeria has experienced in the past 25 years, a period of intense and persistent droughts, characterized by a significant rainfall deficit, estimated at around 30% across the country, while exceeding 50% in the central and western parts of the country and 30% in the East (Ministère de l'Aménagement du Territoire et de l'environnement (MATE), 2010), resulting in significant impact on water resources and crop yields (Meddi & Meddi, 2009). Review of drought events in three stations in Algeria (Oran, Algiers and Annaba) during the period of 1930-1995, clearly shows that the **drought has significantly increased both in terms of frequency and duration (Table 2)**.

Table 2: Dry and very dry years in Oran, Algiers and Annaba Stations

Station	1930-40	1940-50	1950-60	1960-70	1970-80	1980-90	1990-95
Oran (North West of Algeria)	none	1941-44 [7] - 45-47	1959	1961-1966	1970-1978	1981-83-85-88-89	1994
Algiers	Not known before 1937	1941-1945	none	1961	1977	1981-83-87-89	1990-91-93-94

[6] Having witnessed numerous droughts of variable severity, all the analysis available on-line for Algeria are for the north western part of the country.

[7] It is not clear in the original document whether the dash "-" refers to comma, or a separator between the beginning and the end of the drought.

Station	1930-40	1940-50	1950-60	1960-70	1970-80	1980-90	1990-95
Annaba (North East of Algeria)	Not known	Not known before 1945	none	1960-61-66- 68	1970-74-75	none	1994

Source: (MATE, 2001)

The test on sequential patterns of rainfall in the western part of the country during the past century, indicated the existence of three major trends; an increase in rainfall since 1945 which followed a relatively dry phase, and a decrease in rainfall from 1975 (Meddi and Meddi, 2013). According to Meddi and Meddi (2013), a reduction in rainfall of 20% has been observed in the plain of Mitidja (located in the central north) and over 25 % in the plain of Ghriss West (about 100 Km South east of Oran located in the western part of the Northern coast). The study of persistent drought , using Markov chain (1930-2003) made by the same authors in 2009, to study the dependence of inter-annual rainfall at different scales, shows that **within the area of their study -involving seven Algerian Planes** known for their agricultural production and their economic contribution (Mitidja and Maghnia planes in the extreme west of Algeria, the upper, mid and lower Chelif, Habra Sig, and Ghriss, planes), the **probability of occurrence of a non-dry year after a dry year, is more likely in the central than in the western plains, while the likelihood of occurrence of two successive dry years is higher in the western plains of the country than at the Centre**. The study also assessed the dependence of inter-annual rainfall at the seasonal level, which includes a high level of detail beyond the scope of this assessment.

Flood Episodes in Algeria are as devastating as droughts (MATE, 2010). Floods affect the entire country repeatedly; and can occur during any year or month but predominantly from autumn to spring (MATE, 2001). Figure 1 shows the areas that are potentially affected by floods in Algeria which occur after heavy storms and torrential rains, especially in the eastern part of the country and also in wet lands in the north and the south, as represented by the concentrations of the blue spots in Figure 1. According to the census conducted by the Civil Protection Services, **one in every three communities (out of the 485 in the country) is likely to be flooded in part or whole**. The inventory of floods across the country for the period 1969-2008 indicates that these events are unpredictable in time and space. Also, it appears that large floods caused by extreme generalized rainfall affecting large watersheds and several regions can sometimes reach the size of a national disaster (Ministère de L'intérieure et des Collectivités Locales (MICL), unknown date).

Analysis of the Dartmouth Flood Observatory (DFO)[8] on flood events, between 1985 and 2009 **(See Annex 1-Algeria)** indicates that **most of the flood events occurred in Northern Algeria**, particularly in central and north eastern regions (also confirmed by flood risk maps of the "Prevention, Preparedness and Response to Natural and Man-made Disasters (PPRD) South Programme for the period 1990-2009)[9].Other events recorded, however to a lesser degree, were in north western provinces and least incidents were recorded in south of Algeria. **Annex 1-Algeria** also shows the **trend of flood events increasing across the three decades (1985-2009)**. Herein, the **flood events in 2001-2009 represent 67% of the total events occurring in the past three decades** (18 events from 27).

[8] http://www.dartmouth.edu/~floods/Archives/index.html

[9] http://www.euromedcp.eu/index.php?option=com_content&view=article&id=721&Itemid=1070&lang=en

Table 3 which clusters the flood events in Algeria by severity and magnitude, indicates that **the most frequent flood event were of severity type 1 (S1[10]), and magnitude[11]M>4**, representing 85% of total events occurring across the three decades. Nevertheless, records also indicate an increase of flood events in both groups: S1, M>6 and S2[12], M>6, in the last decade (from zero to 11% and 6%; respectively). Speculations could be raised with regards to an increase in the severity and intensity of flood events between 2001 and 2009.

Potential Linkage to Climate change: Analysis of the evolution of the climate during the periods 1931-1960 and 1961-1990 made for the three major geographical regions in Algeria: West, Central and East shows that, between the periods 1931-1960 and 1961-1990 there was an increase in temperature in the order of 0.5°C, resulting in increased potential evapotranspiration, while rainfall has decreased on average by 10% (MATE 2001). These results are consistent with the results of other work carried out in Algeria and in the Mediterranean region (MATE 2001). Despite the decline in rainfall and a marked increase in the frequency of droughts and floods, the frequency of autumn, spring and summer rain storms increased causing catastrophic floods (MATE 2010).

Figure 1: Potentially flood affected areas in Algeria

Source: Natural Hazard Risk Management Algeria[13]

Table 3: Percentage of flood events in Algeria by severity and magnitude (1985-2009)

Type of Flood	1985-90	1991-2000	2001-09	% of Total Events
S1, M>4	100%	100%	78%	85%
S1, M>6	0%	0%	11%	**7%**
S1.5[14], M<4	0%	0%	6%	**4%**

[10]S1 = Class 1; representing large flood events with significant damage to structures or agriculture; fatalities; and/or with a return period of 10-20 years.

[11] Magnitude is expressed in the logarithm of the "Duration X Severity X the Affected Area (in square km)"

[12]S2=Class 2; representing extreme events: with an estimated recurrence interval greater than 100 years

[13] Available at: http://info.worldbank.org/etools/docs/library/114813/bestcourse/docs/Course%20Projects/Best%20End%20of%20Course%20Projects/SVETLANA/Ousalem%20-%20final%20project.pdf

Type of Flood	1985-90	1991-2000	2001-09	% of Total Events
S2, M>6	0%	0%	6%	**4%**
Total No. of Events (27)	**100%**	**100%**	**100%**	**100%**

Source: Author; based on the analysis of the flood records provided by DFO for Algeria (1985-2009)

1.1.2 EGYPT

Drought Episodes: The **only region in Egypt where rain-fed agriculture is practiced is the coastal area in the North-west of the country.** For this area, the SPI calculations undertaken for data sets extending between 1901-2007 indicates widespread droughts for the years 1962, 1963, 1970, 1971, 1981, 1999, and 2001. However, only sections of the north-west coast were drought affected in 1968, 1983, 1984, 1986, 2004, and 2007. **The most severe drought during the last fifty years of the total period examined by the authors was that of 1999** (Göbel and De Pauw, 2010).

In the absence of appreciable rainfall and significant rainfed agriculture, Egypt's vulnerability to droughts and floods was historically related to the Nile River flows, which rely on runoff from the Nile's headwaters in the Ethiopian and Equatorial Highlands several thousands of kilometres south (United Nations Environment Program (UNEP), 2010) and provides more than 95% of the country's water resources (Attia, unknown date). Until the construction of the Aswan Dam between 1960 and 1970, the Nile River flooded every year during late summer, when water flowed down the valley from its East African drainage basin; wiping during high water years, the whole crops in the Nile floodplains and delta. While during low-water years widespread drought and famine occasionally occurred[15].

Despite the aridity of the country, characterised with very low, unpredictable and irregular rainfall – with an annual average of 51 mm (Attia, unknown date), **Egypt scores high on Storage–Drought Deficit Index**[16] (Eriyagama et al., 2009). The construction of **Aswan High Dam** between 1960 and 1970 has as such contributed to the reduction of Egypt's vulnerability to both drought and floods and has protected it from the droughts in 1972–1973 and 1983–1987 that devastated East and West Africa[17]. However studies show that the Nile flow is very sensitive to temperature and precipitation changes due to its low runoff/rainfall ratio of 4% (Intergovernmental Panel on Climate Change (IPCC), 1998). Furthermore, **analysis of time series rainfall and river flow records during the 20th century reveals high levels of inter-annual and inter-decadal variability in the Nile flows**. The variability is experienced locally in the headwater (humid Ethiopian and East African highlands) regions of the Nile, and regionally; through its effects on downstream in Sudan and Egypt. **The effects of this variability are manifested through exposure of Egypt and Sudan to inter-annual and inter-decadal variability in the flows of the Nile River** (UNEP, 2010), as demonstrated by the prolonged drought episodes between 1979 and 1987 reported by IPCC, 1998. This had forced Egypt to severely cut down on its water use and consumption, as the upstream buffer of the Lake Nasser Reservoir (behind the High Aswan Dam) suffered from diminishing headwater inflow. In the 1990s, Egypt responded to high Nile flows through policies that led to expansion of irrigation. This expansion has in turn increased the exposure and sensitivity of Egypt's agricultural sector to climate induced fluctuations in

[14] S1.5 = Class 1.5; represents very large events: greater than 20 years but less than 100 year recurrence interval, and/or a local recurrence interval of 10-20 years.

[15] http://en.wikipedia.org/wiki/Aswan_Dam#Irrigation_scheme

[16] This is an indicator of how much of the annual (hydrological) drought deficit (relative to long-term mean) is satisfied by the existing storage capacity in a county.

[17] http://en.wikipedia.org/wiki/Aswan_Dam#Irrigation_scheme

Nile flows in the recent decades (UNEP 2010). However, **Egypt's population vulnerability to agricultural drought hazard remains low; in the order of 25.6% (United Nations International Strategy for Disaster Reduction (UNISDR), 2013)**; Figure 8.

Flood Episodes: Natural hazards in Egypt also include flash floods which occur due to heavy storms that last for a short-period and occur in the Red Sea area and Southern Sinai. Several flood incidences were reported' in Egypt's National Report and information on Disaster Reduction, presented to the World Conference on Disaster Reduction in 2005, which resulted in severe damages (Government of Egypt, 2005).However, **the information on these incidences does not provide the basis for statistical analysis of their frequency, magnitude or the areas that are most hit by floods**. On the other hand, **review of the DFO records shows that most of the flood events recorded between 1991[18] and 2009 for Egypt**, as indicated in (Annex 1-Egypt), **were in the south of the country, particularly in the southeast areas and the southern part of Sinai** while the least recorded flood events were in Northeast Egypt.

The trend of flood events shows a reduction in recorded events across time (1991-2009). Herein, events were highest in years 1991 to 2000, followed by a sharp decline of recorded events in the last decade (2000-2009) which represented only 25% of total events (2 of 8**). No conclusive remarks can be made however on the general trend, as the records do not offer confidence with respect to their completeness.**

Table 4 shows that the **most frequent flood events recorded for Egypt by DFO fall under group S1 and M>4, representing the dominant 38% of total events occurring across the two decades**. The lack of flood event records in the Flood Observatory between 1985 and 1990 is not completely clear. However, it does not necessarily suggest non-occurrence of events, but could indicate, absence of records or purposely overlooked insignificant events.

Table 4: Percentage of flood events in Egypt by severity and magnitude (1985-2009)

Type of Flood	1985-90[19]	1991-2000	2001-09	% of Total Events
S1, M<4	0%	17%	50%	**25%**
S1, M>4	0%	50%	0%	**38%**
S1, M>6	0%	17%	0%	**13%**
S1.5, M<4	0%	0%	0%	**0%**
S1.5, M>4	0%	17%	50%	**25%**
Total No. of Events (8)	**0%**	**100%**	**100%**	**100%**

Source: Author; based on the analysis of the flood records provided by DFO for Egypt

Potential Linkage to Climate change: According to the second national communication report (SNCR) to the United Nation Frame work for Climate Change(UNFCCC), 2010, Egypt recently has been suffering from an increased severity and frequency of sand storms, dense haze and flooding (Egyptian Environmental Affairs Agency(EEAA), 2010). Based on the meteorological data of 32 stations distributed all over Egypt, **the severity of extreme weather events in Egypt during the last three decades (1973-2002) has significantly increased and become more frequent.** These extreme

[18]It is not clear if the records between 1985 and 1990 are missing because of incomplete records or due to absence of floods during that period. However the former was assumed in the analysis.

[19]See note 19.

events have had negative socio-economic impacts on almost all sectors such as health, agriculture, livestock, environment, and tourism. In addition, **the Mediterranean coast of Egypt experienced successive increases in the amount of annual rainfall during the same three decades; with a mean trend over the area being in the order of + 0.76 mm per year** (EEAA, 2010).

On the national level, a general decrease in annual SPI per decade and precipitation can be observed between 1901 and 2007 **(See tables 5)** but the **absolute decrease has been very small due to the very low levels of precipitation in the desert areas** (Göbel and De Pauw, 2010), as per **table 5**.

Table5: Drought and Precipitation Trends 1901 to 2007 in Egypt

Change of annual SPI per decade			change of annual precipitation per decade					
			Absolute change			Relative change		
Index points	% of total Area		mm / decade	% of total Area		% / decade	% of total Area	
	> 50 mm	< 50 mm		> 50 mm	< 50 mm		> 50 mm	< 50 mm
0.00 to -0.05	52%	2%	0 to -5	88%	92%	0 to -5	80%	5%
-0.05 to -0.10	35%	7%	-5 to -10	9%	8%	-5 to -10	15%	7%
-0.10 to -0.15	8%	34%	-10 to -15	3%	0%	-10 to -15	4%	10%
-0.15 to -0.20	4%	49%	-15 to -20	0%	0%	Over -15	1%	78%
-0.2 to -0.25	1%	8%	-20to -25	0%	0%			

Source: Adapted from Göbel, and De Pauw (2010)

1.1.3 ISRAEL

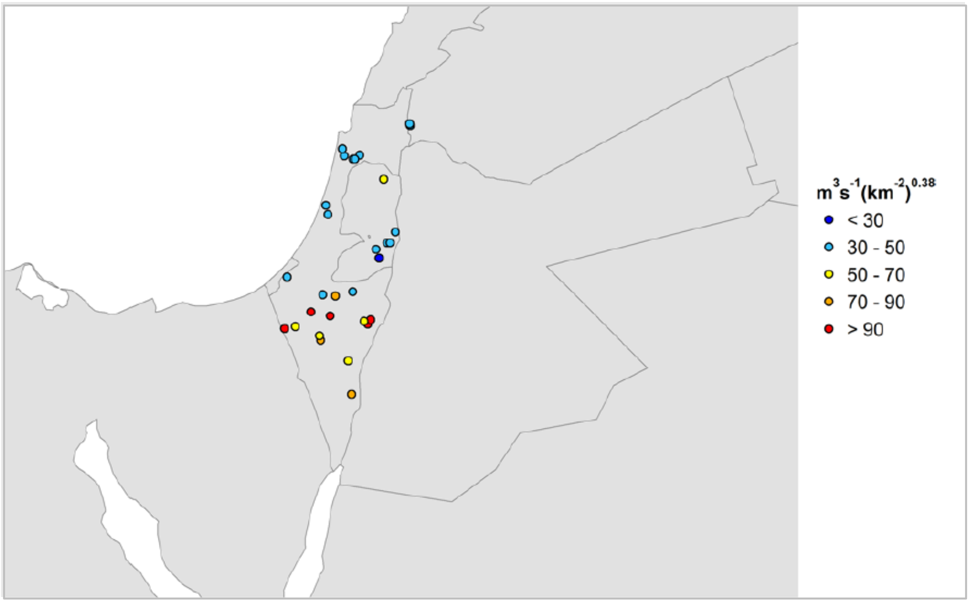
Drought Episodes: According to Zaide M., (unknown date), eight drought periods were recorded since 1915, including several multi-year cycles of drought which occurred during the mid-1990s and developed into a severe crisis; jeopardizing the adequate supply of domestic water. **One of the worst drought in Israel was recorded in 1998/99 which was followed by less than average rainfall until 2002**, leading to a shortfall of about half a billion cubic meters in Israel's water balance each year, in comparison to an average year (Wikipedia, 2014)[20]. Haarezt Newspaper indicated that the **winter of 2010 was also part of a continuing, six-year period of drought (2005-2010),** corresponding to the longest and most severe drought period recorded since the 1920s (Haarezt, June, 22, 2010)[21]. The drought was later reported to continue for the eighth year at the end of 2011 (Arutz Sheva of 1/2/ 2012[22] . According to water authority data, only 80-85% of the mean annual precipitation had been recorded in 2009 in the Lake Tiberias in the Northern part of the country following a reduction in annual precipitation recorded for the previous five years. Accordingly, a state of drought was formally declared for large parts of the arid South[23] which receives Tiberia's water through Israel's National Water Carrier. **No further records of these events or literature were found to enable analysis of the frequency, and severity or spatial extent of droughts in Israel**.

[20] http://en.wikipedia.org/wiki/Water_supply_and_sanitation_in_Israel
[21] http://www.haaretz.com/print-edition/news/despite-winter-rainfall-drought-prevails-1.297542
[22] http://www.israelnationalnews.com/News/News.aspx/151330
[23] http://www.irinnews.org/report/84715/israel-drought-declared-as-five-dry-winters-take-their-toll- (Sep 10 2013).

Flood Episodes: Several studies have proven that **floods are more intense and frequent in the more arid part of the country**. According to Tarolli P. et al (2012), the spatial distribution of floods **(figure 2)** shows that the high intensity events tend to cluster in the semi-arid and arid regions in the southern portion of Israel indicating the potential to produce higher specific peak discharges compared to the Mediterranean part of the country, where extreme floods tend to occur in the autumn and winter seasons (October–February) with some events also occurring in spring (March–May).

The **only readily available inventory of floods that occurred in Israel is provided by DFO for the period 1991 - 2009**[24] **(Annex 1-Israel).** The recorded events indicate that most flood events occurred in the Northern areas of Israel, while the northwest areas witnessed the highest flood events, and, to a lesser extent, the northeast areas. Findings indicate fewer flood events in the south, southwest, and central regions. **This is however, not in line with the findings by Tarolli P. et al. (2012), which suggests incomplete DFO records.**

Figure 2: Atlas of peak discharges of extreme flash floods in the Eastern Region of the Mediterranean (Israel).



Source: Tarolli (2012)

Table 6 summarizes the flood events by severity and magnitude. Out of the total of ten flood events recorded by DFO during twenty years, six took place during the last decade (2001-09). The **most frequent flood events are of S1 and M<4, representing 40% of the total events occurring across the two decades**. Despite the predominance of flood events with the lowest severity and magnitude (S1 and M<4) between 2001 and 2009, records also indicate the occurrence of flood events within the S2 and M>4 group during the same decade; indicating more intensified flood events compared to the preceding decade.

[24] It is not clear if the records between 1985 and 1990 are missing because of incomplete records, or due to absence of floods during that period. However the former was assumed in the analysis.

Table 6: Percentage of flood events by severity and magnitude in Israel.

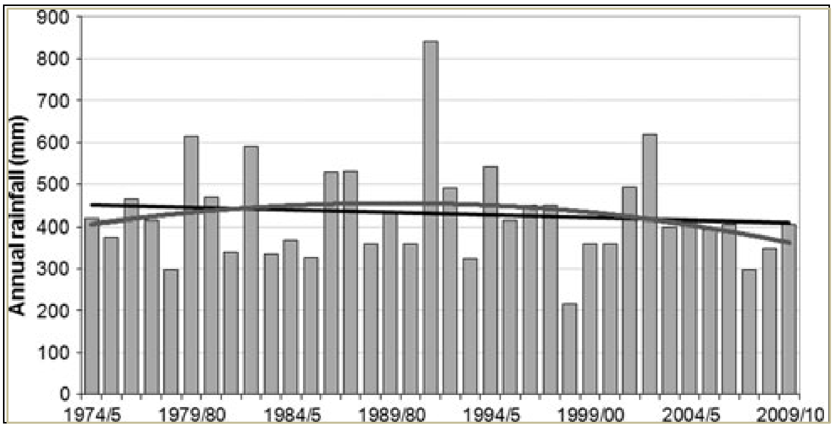
Type of Flood	1985-90[25]	1991-2000	2001-09	Total Events
S1, M<4	0%	20%	60%	40%
S1, M>4	0%	40%	20%	**30%**
S1.5, M>4	0%	40%	0%	**20%**
S2, M>4	0%	0%	20%	**10%**
Total No. of Events (10)	**0%**	**100%**	**100%**	**100%**

Source: Author; based on the analysis of the flood records provided by DFO for Israel

Potential Linkage to Climate change: Results of the analysis made by Ziv et al (2013) of the **trends in rainfall regime** (1975–2010), showed **negative trend over most of Israel (Figure 3)**, which is **statistically significant in the super-arid region**, **while the decrease in rainfall is only significant over most of Israel in the spring, reflecting a shortening of the rainy season, (3 days/decade).** The results also showed longer dry spells significantly in most of the examined stations. In addition, an increase in rainfall toward the 1990s was distinguished, which was followed by a decrease, at a higher rate, towards the end of the study period. This is respectively accompanied with a **southward and northward shift of the 200 mm isohyte; representing the border between the semi -arid and arid regions of the country** (Ziv et al., 2013).

According to Israel's Second National Communication on Climate Change, **an increase incidence of major flood events was observed in recent years, which may be attributed to Climate change** (Ministry of Environmental Protection (MEP), 2010).

Figure 3: Inter-annual variations of the annual rainfall averaged over Israel with rainfall >100 mm, together with the linear trend (black) and the polynomial curve (third-order, gray solid) for the study period (1975–2010).



Source: Ziv et el. (2013).

1.1.4 JORDAN

Drought Episodes: Analysis of 50 years data for the hydrological years "1961/62-2010/11" provided by the Ministry of Water and Irrigation (MWI), 2013 on the national scale, indicate that during the said period, the **probability of occurrence of drought years in Jordan, regardless of its severity, is 52% (compared to 46.6% between 1937/38 and 2010/11**. **While the probability for an extreme and mild drought is equal (14%; each). Moderate droughts occur at 8% probability, while severe drought is at 16%. Out of the seven extreme droughts that occurred during the past 50 years, five**

[25] See footnote above (No. 24)

of them occurred between 1980/81 and 2010/11; i.e. a probability of about 16.7% during thirty years, compared with 14% during 50 years (Table 7).

The above is also confirmed in the Climate and Drought Atlas for parts of the Near East by Göbel and De Pauw (2010). Based on the Standard Precipitation Index (SPI) for the assessment of meteorological drought in Jordan (1901-2007), the country was severely drought affected in 1962, 1973 (except for the Northwest), 1976, 1978, 1981, 1993, 1995, and 1999. While, two thirds of the most severe and widespread droughts happened during the second half of the 20th century.

Table 7: Frequency and severity of droughts in Jordan (1961/62-2010/11)

	Mild Drought	Moderate Drought	Severe Drought	Extreme Drought
Probability	14%	8%	16%	14%
Return Period (Years)	7	12	6	7
Years	1961/62, 1975/76, 1986/87, 1989/90, 2000/01, 2001/02, 2006/07	1965/66 1984/85 2003/04 2010/11	1976/77, 1977/78, 1978/79, 1985/86, 1992/93, 1995/96, 2005/06, 2008/09	1962/63, 1972/73, 1981/82, 1983/84, 1998/99, 1999/00, 2007/08

Source: Based on analysis of rainfall data provided by MWI (2013).

Flood Episodes: Jordan had witnessed recently a sharp increase in flood severity and frequency of occurrence. Generally, floods occur on a seasonal basis in some areas at either the beginning or end of the rainy season. **Floods and flash floods** remain the main cause of death due to natural disasters in the country; **representing around 53% of disaster-related mortality between 1980 and 2012** and producing losses in properties, and destruction of infrastructure[26] .

The **flood events recorded by the Dartmouth Flood Observatory for Jordan, were limited to the period 1991-2000** (Annex 1-Jordan) with most of the flood eventsreported by DFO during that decade located in the northwest and, to a lesser extent, southern areas. Similar to Egypt and Israel, the absence of records between 1985 and 1990 and in the specific case of Jordan between 2001 and 2009,does not necessarily suggest non-occurrence of events, especially when considering other information sources for Jordan which refer to events that are of severity class between 1 and 1.5 (the case of Wadi (W.) Yutum floods in 2006; see table 10).

Table 8 classifies **the most frequent flood event during the recorded period; with group S1 and M>4, representing a dominant 43% of total events**.

Table 8: Percentage of flood events by severity and magnitude in Jordan

Type of Flood	1985-90[27]	1991-2000	2001-09[21]	Total Events
S1, M<4	0%	29%	0%	**29%**
S1, M>4	0%	43%	0%	**43%**
S1.5, M>4	0%	29%	0%	**29%**

[26]http://www.desinventar.net/DesInventar/profiletab.jsp?countrycode=jo

[27] Not recorded

Type of Flood	1985-90[27]	1991-2000	2001-09[21]	Total Events
Total No. of Events (7)	**0%**	**100%**	**0%**	**100%**

Source: Author; based on the analysis of the flood records provided by DFO for Jordan

Two of the most extreme flood events that occurred in the country was in 1991, which hit the ancient city of Petra in addition to Ma'an, Tafila, and Karak - all in the **southern part of Jordan; the part most targeted by floods of different levels of severity**. **Table 9 lists those floods that took place during the past fifty years** which were compiled from different sources. **However, this information still falls short of providing the characteristics of the various flood events**.

Potential Linkage to Climate change: Analysis of meteorological data of 19 stations throughout the country for the period 1961-2005 shows **decreasing trends in the annual precipitation by 5-20% in the majority of the country's stations while very few stations in the extreme east and in the northwest showed increased annual rainfall by 5-10%** (Ministry of Environment (MOE-JO, 2009). Larger rainfalls associated with a decrease in the number of rainy days in these stations may lead to an increase in the daily rainfall intensity and, thus, an increase in the chance of recording extreme precipitation. On the other hand, Göbel, and De Pauw (2010) indicated that **over the last century Jordan faced negative trends of annual precipitation, with about 58% of the area witnessing an absolute drop in annual precipitation of 15-20 mm per decade** (Göbel and De Pauw, 2010**). See also table10.** The global climate change is also expected to be translated in the country with decreased precipitation and less availability of water to recharge aquifers and feed surface runoff (Economic & Social Commission for Western Asia (ESCWA), 2005).

Table 9: Flood events in Jordan (1963-2013)

Year	Region	Flood Flow and/or return period	Casualties[28]
1963	Floods in Amman (north centre) and W. Musa (Petra touristic city in the south)	100-year return period, Water depth about 10 m in some areas of the Siq passage (according to eye witness) **(Severity class according to DFO criteria is between 1.5 and 2)**	8 dead
1966	Ma'an (south)		95 dead, 86 injured, & 7 missing
1966	Ma'in (Centre)		295 dead & 92 injured.
1987	Zarqa City (Centre)		9 dead & 29 injuries.
1991	Ma'an, Tafila, and Karak (south)		8 dead & 18,000 affected
	Petra (south)		
Jan-95	Petra (south)		
Nov-96	Petra (south)		
2006	W. Yutum part of Aqaba district (south)	550 CMS **(return period between 10 and 40 years i.e. Severity class of 1 to 1.5 according to DFO criteria)**	6 dead

[28] When an event is cited in more than one reference, the number of casualties is adopted from the more official source.

Year	Region	Flood Flow and/or return period	Casualties[28]
2006	W. Ouhadah west of Ma'an city (south)	320 CMS	2 dead
2007	Ma'in (Centre) - the waterfall and the hot springs		2 dead & 3 injuries
2012	Wadi T (Um Nseileh), and the coastal wadis of Shallaleh, and Jeyshiyeh in Aqaba city (south)		2 dead
2012/13	General floods in the country (Mafraq (east), Zarqa, Amman, Yarmouk river (North), Jordan Rift Valley (East), Ma'an and Aqaba (South)		9 dead, 2 lost and 4 injuries,

Source: Compiled from different sources (Al-Weshah and El-Khoury, 1999; USAID, 2011; Al-Quda, 2011; [29], [30]).

Table10: Drought and Precipitation Trends 1901 to 2007 in Jordan

Change of annual SPI per decade		change of annual precipitation per decade			
		Absolute change		Relative change	
Index points	% of total Area	(mm / decade)	% of total Area	% / decade	% of total Area
0.00 to -0.05	2%	0 to -5	1%	0 to -5	14%
-0.05 to -0.10	10%	-5 to -10	8%	-5 to -10	15%
-0.10 to -0.15	15%	-10 to -15	21%	-10 to -15	41%
-0.15 to -0.20	40%	-15 to -20	58%	Over -15	30%
-0.2 to -0.25	33%	-20to -25	12%		

Source: Adapted from Göbel, and De Pauw (2010)

Further information on drought and flood episodes during the past decade (i.e. 2000/01-2010/11) is provided in the Chapter 1.2 and Chapter 1.3 – The Case Study of Jordan

1.1.5 LEBANON

Drought Episodes: Analysis of countrywide annual rainfall data available in Shaban (2009) reveals that between 1967 and 2005, Lebanon witnessed mild to moderate drought[31] with a respective return period of 1 in 3 and 1 in 8 years. Hence, **the probability that a drought of a mild or moderate severity occurs during the study period is about 1 every 2 years (46%).** However, **when considering that most of the mentioned droughts occurred between 1980 and 2005 (18 droughts during 26 years), this frequency increases to almost 70%.** This is also evidenced by the decreasing trend in

[29] http://www.trust.org/item/?map=jordan-readies-its-first-policy-on-climate-change
[30] http://www.disaster-report.com/2013/02/recent-natural-disasters-list-february-2.html
[31] Severity of drought is expressed in precipitation deficiency. It refers to the per cent of normal (average) precipitation for the country for the period 1967-2005); whereby extreme drought refers to precipitation <70% of normal, severe: precipitation between
70% and 80% of normal, moderate: precipitation between 80% and 90% of normal, mild: between 90% and 100% of normal precipitation.

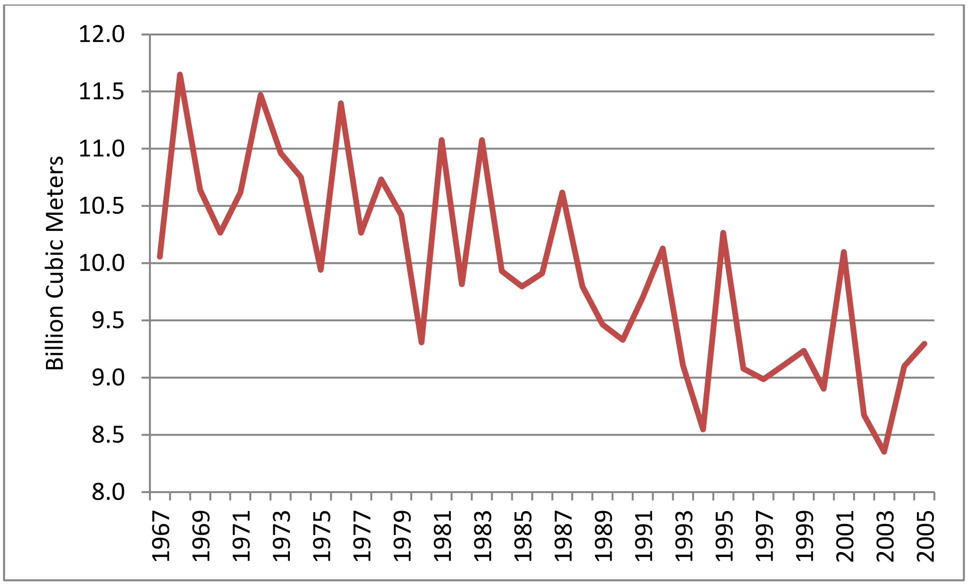
rainfall, country wide **(see figure 4)**. According to Göbel, and De Pauw (2010), unusual dry years between 1957 and until 2007 were witnessed in 1958, 1959, 1960, 1972, 1973, 1989, 1990, 1995, and 1999 with nearly all the wettest years falling into the first half of the century, while **most of the droughts happened during the second half**.

According to Erian (2011), **17.13% of Lebanon's total area** of 10,400 km^2 is **subject to high agriculture drought risk**, while the percentage areas that are subject to moderate and low risk is 25.67% and 16.45%; respectively, with the remaining 40.775% being at no risk **(Figure 9)**. **Agricultural drought also affects 88.4% of the Lebanese population**; estimated at 4.14 million, of which 14.9% are highly affected, while 23.7 are moderately affected, with the remaining 49.8% being slightly affected **(Figure 8)**.

Flood Episodes: Lebanon faced many flood events of intense rainfall with relatively short duration during the last 40 years. The **incidences of flood events were observed to increase in frequency and magnitude and in time scale, with landslides becoming more severe.** **Table 11** shows that major floods and landslides have increased significantly between 1971 and 2003 (Abdallah, 2007).

Most of the floods recorded by the DFO, between years 1985 and 2009 **(Annex 1-Lebanon)**, **were mainly located in the northeast areas** and, to a lesser degree, central west areas of Lebanon, with **the flood events recorded in the latter decade being within group S1 and M<4**, and **representing 50% of the total events recorded during the reported period**. It is important to point out that **the low records does not necessarily suggest non-occurrence of events, but could indicate, absence of records or insignificant events, which makes deciding about the changes in the severity of events inconclusive**(**table 12**).

Figure 4: Annual Rainfall in Lebanon (1967-2005) in Billion Cubic Meters (BCM)



Source: Based on data available in Shaban (2009) (Table 3, Page 1881)

Table 11: Number of flood and land slide events in Lebanon (1971-2003)

Month	1971-1981		1982-1992		1993-2003	
	F[32]	L[33]	F	L	F	L
November (N)			2			2
December (D)	1		3	2	3	3
January (J)	4	1	2	1	2	2
February (F)	3		5		3	2
March (M)	2		3	2	6	3
Total	**10**	**1**	**15**	**5**	**16**	**12**

Source: Abdallah, 2007

Table 12: Percentage of flood events by severity and magnitude in Lebanon

Type of Flood	1985-90	1991-2000	2001-09	Total Events
S1, M<4	0%	0%	100%	**50%**
S1, M>4	0%	100%	0%	**25%**
S2, M<4	100%	0%	0%	**25%**
Total No. of Events (4)	**100%**	**100%**	**100%**	**100%**

Source: Author; based on the analysis of the flood records provided by DFO for Lebanon (1985-2009)

Potential Linkage to Climate Change: According to Lebanon's SNCR to the UNFCCC in 2011, **the long-term daily meteorological records for Beirut** for the period 1980 to 2000 **revealed significant warming,** whereby both the number of hot "summer days", and "tropical nights" exhibited a clear upward trend. In addition, the absolute extreme of the maximum temperature within a year increased sharply between 1981 and 2000, while the **precipitation-related indices indicated an overall decrease in total annual rainfall**. In addition, a decrease in the amount of rain falling in a 5-days period and a large increase in the Consecutive Dry Days, were reported, while a simple measure of the daily intensity of rainfall showed no change (MOE-LB, 2011). However, **Shaban (2011) indicated that no considerable changes in trends of rainfall were observed in the country**, but there is **an increase in temperature, which enhances snow-melting** and reduces its spatial cover. The **trends of rainfall between 1967 and 2009 revealed a relatively small decline in rainfall amount, but not as much as it were figured out by several studies**, with the decline range falling within a limit of less than 50 mm. Translated to mm/decade (about 11mm/decade), this seems to be **consistent with the findings of Göbel, and De Pauw (2010).** According to the latter, about 80% of the country is subject to an absolute change in annual precipitation trends per decade of -10 to -15 mm/decade **(See table 13).**

Table 13: Drought and Precipitation Trends 1901 to 2007 in Lebanon

Change of annual SPI per decade		change of annual precipitation per decade			
		Absolute change		Relative change	
Index points	% of total Area	(mm / decade)	% of total Area	% / decade	% of total Area
0.00 to - 0.05	3%	**0 to -5**	0%	**0 to -5**	100%
-0.05 to -	96%	**-5 to -10**	15%	**-5 to -10**	0%

[32] F = Number of floods
[33] L is number of landslides

0.10					
-0.10 to -0.15	1%	-10 to -15	80%	-10 to -15	0%
-0.15 to -0.20	0%	-15 to -20	5%	Over -15	0%
-0.2 to -0.25	0%	-20to -25	0%		

Source: Adapted from Göbel, and De Pauw (2010

1.1.6 MOROCCO

Drought Episodes: An investigation by Chbouki (1992)[34] identified since 1896, twelve main very dry periods that were generalized in the major parts of the country and had moderate to strong intensities. Those which are relevant to the study period are: 1960-61; 1974-75; 1981-84; 1986-87; 1991-93; 1994-1995 and 1999-2003. The other, less generalized ones during the past fifty years are 1965-67 and 1972-73. However, from the agriculture point of view, the agricultural seasons of 1982-83, 1994-95 and 1999-2000 were among the driest years. **Statistical analysis of historical rainfall records** (1961-2004) made by Stour and Agoumi (2009) for seven stations; representing the majority of climatic zones in Morocco **showed an increase in the droughts frequency, severity and spatial distribution**. The cities that are **mostly hit by drought** of various severities are Oujda; with estimated drought frequency of 46%, followed by Agadir, Marrakesh and Rabat at 43% **(Table 14)**. The most persistent drought in Morocco occurred during the last twenty years of the study period (1961-2004), consisting of 3-5 years of consecutive droughts, compared to isolated droughts between the 1960's and the 1970's. Stour and Agoumi (2009) distinguished between two periods; before and after 1972. During the latter period, Morocco increasingly witnessed droughts that often affected the majorities of the region, whereby, **during the last twelve years of the study period, the country witnessed ten years of partial droughts of which two were general (affecting the seven regions)**.

Table 14: Frequency of dry, normal and humid years in seven cities; representing the main climatic zones in Morocco (1961-2004)

City	Location	Frequency of Dry Years	Frequency of normal Years	Frequency of wet Years
Agadir	South West	43%	32%	25%
Casablanca	Central West	39%	34%	27%
Ifrane	Western slope of Middle Atlas	45%	30%	25%
Marrakech	Centre	43%	14%	43%
Oujda	North East	46%	18%	36%
Rabat	North West	43%	23%	34%
Tanger	ExtremeNorth West	41%	32%	27%

Source: Stour and Agoumi (2009).

Furthermore, the evolution of the SPI during the period 1961-2004 in the seven cities/regions, indicate that the **most frequent droughts occur during fall and spring**, followed by winter and spring droughts which respectively affect more than 40% and around 29% of the regions. While droughts during fall and winter and that of fall to spring is less common and affect less than 15% of the regions. During the same period, no severe drought event was recorded. However, the results indicated that the **likelihood of occurrence of a moderate drought is one in five years in the case of**

[34]There is doubt about the date of the reference, when considering that the temporal extent of the findings goes beyond the date of publication

Marrakesh compared with one in three years for the rest of the regions (Table 15). The respective likelihood of occurrence of severe drought in Marrakesh is about one in four years, while that in Casablanca and Agadir falls down to almost one in 11 years. Generally speaking, the frequency of occurrence of the drought types decreases with the increase in its severity.

Table 15: Frequency of drought by severity type in seven cities; representing the main climatic zones in Morocco (1961-2004)

City	Frequency of moderate drought	Frequency of severe drought	Frequency of extreme drought
Agadir	34%	9%	0%
Casablanca	30%	9%	0%
Ifrane	34%	11%	0%
Marrakech	20%	23%	0%
Oujda	30%	16%	0%
Rabat	30%	14%	0%
Tanger	30%	11%	0%

Source: Stour and Agoumi (2009).

Flood Episodes: Increasingly important floods, both in terms of intensity and frequency occurred during the past 15 years, in the form of flash floods or massive floods hitting different parts of the country; causing very significant casualties and economic damage (Ministère de l'Aménagement du Territoire, de l'Urbanisme, de l'Habitat, et de l'Environnement (MEMEE), unknown date). Review of the **DFO** records for the period between 1991[35] and 2009 **(Annex 1-Morocco)**, indicate that **for the recorded events, the floods were mainly located in the north east, north central**, and to a lesser degree, in the northwest and southwest of Morocco. An increased trend of flood events is noticed during 2001-2009 compared to the preceding decade; with the **highest flood events observed during 2001-2009**, **representing 60% of the total events across the specified period** (9 of 15 events). According to table 16, the **most frequent flood events were of class S1 and M>4, representing the major part (60%) of the total events** occurring across the reference period. Records also indicate more intensified flood events in the last decade, whereby an **increase in flood events within the group S1.5 and S2 of M>6 (from 0 to of 11%), in addition to an increase from 17% to 22% in S1.5 and M>4.**

Table 16: Percentage of flood events by severity and magnitude in Morocco

Type of Flood	1985-90[36]	1991-2000	2001-09	Total Events
S1, M>4	0%	67%	56%	**60%**
S1, M>6	0%	17%	0%	**7%**
S1.5, M>4	0%	17%	22%	**20%**
S1.5, M>6	0%	0%	11%	**7%**
S2, M>6	0%	0%	11%	**7%**
Total No. of Events (15)	**0%**	**100%**	**100%**	**100%**

Source: Author; based on the analysis of the flood records provided by DFO for Morocco

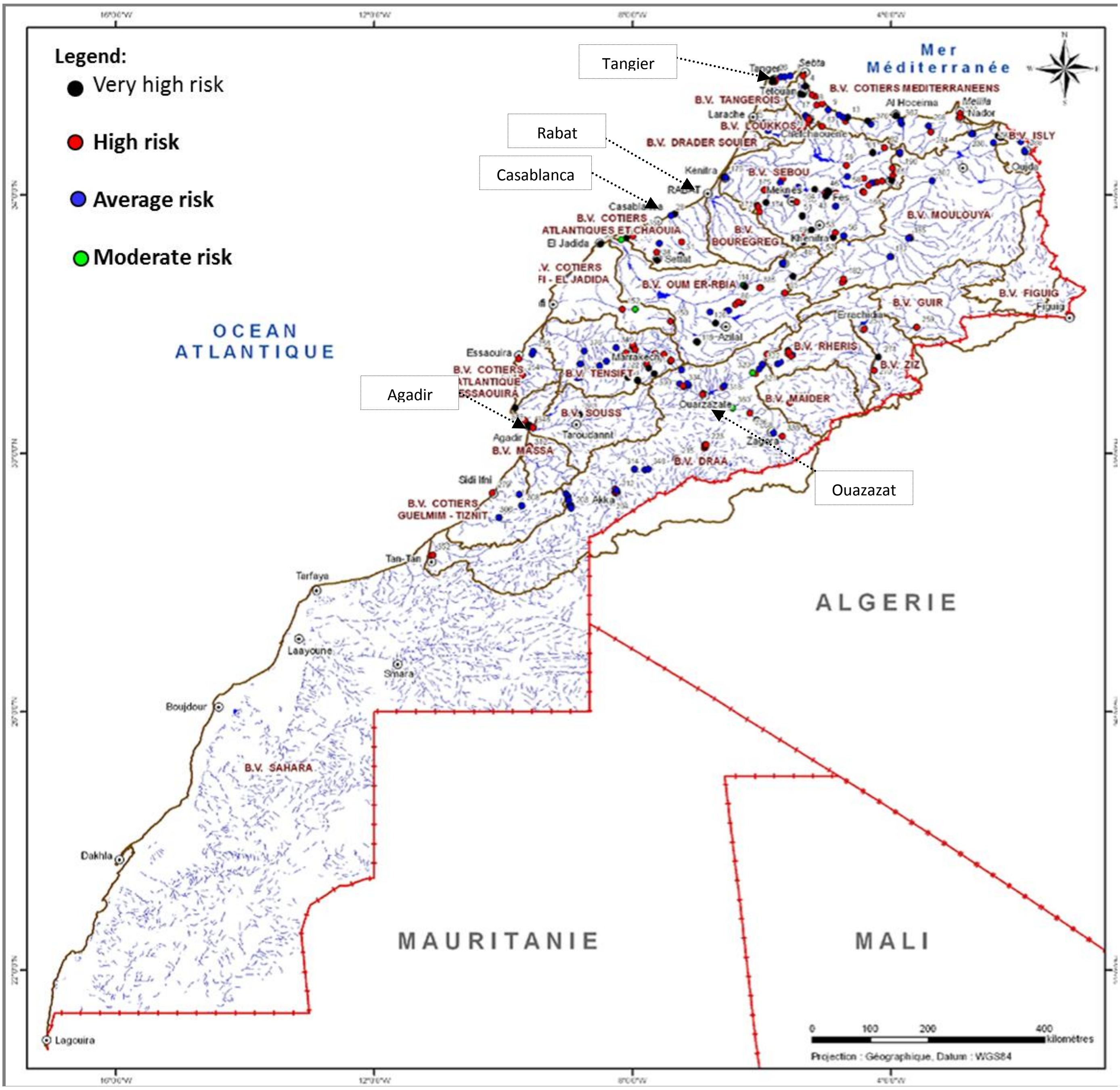
Compared to most of the other partner countries, **Morocco has identified the risk of floods in the country as part of the study undertaken by the MEMEE for the realisation of an information system**

[35] It is not clear if the records between 1985 and 1990 are missing because of incomplete records or due to absence of floods during that period. However the former was assumed in the analysis.
[36] See footnote above (No. 33)

that maps the major risks in Morocco. Accordingly, the types of floods in the country and their characteristics were provided, together with the major flood events during the period 1980-2010. **However** the **information related to the characteristics of these flood events and their return periods were not addressed**. One of the outcomes of the study is a map of the spatial distribution of the risk of inundation in Morocco (Département de l'Environnement, 2008); **see figure 5**. **According to this figure, the three categories of very high, high, and moderate flood risks dominate the central stretch of the country** (from the north at the Mediterranean coast to the south east at the Saharan border) and involve known cities and towns such as Casablanca, Marrakech, Fez, Meknes, Tangier.

Potential Linkage to Climate Change: Climate observations, concerning Morocco, conducted over the last decades attest to the **growth of the semi-arid climate to the northern part of the country** (MEMEE, unknown date). Examination of the last three decades (1970-2000) show revealing signs of climate change, including **increased frequency and intensity of droughts and unusually devastating floods** (MEMEE, 2001). The second national communication of Morocco presented in 2010 has also confirmed this. All General circulation models predict that global warming should continue in this area and even take another dimension in the coming decades (MEMEE, Unknown date).

Figure 5: Risk of inundations in Morocco



Source: Département de l'Environnement (2008).

1.1.7 PALESTINE

<u>Drought Episodes:</u> **Nearly 46 % of the country's area is "highly" and "moderately" affected by droughts** and around 15%is "slightly" affected **(Figure 8)**. Although there are countries with higher percentages of vulnerability, **the drought impact is more devastating in Palestine** due to a very low per capita water availability of 75 l/day in the first place, which makes the effect of any further reduction in the allocations more severe; greatly impacting human health and reducing agricultural production.

Analysis of 30 years of meteorological data by Rabi et al. (2003) indicated that the frequency of occurrence of drought years (annual rainfall depth below the average) does not show any uniform return periods. Within the same period of analysis undertaken by Rabi el al (2003), **the most extreme drought occurred in 1998/99**, with the **annual average rainfall in six stations representing between 32 and 45 % of the long term average**. Moreover, the rainfall during the critical months for agriculture: October and November were less than 16% and 10% respectively of the normal averages; causing enormous losses to the agriculture sector.

Göbel and De Pauw (2010) report that widespread drought occurred in 1962, 1978 and 1981 (except for the North), 1993 (except for the South), 1995, 1998 (except for the North), and 1999, with 1999 being the most extreme droughts. **There are no official records on the spatial distribution of drought**. However, according to the case study for Palestine, there is an extreme variability in the spatial distribution of drought between the west bank and Gaza. More detailed information on drought episodes during the past decade (i.e. 2002-2012) is **provided in Chapter 2.2 – the case study for Palestine**.

Flood Episodes: There is no readily available on-line information on floods during the past decades in Palestine. **Even the records provided by DFO for the country are not complete (Annex 1-Palestine);** involving one single incident of class S1 and M>4; reported for the period 1991-2000. Unavailable data could result from overlooking insignificant events or due to limited access to records. However, **the availability of higher flood records for nearby areas, namely, Jordan, Sinai (Egypt) and Israel, indicates under reporting of flood events in Palestine**. For the list of flood episodes during the past ten years, the reader is referred to **Chapter 2.2 - the case study of Palestine.**

Potential Linkage to Climate Change: The case study of Froukh (2010) indicates a clear decline of the rainfall for the ten years period considered. The same conclusion is supported by Rabi in the case study for Palestine; where the **analysis of rainfall occurrence over the past ten years has shown a downward trend** as reflected in Figure 16. However, **the magnitude and the extent of the drought remain not fully predictable**. Although the work of Rabi covers a short period of time**, other studies covering larger spectrum of time arrived at similar conclusions**. For instance Göbel, and De Pauw (2010) using the SPI and analysing the meteorological records from 1901 to 2007 came to the conclusion that the **SPI has decreased from 0.00 to -0.05 for the 61 % of the West Bank area and from 0.05 to -0.10 for 39% of the West bank area and 100% for the Gaza Strip (See table 17)**. Similar decreasing trends can be observed for the change in the absolute values of the annual precipitation **(table 17)**. Should these conclusions remain valid; the combination of decreasing rainfall and increasing demand originating from the rapid increase in population and the foreseeable increase of living standards will render satisfying the demand even more problematic.

Table17: Drought and Precipitation Trends 1901 to 2007 in Palestine

Change of annual SPI per decade			change of annual precipitation per decade					
			Absolute change			Relative change		
Index points	% of total Area		mm / decade	% of total Area		% / decade	% of total Area	
	West Bank	Gaza		West Bank	Gaza		West Bank	Gaza
0.00 to - 0.05	61%	0%	0 to -5	32%	0%	0 to -5	100%	100%
-0.05 to -	39%	100%	-5 to -10	65%	100%	-5 to -10	0%	0%

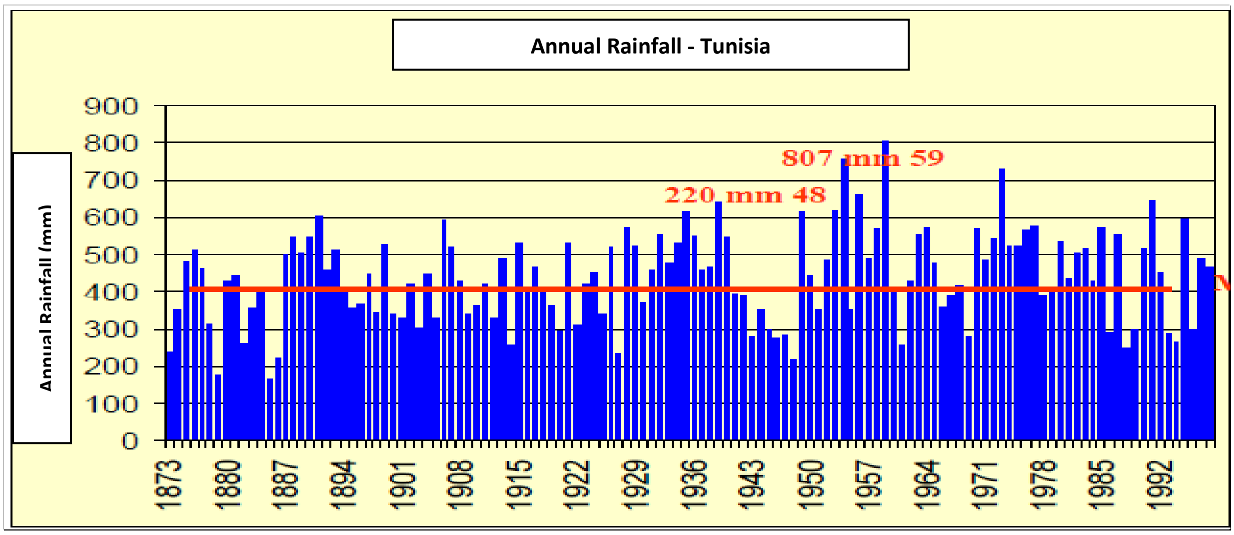
0.10								
-0.10 to -0.15	0%	0%	**-10 to -15**	3%	0%	**-10 to -15**	0%	0%
-0.15 to -0.20	0%	0%	**-15 to -20**	0%	0%	**Over -15**	0%	0%
-0.2 to -0.25	0%	0%	**-20to -25**	0%	0%			

Source: Adapted from Göbel, and De Pauw (2010

1.1.8 TUNISIA

Drought Episodes: Based on information derived from the Mediterranean Drought Preparedness and Mitigation Planning (MEDROPLAN) initiative of the EU[37], drought events have been reported for the periods 1987-1989, 1993-1995 and 2000-2002. **Figure 6** shows four drought events (two isolated events in the early and late sixties) and two consecutive droughts after 1965. A study carried out by the National Institute of Meteorology on behalf of the Ministry of Agriculture, using rainfall data for the period 1931-2000, came to the conclusion that **on an average one to two generalised drought episodes occur in the whole country per decade, showing geographical maxima with frequencies between 26% and 33% for the northern parts of the country, and the highest numbers of dry years for the central and southern parts of Tunisia, with frequencies between 36% and 41**% (Laatri et al., unknown date). Given a dry autumn, the probability that the whole year is dry is generally very high (varies between 67% and 90%). The corresponding frequency for a dry year to occur after a normal or wet autumn is low and ranges between 9% and 22 %. According to the Tunisian Ministry of Agriculture, environment and Water Resources, the probability of drought to occur in three consecutive years such as those witnessed between 1987 and 1989, 1993 and 1995 and 2000-2002 ranges between 11 and 34% (Ministry of Agriculture, Environment and Water Resources (MAEWR), 2004).

Figure 6: Annual Rainfall in Tunisia



Source: MAEWR, 2004.

[37] http://www.iamz.ciheam.org/medroplan/guidelines/examples_tunicia_drought.html

Floods Episodes: Analysis of the inventory of flood events that occurred in Tunisia between 1985 and 2009 **(Annex 1-Tunisia)** indicates that most of the flood events during the said period occurred in the Northern and Central Tunisia (mostly in the Northern part of the country). **Table 18** indicates the increasing number of flood events during the period 2000-2009**; five out of the total of seven flood events recorded during the 25 years occurred during the last period** (representing more than 70% of the total events). The **events were all of class 1 severity** (i.e. large flood events causing significant damage to structures or agriculture; with fatalities; and/or with a return period of 10-20 years), while **those with a magnitude greater than 4 represented 57% of the total events**.

Table 18: Percentage of flood events in Tunisia by severity and magnitude (1985-2009)

Type of Flood	1985-90	1991-2000	2001-09	Total
S1, M<4	0%	0%	40%	**29%**
S1, M>4	100%	0%	60%	**57%**
S1, M>6	0%	100%	0%	**14%**
Total No. of Events (7)	**100%**	**100%**	**100%**	**100%**

Source: Based on the flood records provided for Tunisia (1985-2009)[38].

Potential Linkage to Climate Change: The study of long rainfall series, both at the national and regional levels shows **no clear and statistically significant indications** which may suggest upward or downward trend in precipitation indices (Bin Boubaker, 2007**). On the other hand, the number of extreme droughts and floods has increased significantly over the last decade with a total of 11 events;** constituting a period most loaded with events. In addition the **more frequent floods over the past ten years, suggest a previously unknown frequency and intensity of rainfall**. See Chapter 3.3 - the case study of Tunisia

1.2 REVIEW OF THE STATUS OF DROUGHT AND FLOOD MANAGEMENT IN THE THREE FOCUS COUNTRIES

Despite the scarce literature on the status of drought management in the project countries, available references indicate that the **traditional approach that has been so far adopted in most of the SWIM countries in response to drought and flood is that of crisis management**; through the provision of emergency relief to the affected areas or sectors. In the case of drought, decision makers in most of the PCs, usually act when it reaches alarming levels in terms of intensity and areal extent and when water management options are quite limited. **Often, a national inter-government committee is formed to address the drought** and its associated economic, social and environmental impacts; involving implicated line ministries (Ministries of Water, Agriculture, Finance, Interior including civil defence departments, Trade and industry, etc.), in addition to nongovernment organisations (NGOs), and community based organisations. However, in most cases**, once the drought cycle is over, the activity of the committee is abandoned**, without due consideration to the lessons learnt from the previous drought episodes. This approach has been characterized as ineffective, poorly coordinated and untimely and often leads to costly short term solutions under emergency situations; involving high tensions between public administrations and affected groups, and competing sectorial interests.

[38] http://www.dartmouth.edu/~floods/Archives/index.html

Faced with increased risk of natural disasters in Algeria, a series of measures led to the promulgation of the 2004 law on the management of disasters in the context of sustainable development[39]. Likewise, **a more pro-active approach to drought has emerged in Morocco** through the adoption of a National Programme for Drought Mitigation that includes a structured drought planning programme focusing on a long term pro-active approach to drought mitigation. A flood "prevention plan" and "management strategy"; involving a program to contain or reduce the risk of floods were also developed. The program consists of several actions around (a) prevention: knowledge and risk awareness, (b) protection against risks; (c) preparation, forecasting, monitoring and alerting, (d) relief and rehabilitation, and (e) contribution of Non-Governmental Organizations NGOs' and international collaboration (Ouassou et al. , 2005).

Review of the status of drought and flood management in the three focus countries; conducted within the framework of this assessment, for Jordan and Palestine and Tunisia, shows that in **the case of the first two countries, there is no regulatory text directly addressing drought and flood management**. Instead, these are embedded in civil defence law as part of the natural calamities which the civil defence department is mandated to manage in cases of emergency. On the other hand, **Tunisia has developed dedicated laws/decrees pertaining to natural disasters, their prevention and relief,** which set out the modalities for the development and implementation of national and regional plans and the composition and mode of operation of designated committees at the national, regional and local levels **before, during and after the disasters**. Table (19) gives an overview of the status of drought management in the focus countries (Jordan, Palestine and Tunisia) which is further elaborated in the respective case studies.

Table 19: Overview of the status of drought and flood management in the focus countries (Jordan, Palestine and Tunisia)

Area of Analysis	Jordan	Palestine	Tunisia
Legal / policy framework	Multiple texts vaguely addressing climate induced calamities, with overlapping mandates between institutions and unclear responsibilities to ensure effective management of drought and flood events.		Drought and floods are addressed in laws/decrees pertaining to the fight against natural calamities
	No drought or flood mitigation strategies or policies		
Institutions & mechanisms	- Committees are formed upon need and dissolved after the event. No permanent mechanisms are in place to supervise and coordinate the development and implementation of drought/flood mitigation plans.		- Clear mechanisms involving a permanent national committee mandated to supervise the execution of all operational actions before, during and after the event, which work in coordination with regional and sectorial or specialized committees. - Complex institutional water management framework, with water competencies and

[39] Available at: http://info.worldbank.org/etools/docs/library/114813/bestcourse/docs/Course%20Projects/Best%20End%20of%20Course%20Projects/SVETLANA/Ousalem%20-%20final%20project.pdf

Area of Analysis	Jordan	Palestine	Tunisia
	- Institutional fragmentation. No unified vision or policies; resulting in segregated efforts and absence of integration of drought and flood management planning with on-going development efforts such as land use planning.		responsibilities spread among several institutions may compromise coordination. - Consolidated responsibility for water, agriculture and environment within one ministry, minimises competing interests and provides better alignment of sectorial needs, especially during the times of drought.
Institutions & mechanisms (Continued)	- Floods are being managed at the national level as part of water resources management efforts. Implementation is highly centralised but with more participatory approaches adopted in Tunisia. Example: according to the study for the amendment of the Tunisian water code (Ministère de l'Agriculture, 2012), the state is expected to carry out flood risk management plans in cooperation and participation of institutions and populations, with risk reduction measures coordinated at the local or regional level. - Due to their local characteristics and sudden nature of occurrence, flood management in Jordan is being increasingly addressed at the local level where decentralisation of authority is in place (Aqaba and Petra). - There is still a need for a national strategy to deal with floods within the overall Integrated Flood Management policies duly recognising the subsidiarity principle.		
	State funds are allocated only upon the evaluation of damages. Due to financial constraints, they are allocated only when severe impacts are recorded.	Compensations provided by the state (Ministry of finance) based on reported damages	Mutual funds for the compensation of farmers against damages ensuing from natural disasters. However, the level of contribution by the private sector is limited.
Information Systems	Although relevant drought and flood management information sources exist and complement each other, but they are scattered and diversified. This constrains information exchange and hampers efficient valorisation of information.		
Drought and flood preparedness, planning and management	- No drought or flood management plans exist (No characterisation of drought or floods. Drought thresholds or indices are not identified; neither at the national or local level. No risk and vulnerability		- Prediction of hydro-climatic situation -Practical guideline for drought management, consisting of methodological approaches; identifies the principal drought indices, describes the drought preparedness and management process, and maps the intervening parties.

Area of Analysis	Jordan	Palestine	Tunisia
	assessments are in place). - No alert mechanisms established. - Drought mitigation plans including reducing socio-economic vulnerability are mostly developed reactively and implemented under emergency conditions.		- Execution of the drought mitigation programmes depending on the type, intensity and duration of the drought event. **However, the drought mitigation plan needs regular evaluation and revision based on evolving technologies, emerging programmes and changing institutional responsibilities** - An initiative for assessing and mapping flood risk in all significantly vulnerable regions has been launched recently. This should provide a good step for developing flood management plans.
	- Long term supply and demand management actions driven by severe water shortage also serve the country during periods of drought.	Information not available	

Due to the political situation in Palestine, water resource systems are not as well developed as in Jordan and Tunisia. Currently, nearly 30% of the Palestinian communities are not connected to water networks. Local springs and rainfall collection systems are the major sources of water supply for domestic and agricultural uses in many of these communities (Mediterranean Water Scarcity and Drought Working Group (MWSDWG), 2007). In addition, the hydro-political situation in Palestine, limits the country's ability to respond to drought **(See Chapter 2.6 - the Case Study of Palestine for details).**

1.3 WATER, ENVIRONMENT AND CIVIL DEFENCE SECTORS RESPONSE TO DROUGHT AND FLOOD IN THE FOCUS COUNTRIES

Below is a summary of traditional water sector response in the three focus countries during droughts:

Short term measures:

- Over-exploitation of groundwater resources and mobilization of additional resources (such as drilling of new wells).
- Strict application of water demand management measures including minimization of waste and fining practices that result in wasting water.
- Rationing in water distribution for drinking purposes.
- Reallocation of water between the sectors with water for municipal purposes given priority.

- Transfer of water between hydrological and administrative units.
- Equipment of water points for domestic use and Distribution of water by tankers.
- Regular monitoring of water quality and quantity (both groundwater and surface water)
- Increased reuse of treated wastewater in irrigation (especially applicable in Jordan).
- Increased public awareness campaigns involving all water users to promote saving, and alarm implicated users of any degradation in water quality.

Long term measures

Faced also with increasing water scarcity as a result of high competing pressures on existing water resources, which is exacerbated by climate change, the three focus countries have adopted – to different extent - long term measures, as part of water resources management under water scarcity conditions that can increase the countries' resilience to drought. These include:

- Development of additional water resources, including the construction of dams and reservoirs to regulate surface water flows, control floods and increase water resources availability.
- Construction of transfer systems between water surplus areas and deficit areas.
- Utilization of non-conventional water resources (moving towards desalination of sea and brackish water and reuse of treated effluent in irrigation and landscaping, water recycling in industries, etc.)
- Groundwater recharge (and control of abstractions in the case of Jordan)
- Minimization of losses in the water supply systems and irrigation networks. This includes rehabilitation of domestic and irrigation networks, cement lining of irrigation canals, or the conversion of surface canals into pressurized pipes.
- Legal amendments and adoption of water demand management measures including the progressive structuring of tariffs according to water consumption.
- Conservation of soil and water (Structures for spreading floodwaters, Benches, reforestation, etc.
- Promotion of new technologies, water saving irrigation techniques, crop selection and adoption of drought tolerant crops. etc.
- Changes in the education curricula in favour of increased water and environmental awareness and for the promotion of water conservation and saving.

The above measures also lower the risk of damage and contributes to preparedness. A **good example in this regards is what is provided in the case study for Jordan (Chapters 1.6 and 1.7)**. Since Jordan is one of the four water poorest countries in the world, "**an intricate water transfer system was constructed to transfer the fresh surface and ground water from areas dominated by irrigation activities;** namely in the Jordan Rift Valley, **to meet the municipal demands of the urban areas** (mainly in Amman and Irbid cities) **in exchange with its treated wastewater.** This has helped buffer the impact of drought on all sectors including irrigated agriculture in the Jordan Rift Valley". Presently **Jordan uses more than 90% of its treated effluent**; mostly in irrigated agriculture. It is expected that with the increasing amounts of treated wastewater from the above mentioned cities, an increasingly reliable source of irrigation would be available during droughts for agriculture in the Jordan Rift Valley (JRV). Likewise in **Israel, there is increasing dependence on treated wastewater in agriculture; constituting about 30% of the total water use by the sector**.

Short term water sector responses to floods are confined to regulated river basins or wadis; mostly in the optimisation of the operation of the dams or reservoirs. **While the long term response** is more structural; involving the construction of dams, weirs, embankments, diversion channels, storm water collectors, etc.; the responsibilities of which are shared with non-sectorial line ministries or administrations.

Environmental institutions/departments in the three focus countries do not have a specific role in water resources management or drought and flood management. Monitoring water quantity and quality also falls under the direct responsibility of the water departments. Furthermore, when considering the legal mandate **in the case of Jordan, the environmental law does not stipulate any provisions related to any type of environmental disasters**; regardless of their type or origin. **In Palestine,** the task of preparing emergency plans to deal with environmental disasters is mandated to the Environment Quality Authority. Yet, **the definition of environmental disasters as "the accident resulting from nature or human act which causes severe damage to the environment" is broad and does not expressly mention droughts or floods**.

However, **environmental institutions/ministries/authorities in the three focus countries are indirectly involved as counter parts and/or focal points for climate change adaptation projects**; also setting climate change policies and strategies and programs for nation-wide actions that address the direct and indirect impacts of the climate change and suggest adaptation capacities in the sectors affecting the environment. **The role of the environmental institutions can be prominent in this regard through planning and ensuring inter-alia that concerted actions are undertaken for the conservation and increasing the resilience of ecosystems and biodiversity[40] to climate change, restoration of rangelands, conservation of soil, curbing desertification, etc., and that protected areas are designed and managed in light of the emerging and increasing challenges related to climate change and global warming**.

The response of the civil defence is mostly related to incidences of floods, as they are responsible for facing emergency situations and implementing the necessary precautionary measures including awareness-raising; to protect the citizens and alarm them to avoid potential flood areas. Once struck by floods, they intervene to bring aid and assistance to the affected people, and undertake evacuation and/or rescue, as necessary.

1.4 TRADITIONAL COMMUNITIES' RESPONSE TO PAST DROUGHT AND FLOOD EPISODES - INDIGENOUS BEST PRACTICES

Community development in the PCs can look back on a long history of coping with drought and flood-induced challenges and rely on the indigenous experience in risk management practices locally applied to agriculture and settlements. Over generations such empirically grown practices became an informal cultural asset which has allowed ancient populations to withstand unfavourable environmental conditions, and highly variable fluctuations in climatic events. There are various

[40] Guidelines provided by the Secretariat to the Convention on Biological Diversity suggest that timely identification of threats, concerted conservation action to increase and maintain the resilience of species and ecosystems, availability of connected and safe protected areas and conducive refugia for affected species, and the use of an integrated ecosystem approach are practical and effective climate change adaptation strategies.

definitions of indigenous and traditional knowledge, but one commonly accepted working definition adopted in the United Nations (UN), 2013, refers to such knowledge systems as cumulative bodies "of knowledge, practice and belief, evolving by adaptive processes and handed down through generations by cultural transmission, about the relationship of living beings (including humans) with one another and with their environment".

The traditional response to past drought and flood episodes by agro-pastoralist societies can be categorized for the communities of the PCs as shown in **table 20**. Such responses represent preventive response measures, which offer an appropriate level of preparedness. They also constitute autonomous actions undertaken by individuals and communities, and help to independently adjust to the communities' perceptions of disaster risk. Such autonomous actions may be short-term adjustments and are often considered as a reactive or bottom-up approach (Elasha, 2010).

Table 20: Examples of traditional response measures to drought and floods in the PCs

traditional response measures	Nature of Measure	Impact/Objective	Droughts	Floods
Investment in digging of wells, cisterns and in **rain and flood water harvesting systems**	physical	Increase water availability for drinking and irrigation and/or protect land against floods (soil erosion control) -depending on the selected measure.	x	x
Earth-dams	physical	storage of irrigation water	x	
Floodplain zoning	land management	land-use restriction		x
Dry-wall fencing and retention walls	physical		x	
Terracing	land management	erosion / top-soil conservation	x	x
Mixed and inter-cropping	land management	soil erosion	x	x
Diversified crop rotation	land management	soil erosion	x	
Low tillage of soils	land management	soil erosion	x	
Mobile or transhumant[41] grazing practices that reduce risks of having insufficient forage in any location.	land management	erosion / top-soil conservation	x	
Storage of surplus grains	management	food security	x	
Keeping contingency livestock to be liquidated during a drought	management	agro-economic risk buffer and food security	x	
Diversification among animal species and	management	agro-economic risk buffer and food security	x	

[41]This refers to the seasonal movement of people with their livestock between fixed summer and winter pastures. Vertical transhumance implies movement between higher pastures in summer and lower valleys in winter. In contrast, horizontal transhumance is more susceptible to being disrupted by climatic, economic or political change.

traditional response measures	Nature of Measure	Impact/Objective	Droughts	Floods
breeds within species.				
Flexible flock sizes and stocking rates	Land management and Management	optimization of adaptive capacity and reducing risk of land degradation	x	
Applying drought resistant seeds	management	food security / agro-economic response	x	
Reciprocal grazing with more distant communities for access to their resources in dry years	management	food security / agro-economic response	x	

For more information, Hazell et al. (2001) also provide an oversight on strategies which have been developed by communities within the MENA region to manage droughts.

The most dominant principle among successful DRM practice is that of a community-level basis for action. **Initiatives on community level that are** generally low cost, locally appropriate, technically sound, and compatible with the local government while **rooted in indigenous knowledge and practices** have proven to be most successful. Integrated programmes that address local water resource management, livelihood security, education, health and **participatory** development planning have been successful in a number of locations all over Africa and Asia and are fairly replicable with the ability to be scaled-up (Venton, 2012). Water Harvesting Techniques (WHT) offer good example that provide a huge potential for replication of indigenous best practices (IBPs) in the PCs and for up-scaling to become “community-based” response in favour of disaster preparedness, and for dissemination; possibly through established institutions and networks on the local and regional levels.

Short-, mid, and long-term-measures can be selectively chosen from options in the range of drought and flood risk management activities, exemplified by Venton (2012). Initiatives at the community level, actively involving all sectors of the community, provide an integral part of disaster risk management. It remains crucial to define the entry points for deciding on the most suitable measure; depending on specific local contexts. However, low cost methods could be identified and implemented by farmers or concerned local groups, based on traditional techniques which could easily be applied and shared across the communities. In absence of well performing governmental accountability in the PCs, decentralization becomes a key-success factor for any effective disaster preparedness. Table21 provides oversight on the main water harvesting techniques used in PCs.

Table 21: Overview of the main water harvesting techniques used in the PCs.

Water Source	Objectives	Water Harvesting Techniques	Country
Rainfall	-Increase rainfall effectiveness - Conserve water (and soil)	Terraces	Jordan, Tunisia
		Contour-ridge terracing	Syria, Tunisia, Jordan
		Dams	Egypt, Tunisia, Jordan
Local runoff	- Collect water - Store harvested water	Micro-catchment	Egypt, Syria, Jordan,

Water Source	Objectives	Water Harvesting Techniques	Country
	(also used for domestic supply)		Morocco
		Cisterns	Egypt, Jordan, Morocco
Wadi flow (flood and base-flow)	- Divert water for irrigation - Protect land against floods (soil erosion control) - Extract from alluvial fill	Earth dykes / Kesaria (spate irrigation and small-head pumps & earth canals); Fogarras; Jessour	Egypt, Tunisia, Jordan; Algeria, Morocco
		Wadi-bank enforcement	Jordan (Aqaba)
Spring water	- Deliver water to users within water rights limits - Store limited quantities of water for short periods (also used for domestic supply)	Earth canals	Egypt
		Rock conduits	Jordan
		Cisterns	All PCs
Groundwater	- Abstract water from shallow aquifers (also used for domestic supply) - Exploit groundwater stored in the coastal sand dunes	Shallow dug wells and pits	Egypt, Jordan, Morocco
		Galleries	Egypt

Source: Adapted from Nasr (1999).

Box 1: Water Harvesting Techniques in North Africa

Foggaras owe its origin in Iran where it is known as qanat. The equivalent of Foggaras is also found in Morocco where it is called rhettaras. The foggaras are found in Saharan Algeria where the occurrence of oasis is very common. This indigenous system uses the principle of gravity flow to transport water to the oasis throughout the year.

Jessour is an Arabic term describing the widespread indigenous wall structures built across relatively steep wadis in southern Tunisia. The walls are usually high because the slope is steep. They are made of earth, stones or both, but always have a spillway, usually of stone. This system is similar to wadi-bed cultivation except that it is used on steep wadi beds and always includes a spillway to release the excessive water.

Photos of Foggaras (Up) and Jesour (Bottom)

1.5 SOCIO-ECONOMIC AND ENVIRONMENTAL IMPACTS OF DROUGHTS AND FLOODS IN THE PCS

DROUGHT

SOCIO-ECONOMIC IMPACTS

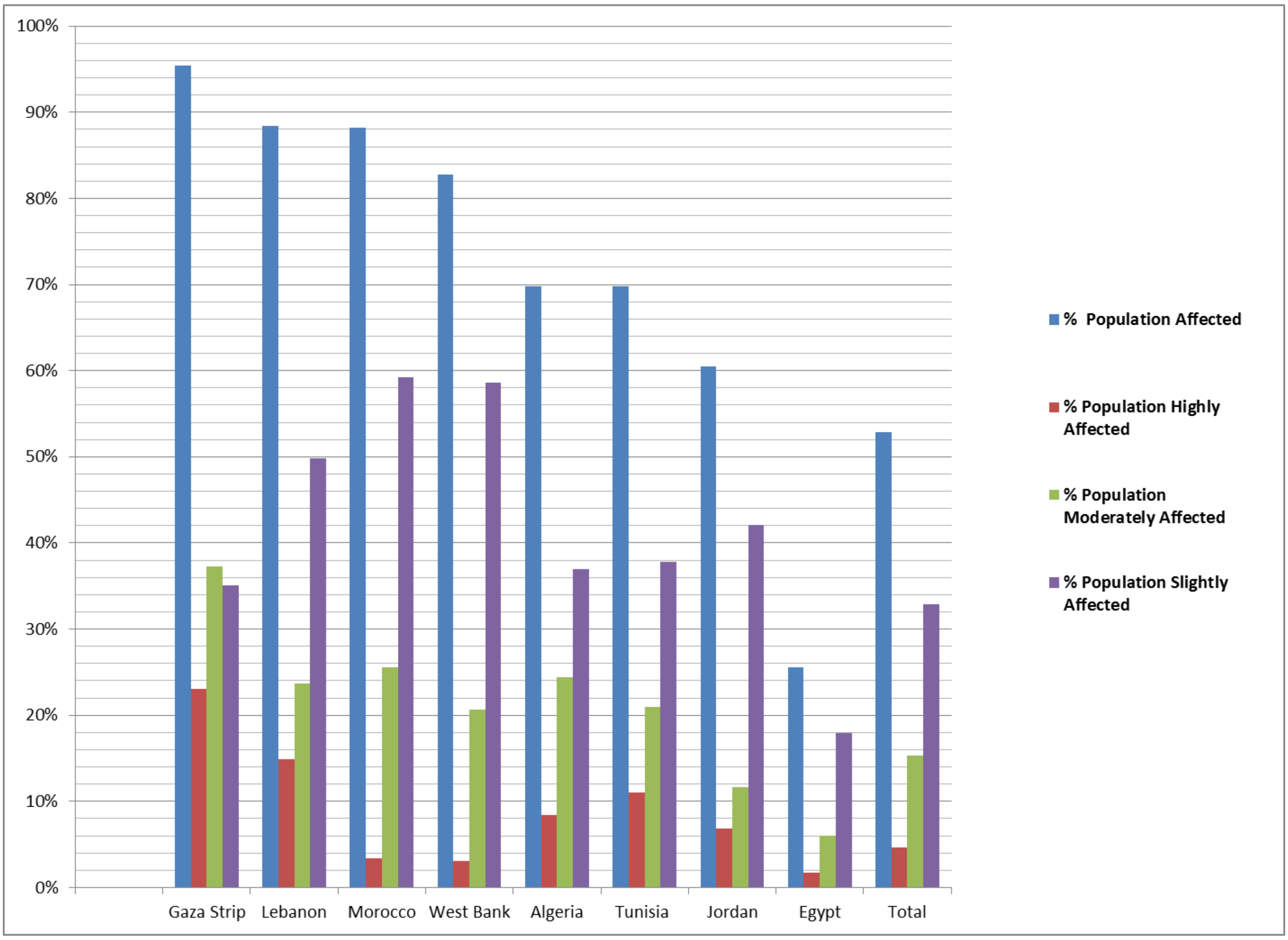
Since **agriculture** is by far the largest user of water in the SWIM PCs (65%-85% is used for irrigation) and the most water dependent sector, the **biggest economic impact of drought is usually hitting the agricultural sector** although other sectors are also affected. Available studies indicate that about 53% of the **population** of the PCs[42] are affected by agriculture drought hazards (**Figure 7**); with "more than 80%" of the population in "Palestine, Lebanon and Morocco" being affected, followed by Algeria, Tunisia and Jordan (between 60% and 70% of the population), and finally Egypt at 25.6% (Erian 2013). The percentage of population that are highly, moderately and slightly affected by drought is also shown by country**. In terms of area affected**, **Figure 8** shows for the same countries the percentages of the total area that are highly, moderately and slightly affected by agricultural drought hazard.

Depending on the precipitation deficit, and restrictions on irrigation uses, serious production losses for both, irrigated and rain fed crops, may result (although the impacts on the latter are much worse). Based on crop production data for selected crops for the years 1999-2011, UNISDR (2013) estimated the changes in crop production for seven of the SWIM PCs and the subsequent economic losses which are depicted in **figure 9**.

Farmers are usually the most affected group in terms of income loss. According to the Food and Agriculture Organization (FAO) 2008, the 1998-2001 droughts which hit several countries of the PCs affected farmers and the economy. In Jordan, some 180,000 farmers and herders were affected, and food security for 4.75 million people was at stake. Only 1% of cereals and 40% of red meat and milk were harvested. In Morocco 1 million hectares of cropland were affected, resulting in 5 million tons of wheat imports in 2001 (US$500 million in total cereal imports). The Agricultural losses in Tunisia were also associated with interventions estimated at US$46 million in terms of livestock vaccinations, nutrition products, subsidizing forage product prices, and attribution of yearly credit for farmers.

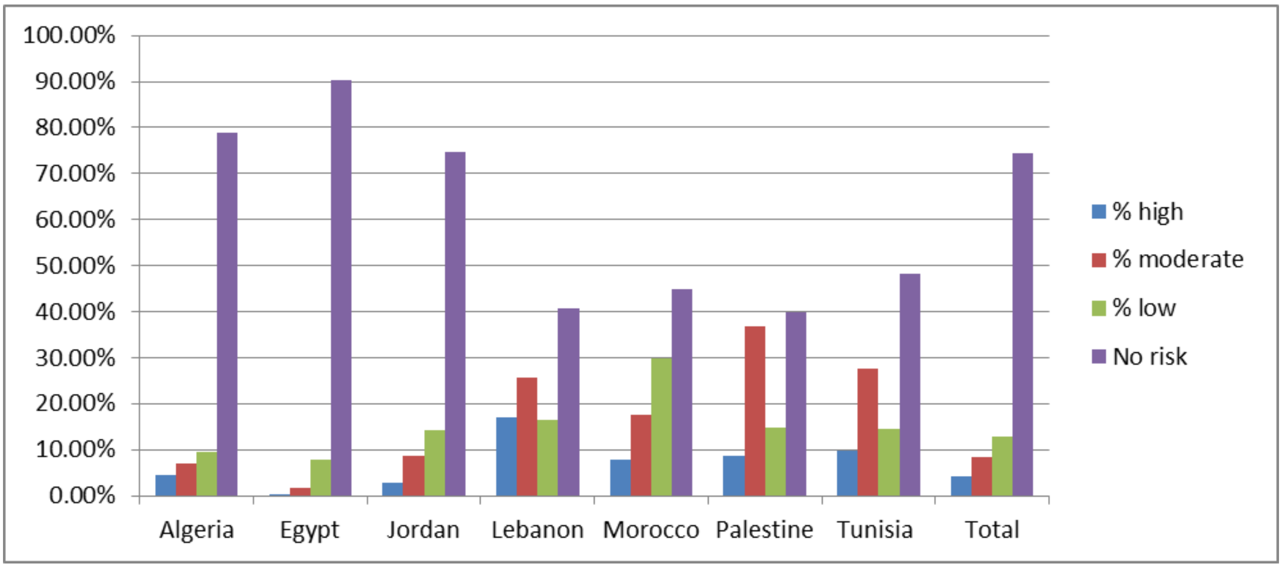
[42] Israel is not included.

Figure 7: Population Affected by Agriculture drought Hazard in selected PCs



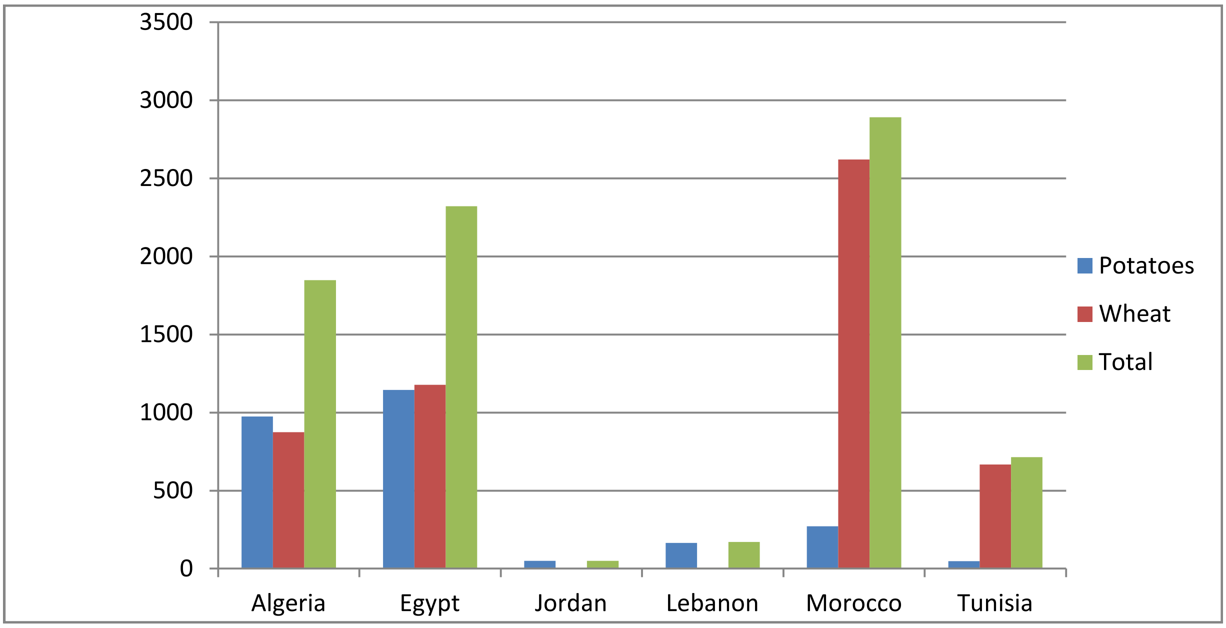
Source: Based on figures provided by Erian, 2013

Figure 8: Agricultural Drought Hazard Areas in selected PCs (% of Total Areas)



Source: Based on figures provided by UNISDR, 2013 (a) (P45)

Figure 9: Total Economic Crop Losses in selected PCs for selected crops (Million US $[43])



Source: Based on figures provided in UNISDR (2013) (pages 285-293).

Table 22: Main socio-economic and environmental impacts of droughts

Sector	Impact
Social	• Damage to public health and safety, by affecting air and water quality or increased fire • Increase in social inequality, • Tensions between public administrations and affected groups • Changes in political perspectives • Inconveniences due to water rationing

[43] United States Dollars

Sector	Impact
	• Impacts on way of life (unemployment, reduced saving capability, difficulty in personal care, reuse of water at home, street and car washing prohibition, doubt on future, decrease of celebrations and amusements, loss of property) • Inequity in drought impacts and mitigation measures distribution • Abandoning of activities and migration (in extreme cases)
Economic	• Decreased production in agriculture, forestry, fisheries, hydroelectric energy, tourism, industry, and financial activities that depend on these sectors. • Loss of livestock's and herds. • Unemployment caused by decrease in production • Economic damage to reduced navigability of streams, rivers and canals • Damage to the tourism sector due to reduced water availability • Pressure on financial institutions (more risks in lending, capitals decrease etc.) • Income reduction for the water utilities due to reduced water delivery • Costs in emergency measures to improve resources and decrease demands (additional costs for water transport and removal, costs of advertising to reduce water use, etc.)

Source: Iglesias A. et al.(2007)

IMPACTS ON THE ENVIRONMENT AND THE ECOSYSTEMS

One of the short-term impacts of drought events is the temporary reduction in water availability. As a result, considerable water stress for humans and ecological systems occur, in order to meet the human needs. The situation is further worsened when coupled with increasing demands, as is the case in the SWIM PCs, resulting in over-exploitation of groundwater resources and surface water retained in dams, and reduction of their ability to recover over the long run, which further exacerbates the impact of drought periods (WWF, 2006).

Taking the impact of droughts for example on the water resources in **Algeria**, the PNUD (2009) referred to a reduction of 10.5% in the water resources potential (a drop from 19.4 to 17 billion m^3 (BCM) per year) as a result of the intense and persistent drought seen in the country during the last 3 decades, which negatively impacted the rivers' flow regimes. According to the same source, the reduced rainfall due to the raging drought since the early 70s also resulted in a steady decline in groundwater reserves of the major aquifers in the north. In many plains of the country, the groundwater level has dropped at an alarming rate (greater than 20 m). The worsening droughts coupled with the over-exploitation of groundwater also resulted in the mineralization of the unsaturated zones of the deep aquifers in the semi-arid regions such as in the Oran Plateau and the high western plains. In addition, the lower levels of hydrostatic pressure in the coastal areas resulted in sea water intrusion into the fresh water reservoirs of the coastal aquifers regions of Mitidja, Oran, Terga and Annab.

Egypt's environmental conditions are not directly affected by drought episodes in the country, as it mostly relies on shared, perennial surface water resources of the Nile River and its more humid headwater regions. Lake Nasser serving as a hydrological buffer, maintains the life-line support of Egypt during drought periods. Moreover, the Nile River feeds groundwater resources along its entire course which contributes to Egypt's particular drought stress tolerance. However, the inter-annual and inter-decadal variability in the Nile flows exposes Egypt to hydrological drought. According to compiled information provided by UNEP, the Nile River and Delta were much affected by the drought in the 1980s which resulted in loss of output from agriculture and fisheries and a drop in water level in Lake Nasser which exacerbated the country's irrigation problems (Abdel-Rahman et al., 1994). Like it applies to other PCs located in the MENA region, drought aggravated the effects of overgrazing, increasing the degradation of natural vegetation and soils.

In **Israel**, the drought of 1999, forced the country to increase its groundwater abstraction from two major groundwater basins by 20% during that year; resulting in a sharp drop in groundwater levels (Abraham et al., unknown date). The groundwater depletion led to significant cones of depression, and the build-up of salinity and pollution. Near the coast, low water levels induced seawater intrusion, increasing groundwater salinity and hence depletion of fresh water reserve. The dry-up of wadis and natural reservoir ponds resulted in the death of plants and animal species, whilst fish colonies and ancillary economic activity were adversely impacted. In addition, desertification found suitable condition for encroachment, especially along the transition zones between the semi-arid regions and the desert.

The 1999 drought which also affected **Palestine and Jordan** had serious economic impacts on both countries with the severe restrictions on agricultural water use, collapse of rain-fed farming and purchase of water in the black market. Water rationing was also practiced in both countries with resulting health implications. Environmental degradation included reduced environmental flows, deterioration of water quality in the wadis (mostly dominated by treated effluent in the case of the Zarqa River in Jordan), increased soil salinity, sharp water depletion and increased salinity of groundwater systems (MWSDWG, 2010). The event had also political consequences between Jordan and Israel, as the latter is bound by the 1994 peace treaty to supply Jordan with 45 million cubic metres of the shared Jordan River and the Yarmouk flow annually; especially that the treaty does not have provisions related to drought events when affecting the whole region[44].

The drought episodes in **Morocco** (1980/81 to 1985/86, 1991/92 to 1994/95 and 2000/2001 to 2002/03) brought about a net decline in the dams' water reserves and groundwater levels, thus imposing limitations on drinking water and irrigation water supply. The drought of these years profoundly aggravated the chronic deficit of surface water flows, resulting in nearly 50% reduction for the period 1980-85 (10 BCM) compared to an annual average of about 19 BCM). The respective figures for the periods 1991/92, 1992/93 and 1994/95 are "10.8, 4.9 and 5.3 BCM. Droughts also resulted in water quality deterioration including increased water pollution; thus leading to the death of fish, dysfunction or interruption in the operations of drinking water treatment plants, and increase in waterborne diseases. The production of hydro-power in the country was also impacted as a result of the reduction in the water level in all dams. Drought episodes greatly affected agriculture and livestock production, and their contribution to overall gross domestic production (GDP); (Ouassou et al., 2005).

No information is available on the impact of drought on **Lebanon**. Drought actually threatens 621,772 people to become under desertification risk, representing nearly 10% of the country's population. Estimates made by Kassas (2008) indicated that 7% of irrigated farm lands are subjected to slight desertification (land degradation resulting **from climatic variation and human activities**). While the rates of desertification (medium and more) for rain-fed and range lands amount to 60% and 90% respectively with the latter being higher than the world percentage of 73%; thus posing serious threat to productive lands and agricultural production, in addition to loss of animal life and biodiversity.

[44] http://www.independent.co.uk/news/israeli-drought-cuts-off-jordans-water-supply-1080964.html

Similar to the rest of the PCs, the drought in **Tunisia** increased water salinity resulting in soil salinization and impacting crop yield, while the clogging of pipes and supply channels as a result of the high turbidity increased the production cost of drinking water. Droughts have also had a negative impact on the flow of hot springs and disrupted therapeutic hydrotherapy. Coupled with overexploitation of groundwater resources during periods of drought, the lowering of water table incurred additional costs for pumping water; estimated at 0.45 million Tunisian Dinar in the watershed of Medjerda in 2010, and loss of hydropower production which is offset during such periods with the production of electricity using fossil fuels; thus resulting in environmental degradation. **See also Chapter 3.9 of the case study of Tunisia for the estimates of the related cost of environmental degradation (**Sherif Arif and Fadi Doumani, SWIM-SM 2012)

Although the Mediterranean **ecosystems** are designed to cope with periodic droughts, droughts often have severe impacts, since the ecosystems already show signs of degradation and are therefore much more vulnerable to drought impacts (WWF, 2006). All the PCs share to different extent the direct impacts of droughts on the environment and a lot of its intermediate and long term consequences, which are aggravated by climate change and improper water use planning **(See table 23)**.

In order to offset the impact of drought and control floods, all the PCs have constructed water reservoirs. In combination with recurrent drought, this has led to the reduction of water flowing into the Mediterranean Sea **with subsequent severe changes in the coastal ecosystems** and saline intrusion in coastal areas, in addition to the regression of dunes and deltas (WWF, 2006). Several examples can be provided in this regard, including the hydro-environmental side effect of the establishment of Lake Nasser represented in the gradual shrinking of the Nile-Delta due to reduced fluvial sediment transport and the diminishing soil fertility in the former flood plain areas adjacent to the river. Deteriorating water quality due to reduced discharge and thus insufficient mixing has triggered additional environmental stress for riverine ecosystems due to increased contaminant loads, and reduced self-regulative capacity.

Table 23: Drought causes, aggravations and environmental impacts

Causes	Impacts	Intermediate consequences	Long term consequences
Reduced precipitation	• Reduced flows in surface waters • Reduced infiltration for groundwater recharge	• Reduced water availability • Higher concentration of pollution and toxics • Warming of water bodies • Boost in nutrients in the water bodies • Reduced groundwater levels • Salinization of aquifers • Saline intrusion in coastal areas • Stress on (ground) water dependent eco-systems • Spread of invasive species • Loss of sedimentation for deltas and estuaries	• Decline in biodiversity: • Loss of aquatic eco-systems • Severe changes in the coastal eco-systems • Regression of dunes and deltas • Loss of species in flora and fauna • Shift of species with increase of thermophiles
Aggravations			
Climate change	• Increase in temperature • Reduced precipitation • Increase of extreme weather events		
Inadequate water use planning	• Reduced flows in rivers • Non-compliance with ecological flow regime • Water pollution • Over-exploitation of aquifers		

Source:WWF (2006).

Overall, the total freshwater brought by all rivers flowing to the Mediterranean Sea has declined by 45% in less than a century (Ludwig et al., 2003). This basin-wide trend is due to declining individual river discharges. In the case of Aswan Dam Lake Nasser, the annual discharge of the Nile river to the sea decreased from 84 to 6 km^3 (-93%). Other quantified examples include a 76% reduction in river Moulouya (Morocco) between 1960 and 1988 following completion of Mohammed V dam. Similarly, the construction of dams upstream of the wadis and rivers that flow into the Jordan River (shared between Israel and Jordan) and the Yarmouk River (shared between three riparian countries; Israel, Jordan and Syria) has resulted in the depletion of the environmental flows in the respective rivers, fragmentation of the fauna population and drying up of the Dead Sea which receives almost all its water from the Jordan River and its main tributary; the Yarmouk River.

Drying up of wetlands illustrates further the combined impact of drought with improper water use planning on the ecosystems. Groundwater abstractions beyond sustainable yields, in addition to recurrent drought have resulted in the significant reduction in the size of Azraq Oasis in Jordan and the subsequent decrease in the number of migratory birds on their African Eurasian route **(See also Chapter 1.9 - the case study of Jordan)**. Wetlands in the Mediterranean support high concentrations of birds, mammals, reptiles, amphibians, fish, and invertebrate species, many of which are endemic to the region (Critical Ecosystems Partnership Fund (CEPF), 2010). They also offer multiple functions and services to the people as they benefit from their direct resources and protection against floods and droughts, recharge of water-tables, and water purification (Mediterranean Wetlands Observatory (MWO), 2012).

Drought has also direct impact on landscape quality, provoking **accelerated soil erosion and land degradation**, increased number and extension of forest fires, **damage to flora and fauna and impacts on air and water quality**. Some of these effects are short-term and may return to normal after the end of the drought. Other environmental effects last for some time and may even become permanent.

FLOODS

As indicated in the section **"REVIEW AND INVENTORY OF PAST DROUGHT AND FLOOD EPISODES IN THE PCS"** above, the Dartmouth Flood Observatory (DFO) - Univ. of Colorado, Boulder, USA, maintains data records on the main flood events which occurred in the PCs since 1985. Although the extent of completeness of the records is questionable, it can still provide an indicative view of the severity and magnitude of the flood events that the PCs are exposed to, together with the associated socio-economic impacts during the recorded events.

Review of the DFO records show a high variability in the spatial and temporal distribution of events, magnitudes and damage incurred, as well as in the overall severity in terms of hydrological significance, human fatalities and impact throughout the PCs. All the floods in the PCs are commonly caused by rapid overland flow (flash floods) and channel flow, following heavy rainfall or intense and brief torrential rainfall. Topographic and morphologic conditions, such as steep slopes, narrow valley bottoms and poorly drained urban infrastructure contribute to the severity of flood events. In addition, where geological substrata show particular susceptibility to mass movements, deadly land-slides can occur.

Bearing in mind the paramount significance of **Agriculture** as the primary sector in all PCs, it appears that the **loss of related productivity and livestock remains the second most severe impact category, following the loss of human lives, casualties and damage to infrastructure;** the core assets of the PCs' socio-economic inventory. This is particularly significant, considering that often the PCs are lacking means and capacity to recover flood-induced impairment or losses. Below is a listing of the major socio-economic impacts based on the review of the DFO data repository:

- Loss of life, injuries and missing people
- Inundation of personal properties and dwellings resulting in evacuations
- Loss of agricultural lands, livestock and fish farms
- Infrastructure damage, associated with interruption of services (water and wastewater treatment, electricity, transportation, and telecommunication) and subsequent disruption to supply services (shops, markets, etc.)
- Damage to archaeological sites
- Fires sparked by flood damages.

In addition, the information in **Box 2**– also derived mostly from the DFO - **summarises the impacts** related to the **most significant events** in the PCs since 1985 (**See also Annex 1 for further details**). **Table 24 lists** the **main impacts of flood as reported from several sources**.

Table 24: Main socio-economic and environmental impacts of floods

Sector	Impacts
Agriculture, Livestock & Fishery	• Loss from crop production including annual and perennial crop losses, infrastructure damage, damage to crop quality, reduced productivity of cropland due to water logging. • Loss of production assets and income for farmers and others directly affected and possible bankruptcy • Decline in food production/disrupted food supply due to increase in food prices and importation; resulting in higher food costs • Loss from dairy, livestock and fishery production • Cost of rehabilitations
Recreation & Tourism	• Loss to tourism industry • Loss to manufacturers and sellers of recreational equipment • Damage to hotel properties and loss of archaeological sites • Cost of rehabilitations
Energy	• Damage of power plants and energy supply assets • Loss due to disruption of electricity supply • Cost of rehabilitation
Industries	• Loss of production assets and properties • Losses due to disruption of industrial activities • Loss to agro-industries and biomass • Cost of rehabilitation
Water Sector	• Decreased water quality and increased turbidity in fresh water systems • Chemical and biological pollution of water • Modified hydrological patterns and natural flood regimes • Losses due to disruption of water supplies • Cost of rehabilitation and development of new or supplemental water resources • Cost of increased groundwater depletion (in the new area)
Infrastructure	• Damage to infrastructures of communication, transportation (roads, bridges, railways, etc.), health care, education, and business and commerce • Losses due to disruption in infrastructure services for communication, transport, health care, education , and commercial services and businesses

Sector	Impacts
	• Cost of rehabilitation for Communication Services, Transport Services, Health Care, Education , And Commercial Services And Businesses
Other Economic impacts	• Cost of relief • Loss of national economic growth, retardation of economic development • Delayed investment in infrastructure and other development activities in the area • Loss of long-term investments by the government and private sector • Loss of economic growth in the affected region (due to migration of skilled labour, inflation, Lack of livelihood) • Decreased prices of lands and properties in the area • Decreased purchasing and production power
Health and Safety	• Higher incidence of death, injury, psychological disorders, and exposure to contaminated water supplies. • Food shortages • Mental and physical stress, traumas • Increases in the potential transmission of water and vector-borne infectious diseases (e.g., malaria, dengue, yellow fever, and some viral encephalitis)
Social	• Increased poverty in general • Loss of property and displacement from homes • Massive migration into informal settlements in risk prone areas • Disruption of services and disruption to business and social affairs • Decreased levels of security in the aftermath of floods and in temporary shelters • Social unrest and public dissatisfaction with government regarding flood response • Loss of cultural sites • Reduced quality of life, changes in lifestyle • Increased data/information needs, coordination of dissemination activities
Environmental Impacts	• Loss and fragmentation of vegetation • Erosion, stripping, sedimentation • Extinction of indigenous species through direct action of flood water • **Contamination of wildlife habitats with extremely toxic substances** • Altered habitat and food resources • Dispersal of exotic species

Box 2: Summary of the impacts related to the most significant flood events in the PCs since 1985

Algeria: Floods recorded for the first half of October 2008, and at the end of January 2009, represent major events reported for Algeria. In October 2008, a two weeks flood with a return period of 20 years, triggered by torrential rainfall, hit the oasis town of Ghardaia, 700 km south of the capital, the adjacent district of Ourghla, the town of Tebessa located 600 km east of Algiers, and M'zab 600 km south of the capitol, affecting a total area of nearly 350,000 km^2. Death toll reached 65 people, and damage occurred to 2,000 buildings inundated and/or severely damaged, including those of the medieval town of Tebessa.

Abruptly developing channel overflow caused the death of 33 and severe injuries for 40 people during the January -floods of 2009; afflicting the desert settlements in the valley of M'Zab, the largest of which is Ghardaia. Sudden storms following heavy rainfall had caused a rapid flooding of river banks in less than 20 minutes which had left the citizens with little opportunity to back-off and relocate, affecting an area of almost 133,000 km^2 (slightly more than the surface area of Greece) damaging house constructions, basic urban services' (including water, electricity and telecommunication) and supply systems (shops and markets), road networks, livestock and agricultural lands. In many cases inhabitants became displaced.

Egypt: In the southern cities of Aswan and Luxor, floods and gusty winds disrupted power lines causing damages to the public electricity grid. Floods following heavy rainfall in mid-November 1996 left thousands of acres flooded, and 260 houses destroyed during a "normal" event (i.e. statistical return interval of less than 20 years), in which 23 people lost their lives.

During flash floods triggered by an intense storm and heavy rainfall, early in November 1994, a total of 593 people lost their lives in Asyut, a village 200 km South of the capitol Cairo, impacted by the floodwater and burning oil from a fuel depot which had been hit by the flood, sweeping through the village: Some 2,513 homes collapsed and 42 km^2 of land was flooded, displacing some 100,000 people being made homeless by flooding, affecting a total area of 44,070 km^2.

Israel: Flood impacts recorded for have mainly affected agricultural lands and productivity, causing temporary road blocks and selective evacuations during the incidents of December 1991, May 1997 and October 2000. By far the most severe flood event turned out however, to be the one of February 1992 in aftermaths of unprecedented snow storms during which 15 people lost their lives in avalanches and floodwaters, when snowmelt coincided with constant rainfall providing extreme discharge.

Jordan: Two floods during the year 1966 hit hardest the southern region of Ma'an, costing the lives of 390 people, leaving behind 180 persons injured and 7 missing. In the **1990s**, two major floods hit the country - both, in the north and in the south causing severe damage to property. Flood events during more recent times continued to show similar impacts on urban infrastructure, basic services' installations, such as mains and WWTP, plus roads and airport facilities. Following torrential rains floods in 2004, and 2006 caused major damage to the city of Aqaba in south of the Kingdom, whereas those in 2006 were of regional nature affecting Palestine, Saudi Arabia and Israel. An extreme flood by the end of 2012/beginning of 2013 hit the entire country, demolishing Syrian refugee camps around Ramtha in the north, destroying plantations and fish-farms along the JRV, and road connection between Aqaba and the Dead Sea, plus the Airport Road in Aqaba, associated with loss of lives, damages by mass movements and land-slides hitting roads, houses and private property (**see also Chapter 2.2 - Case Study on Jordan**). Particularly heavy however, were the impacts on urban settlements and infrastructure situated in the areas of alluvial fans, such as in the lower reaches of all wadis in the Aqaba region, notably W. Yutum.

Lebanon: Brief torrential rainfall took the lives of 10 individuals during the floods in October 1987, and left some 200 people displaced, affecting an area of almost 13,000 km^2, causing severe damage throughout the entire Bekka Valley, ruining 80% of the crops and taking the lives of thousands of cattle, flooding most of the mountain villages. This was followed by an event of similar impact severity during December 2002.

Morocco: Due to its physio-geographical setup, Moroccois as frequently infested by floods as Algeria. By far the severest event was recorded for August 1995 during which 166 persons died, 210 got displaced, and affecting an area of nearly 133,000 km^2. The estimated economic damage was reported to be 10 million US $. In November 2002, a flood caused the death of 63 people who drowned in rapidly forming runoff in the western provinces of the country, namely Benslimane, Khouribga and Settat. Flood damages also sparked a fire at the SAMIR oil refinery in the industrial town of Mohammedia, situated between Casablanca and the capital Rabat, becoming a prime deadly natural disaster striking the north African country in more than seven years, associated with the worst floods in 30 years. Except for the east of the Kingdom, the entire country has been affected by floods of which the one in September 1997 caused a death toll of 60 individuals, following brief torrential rainfall, triggering mud-slides and extensive flooding. Floods have caused extensive damage/loss of agricultural land and productivity, making hundreds of people homeless.

Palestine: One single incident in February 1997 has been documented for Palestine, causing 16 fatalities, following heavy rainfalls which lasted for a period of 5 days; **suggesting incomplete records**.

Tunisia: At the end of September 1986, 20 persons lost their lives, and 500 persons got displaced during a low severity flood event, following brief torrential rainfall in the north of the country, near the capital Tunis, throughout adjacent governorates. A second, even more severe flood took the lives of 25 individuals during a period of 13 days at the end of January 1990 in the provinces of Kairouan, Sfax, Kasserine, Gasfa, Sidi Bou Zid, Tozeur, Nefta and Gabes (central Tunisia), displacing some 152,000people, following intense, heavy rainfall. Eighty (80) villages with a total of 25,000 residential units were completely washed away.

1.6 POLICY RECOMMENDATIONS

As outlined throughout the above chapters, an increasing trend in the occurrence of both, drought and flood episodes has been manifesting in the SWIM countries. High-resolution regional climate models for the Eastern Mediterranean give clear scientific backing to the Intergovernmental Panel on Climate Change (IPCC) projections for the region. In its Fourth Assessment Report, the IPCC predicts that, for the southern and eastern Mediterranean, warming over the 21st century will be larger than global annual mean warming. Hence, the need for effective response to any risk potential associated with the devastating impacts of floods and droughts, **evidently underscores the paramount significance of a proper management and highlights the importance of introducing and/or promoting concepts and methodologies for drought and flood risk management to replace the customarily crisis management of drought and flood in the SWIM region** **(See ANNEX 2: EXISTING DROUGHT AND FLOOD MANAGEMENT FRAMEWORKS)****. A well-established risk management system including contingency plans need to be developed and maintained by governments of the region. However, this requires the adoption of enabling policies and legal framework at the national level as crucial elements for the reduction of, and for coping with these two natural hazards.**

Drought and flood risk reduction policies can be standalone policies, or integral parts of disaster risk policies. No matter what form such policies take, they should establish a clear set of objectives or guidelines to govern the management of droughts and floods and their impacts and to guide the development of regional and local policies and plans which are required to achieve those objectives. A national policy and plan **should specify the respective roles of government, local communities and land users, and the resources available and needed to implement appropriate drought and**

flood risk reduction activities. Although these policies will vary to reflect local needs, any drought or flood risk reduction policies should:

- **link drought and flood risk reduction policy/strategy** with the pursuit of poverty reduction and sustainable development.
- **support "prevention, mitigation and preparedness" concept**; involving actions that can be taken prior to the events, rather than reactive approaches and measures, in order to reduce the potential effects of droughts and floods on the people, the economy and the environment.
- **emphasize risk identification** - through adequate drought and flood "characterisation", "monitoring", and "risk and vulnerability analysis" **in the different sectors, systems and regions** - **and risk management,** as the corner stone for risk reduction plans. **This should be coupled with efforts to improve communities' resilience to flood and drought**. **Risk identification will help determine** the regions, populations, and sectors (economic and environmental) that are most vulnerable to drought and flood impacts, **so that** actions can be identified and implemented to reduce and manage those risks. **Ensure that these assessments address the root causes of vulnerabilities and risks** at national, regional/provincial and trans-boundary scales.
- **promote the principles of risk management** by requiring the development of:
  - **reliable forecasts through allocation of resources to**: **maintain** existing meteorological and hydrological networks, **expand** network coverage, **close** data gaps, **gather and archive** supporting information (socio-economic and environmental), **build** consolidated information systems in support of risk identification and monitoring, and **ensure "access to" and "sharing and dissemination of"** data and information.
  - **drought and flood monitoring (early warning systems)** as principal components of drought and flood risk management policies and plans. **Early warning has to be provided timely enough** to allow the timely launching of the implementation of the preparedness plans. Through analysis of historical records, a drought and flood monitoring system can help assess change in the conditions (such as the way in which hazards and/or vulnerabilities are changing with time), and provide early warnings about potential threats to people and activities at risk.
  - **early warning indicators, and linking them with appropriate mitigation and response actions** to ensure effective drought and flood management**, without discounting the role that the communities can play in early warning and preparedness**.
  - **preparedness and mitigation plans at all levels** (national, sub-national/regional and local) **that lay out the strategies to reduce the impacts of water shortage, social and economic hardships, and conflicts between water users (including the environment)**. They should incorporate monitoring and early warning, risk and impact assessment, institutional arrangements and mitigation, response, and recovery actions. (Hamdy, 2004).

    In addition to drought and flood forecasting and warning, and development of preparedness plans, **mitigation programs include a range of short term and long term measures**. The **former includes** relief programs, crop and flood insurance schemes, compensations and changes in land use practices, and public awareness raising. **Other short term mitigation programs in the case of drought include** conjunctive use of surface and groundwater and use of treated wastewater for irrigation. While **Long term measures i**nclude changing crop varieties (towards drought resilient crops), water harvesting, amendments of laws, construction of reservoirs, etc. **In the case of flood,** mitigation programs vary between structural and non-structural measures. **Structural measures** could take the form of improvement of water installations, construction of dams, barriers, reservoirs, dike networks, levees, and road culverts, river channel improvements, and flood proofing and abatement. **Non-structural measures** include controlling land use and planning, property relocation, and acquisition of flood land.

- coordinated emergency response program that ensures timely and targeted relief during emergencies.

- **Integrate drought and flood with water resources planning and management**. Incorporate strategic planning of water resources management for drought and flood preparedness and mitigation. **Such planning consists of measures that are planned in advance involving**: **(a) long-term actions**, oriented to reduce the vulnerability of water systems to drought and flood, and **(b) short-term actions** taken during the drought/flood event, within the existing framework of infrastructures and management policies.
- **incorporate short, mid and long-term strategies to build the resilience of the institutions and communities to droughts and floods**. Building resilience is **achieved** through **knowledge, advocacy, research and training**, **and making information in addition to up-to date approaches accessible to all stakeholders** through educational material, curricula, and public awareness campaigns with the support of the media, civil societies, religious leaders and powerful organisations. **Building the resilience also necessitates reducing the underlying factors of drought and flood risks** through effective and sustainable environmental and water resources management, social and economic development practices, and land use and spatial planning. **Ensure that strategies** for increasing resilience **are implemented and that drought and flood risk considerations are mainstreamed into land use planning and development activities**.
- consider the combination of scientific approaches, and local indigenous knowledge in the development of mitigation programs.
- **provide for participatory and bottom-up approach**; with effective decentralization and active community participation **in planning, decision making, implementation and review of national action programs.** Participation is needed to ensure that preparedness plans are relevant to the local community and are achievable. It will also help create ownership among stakeholders, thus nurturing commitment and responsibility during the implementation phase of the drought and flood policies.
- **Invest in continuous capacity building** in drought and flood risk identification (including vulnerability assessment), monitoring and early warning, and mitigation techniques. **Focus on knowledge development** including communication and awareness raising; **as building stones for ”political commitment”, and for “competent institutions” and “informed communities” that are capable to identify, assess, monitor and reduce the risks at their respective levels (national, regional and local/ communities)**. **Educate people in flood prone** areas about their role in limiting flood damages and methods of limiting flood losses. **Awareness on the efficient use of water** for effective drought planning and preparedness is also warranted. Coordinated education campaigns should target all levels of the community on the importance of water conservation and tap the knowledge of the elders.

- **provide for and efficient organisational structure and strong institutional setting** to ensure appropriate **coordination of efforts and oversight of the process** of development and implementation of sectorial drought and flood risk reduction strategies and preparedness plans **including progress monitoring**.
- **Clearly designate the responsibility for undertaking mitigation and response actions, to the relevant competent institutions/agencies and stakeholders**. Provide for **regular review** and progress reports on the implementation of mitigation actions and contingency plans. **Modify these actions and update these plans based on their effectiveness, and efficiency in managing the risks, at the different levels, while taking also into consideration changing circumstances and the local specificities (socio-economic, biological and physiographic conditions**);
- **promote policies which develop cooperation and coordination** between donors and the government, the local populations and communities, and facilitate access to appropriate information and technology.
- **support partnership with regional organisations** in order to (a) promote exchange of experience and know-how, (b) support efforts to develop and/or sustain national coping and management capabilities, (c) assist in adapting international capabilities and specialised knowledge/advice to the particular needs of the individual SWIM countries, and (d) facilitate trans-boundary cooperation in the development and implementation of effective drought and flood risk reduction actions and responses, and/or the development of regional early warning system and capacities.
- **Encourage the private sector in developing adaptation capacities** within its business context to ensure business continuity. Foster the role it can play in drought and flood risk reduction through the provision of technical skills, donations, communication and dissemination of risk reduction measures and early warnings.
- **Invest in mitigation and recovery through the establishment of crop/agricultural insurance systems** that protect the farmers and livestock breeders against droughts or floods induced losses (or any other natural hazards) [45]. **Insurance mechanisms are preferred to ad hoc disaster aid**, since the latter encourages farmers to neglect their responsibility for managing their own business risk. In order to discourage production in marginal situations by indiscriminately covering crop losses through disaster aid – e.g. in fragile arid zones, or flood-prone areas, **criteria for insurance should be linked with farmers' reduced vulnerability practices in relation to the drought and flood hazards**.
- **Micro-finance strategies** used in arid agricultural zones can be also be tested and extended to the agricultural and pastoral sectors in the PCs. **Micro-credit can help farmers acquire both, input and conservation techniques.** It can help pastoralists replace livestock after getting struck by a hazard, and can protect from incidences of crop failure and animal losses. As in the case of insurance, **eligibility for financial aid should be strongly tied with the best use of natural**

[45] Morocco is one of the SWIM-PCs that adopted insurance in agricultural activities affected by drought which accounts for partial coverage of operating costs per hectare, given the differences between the estimated average and the actual yields (Bernardi, 1996). There is presently a range of innovative agricultural insurance schemes and risk management techniques that have been developed, and can be adapted for use according to the local specificities in the PCs. For further information, the reader is referred to Kang M. G., 2007. Innovative agricultural insurance products and schemes; available at ftp://ftp.fao.org/docrep/fao/010/a1162e/a1162e00.pdf

resources through the adoption of conservation techniques and long-term sustainability measures to protect natural resources.

Finally **the development of a drought or flood management policies should be associated with the establishment and enforcement of the legal framework and supporting legislations to ensure that drought and flood risk reduction policies are carried out and implemented**. **Political commitment and financial investment in prevention, mitigation and preparedness** measures are also **essential** to reduce the effects of drought and flood hazards. **Evaluation of economic benefits of shifting from a reactive to risk based approach** in several **countries indicate significant savings that can range from 50% to more than 80%.**

REFERENCES

1. Abdallah C., 2007. Use of GIS and remote sensing for mass movement modeling in Lebanon. PhD. Thesis, Université Pierre et Marie Curie Paris 6, France, 300p.
2. Abdel-Rahman, Gad and Younes, 1994.Cited by UNEP via weblink: http://www.unep.org/dewa/africa/publications/aeo-1/038.htm: AFRICA ENVIRONMENT OUTLOOK - Past, present and future perspectives.
3. Abdo, k., 2009. Agricultural Drought: changing perception of planning and management; paper submitted to the 2nd International Conference on the Palestinian Environment; Annajah National University, Nablus , Palestine. http: //scholar.najah.edu/sites/default/files/conference-paper/agricultural-drought-changing-perception-planning-and-management.pdf
4. Aiguo D., 2010. Droughtunder Global Warming. National Center for Atmospheric Research, Boulder, Colorado, USA, John Wiley & Sons Ltd. DOI: 10.1002wcc.81
5. Al-Quda K. A., 2011. Floods as Water Resource and as a Hazard in Arid Regions: a Case Study in Southern Jordan. Jordan Journal of Civil Engineering, Volume 5, No. 1, pp. 148-161.
6. Al-Weshah R. and El-Khoury F.,1999. Flood Analysis and Mitigation for Petra Area in Jordan. Journal of Water Resources Planning and Management, Vol. 125, No. 3, pp. 170-177.
7. Ameziane T., BelghitiM., BenbenisteS., Bergaoui M., BonaccorsoB., CancelliereA., ChristofidesT., Confederación Hidrográfica del Tajo, CubilloF., Euchi L., GabiñaD., GarridoA., GarroteL., HajispyrouS.,IbáñezJ.C., IglesiasA., Keravnou-PapailiouE., LapeñaA., LebdiF., López-FrancosA., LouatiM.H., MathlouthiM., MellouliH.J., MoneoM., OuassouA., PangalouD., PashardesP., QuirogaS., RossiG., RostandiN., SaraçogluD., SibouT., TigkasD., TsakirisG., TsiourtisN., VangelisC., and ZiyadA., 2007. Drought Management Guidelines. European Commission - EuropeAid Co-operation Office Euro-Mediterranean Regional Programme for Local Water Management (MEDA Water) and Mediterranean Drought Preparedness and Mitigation Planning (MEDROPLAN), pp. 78.
8. Arab Centre for the Study of Arid Zones and Dry Lands (ACSAD) and International Strategy for Disaster Reduction (ISDR), (2011) "Drought Vulnerability in the Arab Region. Case Study- Drought in Syria-Ten Years of Scarce Water (2000 – 2010)" Arab Center for the Studies of Arid Zones and Dry Lands. P.O.Box:2440 Damascus, Syria, andUnited Nations, Secretariat of the International Strategy for Disaster Reduction,Regional Office for Arab States, Cairo, Egypt.
9. Attia B., unknown date. Assessment of Vulnerability and Adaptation of Water Resources to Climate Change in Egypt http://en.wikipedia.org/wiki/Aswan_Dam#Irrigation_scheme
10. Baas S., Ramasamy S., DePryck J.D., Battista F., 2008. Disaster Risk Management Systems Analysis: A Guide Book. Environment, Climate Change and BioEnergy Division, Food And Agriculture Organization of the United Nations (FAO), Rome, January 2008
11. Bernardi M., 1996. La planification des stratégies contre les effets de la sécheresse. Available at http://www.fao.org/sd/frdirect/eian0005.htm
12. Bin BoubakerH, 2007. Evaluation des systèmes existants d'Alerte Précoce à la Sècheresse en Tunisie. Projet LIFE. Janvier, 2007.

13. CEPF, 2010.Ecosystem profile of the Mediterranean Basin Biodiversity hotspot. Conservation International, Washington D.C., USA, 251 p. In Mediterranean Wetlands Observatory (2012). First Technical Report. Mediterranean Wetland Outlook, Arles, France.

14. Chbouki N., 1992. Spatio-temporal characteristics of drought as inferred from tree-ring data in Morocco. Ph. D. University of Arizona. USA. *In* Options Méditerranéennes, Series B, No. 58, Chapter 19. Application of the Drought Management Guidelines in Morocco by OuassouA., Ameziane T., Ziyad A. and Belghiti M.

15. Département de l'Environnement, 2008. Ministère de l'Energie, des Mines, de l'Eau et de l'Environnement, Etude pour la Réalisation d'une Cartographie et d'un Système d'Information Géographique sur les Risques Majeurs au Maroc. Mission 1, Identification des Risques - Le Risque D'inondation. Septembre 2008.

16. EEAA, 2010.Egypt Second National Communication to UNFCCC. Egyptian Environmental Affairs Agency, Cairo, Egypt.

17. Elasha Osman B., 2010. Climate Change Adaptation: Options and Good Practices for the Arab Region. Unpublishedreport commissioned by the United Nations Development Programme - Regional Bureau for Arab States). Available at: http://www.arabclimateinitiative.org/knowledge/background/Balgis_CC_Adaptation-AG-Clean2.pdf

18. Erian W., 2011. Drought on trans-boundary rivers' basins in the Arab world. Challenges to future, are we ready? Second Arab Water Forum.

19. Erian W., 2013. Agriculture Drought and Land Degradation Risk in Arab Region. Presentation to the First Arab Regional Conference for Disaster Risk Reduction, 19-21 March, Aqaba, Jordan.

20. Eriyagama N., Vladimir S., and Nilantha G., 2009. Mapping drought patterns and impacts: a global perspective. Colombo, Sri Lanka: International Water Management Institute. 31p. (IWMI Research Report 133).

21. ESCWA, 2005. Economic and Social Commission For Western Asia. ESCWA Water Development Report 1: Vulnerability of The Region to Socio-Economic Drought, United Nations, New York, 2005.

22. FAO, 2008. The Regional Office for the Near East, Cairo, Egypt, National Drought Mitigation Center, University of Nebraska-Lincoln, Nebraska, USA, 2008. The Near East Drought Planning Manual: Guidelines for Drought Mitigation and Preparedness Planning, September 2008

23. Froukh L., 2010. The impact and management of recent drought on the West Bank groundwater aquifer system. In: López-Francos A. (comp.), López-Francos A. (collab.). Economics of drought anddrought preparedness in a climate change context. Zaragoza : CIHEAM / FAO / ICARDA / GDAR /CEIGRAM / MARM, 2010. p. 279-283 (Options Méditerranéennes : Série A. Séminaires Méditerranéens; n. 95)

24. Göbel W and De Pauw E., 2010. Climate and Drought Atlas for parts of the Near East A baseline dataset for planning adaptation strategies to climate change". .International Center for Agricultural Research in the Dry Areas, ICARDA. Available at

https://dl.dropboxusercontent.com/u/33140444/Publications/EMed_%20Final%20Report_Final_v2%26maps.pdf#!

25. Hamdy A., 2004. Drought Preparedness and Mitigation in the Mediterranean Region. In: Water Management for Drought Mitigation in the Mediterranean. Options Méditerranéennes, Série B n. 47.
26. Hazell P., Oram P., andChaherli N., 2001. Managing droughts in the low-rainfall areas of the Middle East and North Africa, EPTD Discussion Paper No. 78. Env. and Prod. Techn. Div., Intl. Food Policy Res. Inst., Washington DC, USA.
27. Iglesias A., Moneo M., and Lopez-Francos, A., 2007. Drought Management Guidelines Technical Annex. Technical Annex of the MEDROPLAN Drought Management Guidelines, issued as a result of the MEDROPLAN Project. Méditerranéennes, Série B 58. Zaragoza : CIHEAM (Centre International de Hautes Études Agronomiques Méditerranéennes)/EC MEDA Water (Euro-Mediterranean Regional Programme for Local Water Management of the European Commission), 496 pp.
28. IPCC, 1998. The regional impacts of climate change: An assessment of vulnerability. A special report of the Intergovernmental Panel on Climate Change Working Group II. Cambridge Univ. Press, Cambridge.
29. Kang M. G., 2007. Innovative agricultural insurance products and schemes. Agricultural management, marketing and finance, occasional paper No. 12. Food and Agriculture Organization of the United Nations, Rome. Italy.
30. Kassas M., 2008. Aridity, Drought and Desertification. In Arab Environment: Future Challenges. (Eds. Mostafa K. Tolba and Najib W. Saab). Report of the Arab Forum for Environment And Development (AFED).
31. Laatri et al., unknown date. Drought in Tunisia – Unpublished Case Study under the Multilateral SMAS (Maghrebian System of Warning about Drought) Project (from 2006-2009), including participating partners from Tunisia, Algeria and Morocco.
32. Ludwig W., Meybeck M. and Abousamra F., 2003. Riverine transport of water, sediments and pollutants to the Mediterranean Sea. MAP Technical Report Series No.141. UNEP/MAP, Athens, 111 pp: In Mediterranean Wetlands Observatory (2012). First Technical Report. Mediterranean Wetland Outlook, Arles, France.
33. MAEWR, 2004. Optimal Management of Drought and Water Resources: Tunisian Case, Palermo, Italy, 8-9 October 2004.
34. MATE, 2001; Elaboration de la stratégie et du plan d'action national des changements climatiques. Communication Nationale Initiale; Alger, Algérie
35. MATE, 2010. Seconde Communication Nationale de l'Algérie sur les Changements Climatiques à la Convention-Cadre des Nations Unies sur les Changements Climatiques (CCNUCC).
36. Meddi H. and Meddi M., 2009.Etudes de la Persistance de la Sècheresse au niveau de Sept Plaines Algériennes par utilisation Des Chaines de Markov (1930-2003), Courrier du Savoir – N° 09, Mars 2009, pp. 39-48.
37. Meddi H. and Meddi M.,2013, Régionalisation et cartographie des précipitations Dans le

Nord Ouest de l'Algérie.

38. MEMEE, 2001. Executive Summary, First National Communication to the United Nations Framework Convention on Climate Change. Morocco, October, 2001.
39. MEMEE, unknown date. the Moroccan Ministry of Energy, Mines, Water and Environment, Les changements Climatiques au Maroc; available at http://www.minenv.gov.ma/PDFs/CLIMAT/changements_climatiques.pdf
40. MEP, 2010. Israel's Second National Communication on Climate Change Submitted under the United Nations Framework Convention on Climate Change. Jerusalem, November, 2010.
41. MICL, unknown date. Les Inondations en Algérie. .Available at: http://www.protectioncivile.dz/pdf/raport%20sur%20les%20inondations%20pour%20DP%20ET%20CABINE1.pdf
42. Ministère de l'Agriculture, 2012. Etude de Révision et d'Aménagement du Code Des Eaux. Etape III. Projet du Loi Portant Refonte du Code des Eaux et Décrets d'Application. Version Définitive. Tunisie.
43. Ministry of Water and Irrigation (MWI), 2013.. Rainfall data from 1961/62-2010/11.
44. MOE-JO, 2009.Second National Communication Report to the United Nations Framework for Climate Change Convention on Climate Change.
45. MOE-LB (MOE), 2011. *Lebanon's second national communication*., United National Development Programme and Global Environment Facility.
46. MWO, 2012. First Technical Report. Mediterranean Wetland Outlook, Arles, France.
47. MWSDWG, 2007. Mediterranean Water Scarcity & Drought report. Technical Report on Water Scarcity and Drought Management in the Mediterranean and the Water Framework Directive.
48. MWSDWG, 2010. State of the art on Drought & Water Scarcity in the Mediterranean: Monitoring water scarcity and drought in the Mediterranean Synthesis note.
49. Nasr M., 1999. Assessing Desertification and Water Harvesting in the Middle East and North Africa: Number 10 - Policy Implications, ZEF – Discussion Papers on Development Policy, Rheinische Friedrich-Wilhelms-Universität Bonn, Bonn.
50. OuassouA., AmezianeT., Ziyad A., and Belghiti M.,2005. Options Méditerranéennes, Series B, No. 58, Chapter 19. Application of the Drought Management Guidelines in Morocco. *In* Iglesias A. (ed.), Moneo M. (ed.). Drought preparedness and mitigation in the Mediterranean: Analysis of the organizations and institutions, CIHEAM, 2005.
51. PNUD, 2009. Problématique du secteur del'eau et impacts liés auclimat en Algérie, Algérie, 7 March 2009.
52. Rabi A., Khaled A. and Carmi, N., 2003. Drought occurrence and impact on the Eastern Groundwater BasinWest Bank/Palestine. Hydrology of the Mediterranean and Semiarid Regions (Proceedings of an international symposium held at Monlpellier, April 2003, edited by Servat, E. et al. IAHS Publ. no. 278.
53. Shaban A., 2009. Indicators and Aspects of Hydrological Drought in Lebanon; Water

Resources Management (2009) 23:1875–1891, DOI 10.1007/s11269-008-9358-1

54. Shaban A., 2011. Analyzing Climatic and Hydrologic Trends in Lebanon, Journal of Environmental Science and Engineering, 5 (2011) 483-492.
55. Sherif Arif et Fadi Doumani. 2012. Tunisie, Coût de la Dégradation des Ressources en Eau du Bassin de la Medjerda. Programme de Gestion Intégrée Durable de l'Eau (SWIM-SM) financé par la Commission européenne.
56. Stour L., and Agoumi A., 2008. Sécheresse climatique au Maroc durant les dernières décennies, Hydroécol. Appl., Tome 16, pp. 215–232
57. Tarolli P., Borga M., Morin E. and Delrieu G., 2012. Analysis of flash flood regimes in the North-Western and South-Eastern Mediterranean regions. Natural Hazards Earth Systems. Sci., 12, 1255–1265, 2012. Published by the Copernicus GmbH (Copernicus Publications).
58. The Government of Egypt, 2005. National Report and information on Disaster Risk Reduction, presented tothe World Conference on Disaster Reduction, Kobe-Hyogo, Japan in 2005.
59. UN, 2013. Framework Convention on Climate Change (FCCC) - Best practices and available tools for the use of indigenous and traditional knowledge and practices for adaptation, and the application of gender-sensitive approaches and tools for understanding and assessing impacts, vulnerability and adaptation to climate change - Technical Paper 2013/11 (unpublished)
60. UNEP, 2010. Review of Adaptation Best Practice in the Nile River Basin Region. Available at: http://www.unep.org/climatechange/adaptation/Portals/133/documents/NileRiverBassin/Adaptationbestpractice_NileRiverBasin.doc
61. UNEP, 2011. Mainstreaming Drought Risk Management - a primer. (unpubl. Report for UNDP, Nairobi).
62. UNISDR, 2013. Background Paper prepared for the Global Assessment Report on Disaster Risk Reduction 2013, Agriculture Drought in Africa Mediterranean and Middle East. Geneva, Switzerland.
63. USAID, Improved Drainage and Flood Control for the Aqaba Special Economic Zone Authority, Volume 1: Final Flood Protection Master Plan for Wadi Yutum and Adjacent Coastal Wadis, December 2011.Study implemented by CDM International, Inc.
64. Venton P., 2012. Drought Risk Management - Practioner's Perspectives from Africa and Asia. (unpubl. Report for UNDP, New York)
65. WMO et al., eds.(2009). Integrated Flood Management Concept Paper. WMO-No. 1047, Geneva.
66. World Bank, 2009. West Bank and Gaza assessment of restrictions on Palestinian water sector development. Report No. 47657-GZ.
67. WWF, 2006. World Wide Fund for Nature. Drought in the Mediterranean: WWF Policy Proposals. Rome (Italy).
68. Zaide, M., unknown date. Drought and Arid Land Water Management. CSD-16/17 National Report Israel 1/11 Planning Division, Water Authority, Ministry of National Infrastructure, Israel.

69. Ziv B.,SaaroniH., Pargament R., Harpaz T.and Alpert P., 2013.Trends in rainfall regime over Israel, 1975–2010, and their relationship to large-scale Variability. Regional Environment Change. Volume 13 – Number 1 – February 2013

Websites consulted:

70. http://en.wikipedia.org/wiki/Aswan_Dam#Irrigation_scheme

71. http://info.worldbank.org/etools/docs/library/114813/bestcourse/docs/Course%20Projects/Best%20End%20of%20Course%20Projects/SVETLANA/Ousalem%20-%20final%20project.pdf

72. http://www.dalilasso.com/information-sur-les-associations-maroc/news/news,631-strategies-de-gestion-des-risques-d-inondations-au-maroc.html

73. http://www.dartmouth.edu/~floods/Archives/index.html

74. http://www.desinventar.net/desinventar/

75. http://www.desinventar.net/DesInventar/profiletab.jsp?countrycode=jo

76. http://www.disaster-report.com/2013/02/recent-natural-disasters-list-february-2.html

77. http://www.euromedcp.eu/index.php?option=com_content&view=article&id=721&Itemid=1070&lang=en

78. http://www.haaretz.com/print-edition/news/despite-winter-rainfall-drought-prevails-1.297542

79. http://www.iamz.ciheam.org/medroplan/guidelines/examples_tunicia_drought.html

80. http://www.independent.co.uk/news/israeli-drought-cuts-off-jordans-water-supply-1080964.html

81. http://www.irinnews.org/report/84715/israel-drought-declared-as-five-dry-winters-take-their-toll-

82. http://www.israelnationalnews.com/News/News.aspx/151330

83. http://www.sdc-drr.net/system/files/ckeditupload/L.%20FS%20RRD%20Carte%20des%20risques.pdf

84. http://www.trust.org/item/?map=jordan-readies-its-first-policy-on-climate-change

ANNEX 1: LIST OF FLOOD EVENTS IN THE PCS (1985-2009); AS RECORDED BY THE DARTMOUTH FLOOD OBSERVATORY

The source of these tables is the Global Active Archive of Large Flood Events; http://www.dartmouth.edu/~floods/Archives/index.html

ALGERIA

Detailed Locations (Algeria)	River	Began	Ended	Duration in Days	Dead	Displaced	Damage (USD)	Main cause	Severity *	Affected km2	Magnitude (M)**	Notes and Comments
Eight desert cities in the valley of M'Zab, the largest of which is Ghardaia		26-Jan-09	27-Jan-09	2	33			Heavy Rain	1.0	132800	5.4	33 people killed and 48 injured. The flooding affected eight desert cities in the valley of M'Zab, the largest of which is Ghardaia, which is located about 600 kilometres south of the capital Algiers. The sudden storms caused the M'Zab river to overflow its banks in less than 20 minutes.
The region of Bechar (South west of Algeria); the oasis town of Ghardaia 700 kilometres south of the capital, the adjacent district of Ourghla, the town of Tebessa 600 kilometers east of Algiers, M'zab 600 kilometers south of the capital		1-Oct-08	17-Oct-08	17	65			Torrential Rain	2.0	34760	6.1	Eight people reported drowned in the southwest of Algeria...The incidents occurred in the region of Bechar, more than 1,000 kilometres (600 miles) from the capital Algiers, after the normally arid region was hit with heavy rain. 30 people dead in Algerian oasis town of Ghardaia and 50 others wounded. The town, 700 kilometres south of the capital Algiers, is home to 100,000 people.Between 300 and 600 houses were inundated. Gas and electricity supplies have been cut and food stores waterlogged. Two people dead in the adjacent district of Ourghla and four died farther to the north in the town of Tebessa, some 600 kilometers (370 miles) east of Algiers. 1,400 houses were severely damaged in this medieval town located in a long and

Detailed Locations (Algeria)	River	Began	Ended	Duration in Days	Dead	Displaced	Damage (USD)	Main cause	Severity *	Affected km2	Magnitude (M)**	Notes and Comments
												narrow valley known as the M'zab, about 370 miles (600 kilometers) south of the capital"
Eastern province of Batna.		15-Jul-08	16-Jul-08	2	3				1.0	76330	5.2	Three people dead and more than 30 injured in flash floods and heavy torrential rain in the eastern province of Batna.
Setif province, Batna region		10-May-08	12-May-08	3	7			Heavy rain	1.0	20670	4.8	Heavy rains cause flash floods. Roads damaged. No specific areas mentioned.
Algiers - Bab El Oued, Bologhine, Bainem, Rais Hamidou, Bouzareah and Bousmail Municipalities. Boumerdes region - Dellys, Sidi Daoud. Oran Province - El-Hamri . Tizi Ouzou. Blida Province. Tssala al-Mardja	Beni Messous	24-Nov-07	02-Dec-07	9	15	1,200		Heavy rain	1.0	21400	5.3	Several days of heavy rain and storms in northern Algeria causes severe flooding and mudslides in Algiers. 11 dead. 3 missing. 400 families evacuated Oran province - 5 dead. Boumerdes - 3 dead in Dellys area.
Provinces: Tizi Ouzou, Algiers, Msila, Laghouat and Oran. Towns: M'sila, Laghouat, Medea	Tegnana	30-Oct-07	02-Nov-07	4	4			Heavy rain	1.0	102100	5.6	Storms cause flooding in western and central Algeria. Floods persist for 4 days in Tizi Ouzou Province.
central Algeria	0	3-Oct-07	04-Oct-07	2	5	0	0	Heavy rain	1.0	360200	5.9	Flash floods from violent storms in central Algeria. Exact locations not specified.

Detailed Locations (Algeria)	River	Began	Ended	Duration in Days	Dead	Displaced	Damage (USD)	Main cause	Severity *	Affected km2	Magnitude (M)**	Notes and Comments
east central provinces - Batna Province, M'sila Province - S'lim municipality. Biskra	Mesrane, Mita	21-Sep-07	24-Sep-07	4	18	0	0	Heavy rain	1.0	78590	5.5	Violent storms and flash floods kill 18. Houses collapsed. A number of towns and villages isolated. tens of hectares crops destroyed. Bridges destroyed.
M'sila region - Souamma	Oued Tamsa	13-Apr-07	15-Apr-07	3	15	0	0	Heavy rain	1.0	7100	4.3	Heavy rains cause flash floods. 15 dead, 7 missing. Many homes washed away. Crops submerged. 600 cattle lost. Roads damaged, several bridges destroyed.
Northern Algeria - Djelfa region. Eastern part of Algiers city.	0	7-Mar-07	11-Mar-07	5	3	0	0	Heavy rain	1.0	53230	5.4	Storms cause flash flooding. More than 100mm rain in a few hours in Djelfa region. 30 houses flooded in eastern Algiers city when a river overflowed for the first time in 15 years.
Northern Regions - Tipaza, Naama, Tizi Ouzou, M'sila	0	3-May-06	08-May-06	6	6	0	0	Heavy rain	1.0	55690	5.5	
Tindouf: Awserd, Smara, Laayoune refugee camps	0	10-Feb-06	15-Feb-06	6	1	60,000	1,070,820	Heavy rain	1.0	180500	6.0	Three refugee camps flooded (Western Sahara Sahrawi refugees). Enormous structural damage to schools, community centres, market areas, and mud brick houses. 70% of food lost. Most severe flooding since 1994. (MODIS observations of flooding on February 15)
Southern Algeria - regions of Alisi, Adrar and Tamenrast		6-Mar-05	09-Mar-05	4	3			Heavy rain	1.0	436800	6.2	Heavy rain in Sahara floods wadis. 3 dead, 9 missing, 70 rescued by helicopters. Damage to roads, agriculture, infrastructure. Several villages inundated. (MODIS observation of wet channels in the desert west of Tamanrasset on March 7, 9)

Detailed Locations (Algeria)	River	Began	Ended	Duration in Days	Dead	Displaced	Damage (USD)	Main cause	Severity *	Affected km2	Magnitude (M)**	Notes and Comments
Berber region - Tizi Ouzou area. Naama region - Assa, Asla. Ain Sefra. Saida, Mascara.		15-Oct-03	18-Oct-03	4	13				1.0	51770	5.3	Rain and hail storms bring flooding and mudslides; "concentrated mainly in three western regions" "heavy rains damaged roads, houses and crops"
Central Algeria - Sahara - Reggane, Tamanrasset		9-Aug-03	11-Aug-03	3	13			Heavy rain	1.0	78730	5.4	Torrential rainstorms cause extensive damage to residential areas, roads and farmland.
Eastern Algeria - Batna area, Zeribet El-Oued near Biskra, El-Hadjeb wadi. Hamma and Boutaleb in the Setif region.		9-Oct-02	12-Oct-02	4	13			Heavy rain	1.0	23940	5.0	
Eastern Algeria - Regions - Tebessa, Oum El Bouaghi, Batna, Mila, Khenchela. Towns: Oued Aouf, Taxent, Teleghma, Dahouara. River: Oued El Hadjama		17-Aug-02	28-Aug-02	12	28	500	1,500,000	Heavy rain	1.0	25340	5.5	Regions of Mila, Oum El Bouaghi, Batna, and, to a lesser degree, Khenchela: Hundreds of homes flooded or battered by hail in the storms and vast patches of farmland destroyed.
Western Algeria - Regions of Naama and Tlemcen. Town: Ain Sefra, Sidi Bel Abbes, Relizane and El Bayadh -- --Eastern Morocco - eastern region of Taza		22-Oct-00	25-Oct-00	4	28	400		Brief torrential rain	1.0	101500	5.6	Six people dead and a dozen missing in western Algeria, near the border of Morocco. Total FATALITIES reached 28 and 100 DISPLACED in Algeria and 300 in Morocco:
Hachima, Bouria, Bechloul		23-Sep-98	24-Sep-	2	1	700		Brief torrential	1.0	15760	4.5	

Detailed Locations (Algeria)	River	Began	Ended	Duration in Days	Dead	Displaced	Damage (USD)	Main cause	Severity *	Affected km2	Magnitude (M)**	Notes and Comments
			98					rain				
Eastern Algeria: Annaba		23-Apr-96	30-Apr-96	8	5			Heavy rain	1.0	101900	5.9	Worst flooding was around the port city of Annaba.
Eastern High Plateau Regin: Oum El Bouaghi		22-Sep-95	24-Sep-95	3	5			Brief torrential rain	1.0	62910	5.3	Annual autumn rains.
Provinces: Bordj Bou Arreridj, Tiaret, Bouira, Tissemslit, Naama, Djelfa, Adrar		21-Sep-94	26-Sep-94	6	32	1,200		Heavy rain	1.0	108200	5.8	Crops damaged.
Relisan province - Oued-Rhiou city. Flooding also reported in provices of Chlef and Tiarette.		19-Oct-93	20-Oct-93	2	22			Heavy rain	1.0	39700	4.9	
Departments - Alger, Tipaza, Blida, Ain-Defla		21-Jan-92	29-Jan-92	9	18	500	900,000	Heavy rain	1.0	12840	5.1	
Provinces - Oum El-Bouaghi, Tebessa, Khenchlahtit		1-Jun-91	04-Jun-91	4	17	1,000		Heavy rain	1.0	32280	5.1	Flooded rivers carried away dozens of cattle and severely damaged crops.
Northeastern		1-Jan-85	05-Jan-85	5	26	3,000		Heavy rain	1.0	92620	5.7	
Algiers city and surrounding towns- Districts: Bab el Oued, Triolet, Ain Benina, Oued Korich, Rais, Hamidou, Hammamet. Frais Vallon region. Other towns: Chlef,		10-Nov-01	14-Nov-01	5	711	24,000	300,000,000	Heavy rain	1.5	970	3.9	Mudslides that plowed through several of the hilly capital's working-class neighborhoods, collapsing buildings, blocking roads, overturning vehicles and knocking out power. Thousands of families were forced to leave their homes ... The flood followed a prolonged drought that forced water-rationing. "One of the worst natural disasters

Detailed Locations (Algeria)	River	Began	Ended	Duration in Days	Dead	Displaced	Damage (USD)	Main cause	Severity *	Affected km2	Magnitude (M)**	Notes and Comments
Tipaza, Relizane, Tiaret, Tlemcen, Mascara, Ain Tenouchent, Bourmerdes, Oran, Mostaganem, Medea, Tizi-Ousou.												in four decades caused by 36 hour downpour“

EGYPT

Detailed Locations (Egypt)	Began	Ended	Duration in Days	Dead	Displaced	Damage (USD)	Main cause	Severity*	Affected km^2	Magnitude (M)**	Notes and Comments
Southern Sinai, Hurghada, and Aswan Governorate.	18-Jan-10	19-Jan-10	2	10	7,000		Torrential Rain	1.5	226100	5.8	Flash floods on and after 18 January left 780 homes totally destroyed, 1,076 submerged and the area suffered material losses of over US$25.3 million.. The floods ruined 59km of roads, killed 1,838 animals and felled 27,820 (mostly olive) trees. The total death toll due to the flooding in the southern Sinai Desert reached 10. Clashes between the bedouins (angry that the government was downplaying the magnitude of their losses) and the security forces in South Sinai injured a senior police officer and two of his men. - Heavy rain and flooding also forced hundreds of people from their homes in Khan Younis in the south of the Gaza Strip.. About 115 homes were damaged and the sewage system was reported to be overflowing. Over 100 families had been made homeless. Gaza's poor infrastructure is unable to cope, and there was a risk that sewage mixed with floodwater could cause communicable and water-borne diseases. - Evacuation of 75 patients at the El-Arish general hospital in the Sinai. Some 300 families

Detailed Locations (Egypt)	Began	Ended	Duration in Days	Dead	Displaced	Damage (USD)	Main cause	Severity*	Affected km²	Magnitude (M)**	Notes and Comments
											were also displaced. - In the southern city of Aswan, floods and strong winds disrupted power in several neighbourhoods., - In the city of Luxor: power failures in several neighborhoods. Disruption of Nile cruises, sailboat and ferry schedules. - In neighboring Israel, a woman drowned when her car was caught in a flash flood in the south, where stormy weather also blocked the main road to the Red Sea resort of Eilat. - A bridge collapsed near a cargo crossing between Egypt and Israel. - Damage to the roof of Sharm el-Sheik's old airport
Southern Egypt - Shalatein	9-Mar-02	11-Mar-02	3	4	800		Heavy rain	1.0	560	3.2	"Floods hit Shalatein, on the Red Sea, about 900 kilometers southeast of Cairo. A mother and her three children died when their Bedouin house collapsed...A large number of sheep also died and around 200 Bedouin tents and houses were reported destroyed."CAUSE:Rain
Mansura, the Delta - Damiette province, Sinai peninsula	10-Dec-97	14-Dec-97	5	4			Heavy rain	1.0	113100	5.8	10 hr storm in Damiette province, the hardest hit area.
Aswan Province, Suez Province, Zafarana, Sinai peninsula	17-Oct-97	23-Oct-97	7	12			Heavy rain	1.0	307600	6.3	
North: Cairo region	2-Mar-97	04-Mar-97	3	4			Heavy rain	1.0	68460	5.3	
Provinces: Aswan, Sohag, Asyut, Minya, Qena	13-Nov-96	25-Nov-96	13	23	1,050		Heavy Rain	1.0	37940	5.7	Thousands of acres of land flooded. 260 houses destroyed.

Detailed Locations (Egypt)	Began	Ended	Duration in Days	Dead	Displaced	Damage (USD)	Main cause	Severity*	Affected km^2	Magnitude (M)**	Notes and Comments
Provinces: Asyut - Dronka (Durunka), Sohag, Qena	2-Nov-94	08-Nov-94	7	593	100,000	500,000,000	Heavy rain	1.5	44070	5.7	Flood waters carrying burning oil from a fuel depot swept through Dronka. 507 killed in Dronka, 86 killed by flooding in other provinces. Sohag: 750,000 oxen, goats, sheep, and poultry killed. 2,513 homes collapsed and 4,200 hectares (10,400 acres) of land flooded.
Sidi Abdel-Qadar	5-Dec-91	06-Dec-91	2		6,000		Dam/Levy, break or release	1.0	3170	3.8	Irrigation Dam cracked, flooding the village.

ISRAEL

Detailed Locations (Israel)	Rivers	Began	Ended	Duration in Days	Dead	Displaced	Damage (USD)	Main cause	Severity *	Affected Km^2	Magnitude (M)**	Notes and Comments
Northern Isreal - Western Galilee - Nahariya area and Kafr Mazra'a.	Nahal Ga'aton, Nahal Beit Ha'emek.	29-Jan-03	30-Jan-03	2	0	150		Heavy rain	1.0	276	2.7	Extensive flooding and property damage in the Nahariya area. Level of Lake Kinneret raises 15cm in few days.
Qumran	0	12-May-07	13-May-07	2	4	21	0	Heavy rain	1.0	320	2.8	Flash floods from rare downpour in Qumran area kill four and 21 rescued from floods. "The area averages about 2 inches of rain annually, but the recent storm dumped 1.97 inches"
Dan region - Tel Aviv area. Bat Yam, Holon, Kikar Struma.		21-Jan-03	22-Jan-03	2	0			Brief torrential rain	1.0	330	2.8	80 millimeters of rain in four hours. extensive flooding in Tel Aviv; over 50 buildings flooded.
Tel Aviv area, Jaffa; Gaza Strip		24-Oct-00	26-Oct-00	3	1	600		Heavy rain	1.0	3000	4.0	"Naval commandos rescued trapped families from their balconies as rain-driven floods swept across the Tel Aviv area, temporarily closing the city's main highway and driving hundreds of residents from their homes" CAUSE:Heavy rain - 3

Detailed Locations (Israel)	Rivers	Began	Ended	Duration in Days	Dead	Displaced	Damage (USD)	Main cause	Severity *	Affected Km^2	Magnitude (M)**	Notes and Comments
												inches of rain fell in six hours
Jordan Valley, Wadi Ara, Musmus, West Bank, Megilot district, Julis, Western Galilee	0	2-Apr-06	03-Apr-06	2	5	0	0	Brief torrential rain	1.0	11510	4.4	Up to 2 meters of floodwater. One of Israel's rainiest days during the year - more than 112 mm of rain in Jerusalem, 67 mm in Tel Aviv, 21 mm in Haifa, 17 mm in Beersheba. Western Galilee agriculture, crops and greenhouses, was hit especially hard. Avocado, litchi and banana crops were severely damaged at Moshav Avdon.
Eilat, Beersheba		24-Mar-91	25-Mar-91	2	8			Brief torrential rain	1.0	12330	4.4	Farmland and highways swamped. Eilat cut off.
Eilat, Beersheba, Negev desert, Qumran area, Jerusalem		17-Oct-97	19-Oct-97	3	15			Heavy rain	1.0	23910	4.9	
Southern and Coastal areas - Tel Aviv		31-Dec-91	03-Jan-92	4		400		Rain and snowmelt	1.5	23370	5.1	400 evacuated from Tel Aviv suburbs, record high water level of 2 ft in the streets. Highest rainfall in Jordan in 40 yrs.
Israel: Jerusalem, Haifa, Fureidis **Jordan**: Amman, Aghwar **Syria**: Jordanian border	Jordan, Yarmouk	1-Feb-92	15-Feb-92	15	15	4,200	9,000,000	Rain and snowmelt	1.5	26220	5.8	Harshest winter in more than 40 years - 15 people dead in floods and avalanches. 30 families evacuated in Fureidis Village (Israel); dozens of families in Tel Aviv, Jaffa area, 4000 in Lebanon; affected 2,800 hectares in Jordan alone. Dam collapse in the Golan Heights on the Jordan River.

Detailed Locations (Israel)	Rivers	Began	Ended	Duration in Days	Dead	Displaced	Damage (USD)	Main cause	Severity *	Affected Km^2	Magnitude (M)**	Notes and Comments
Wadi Ara	Irron	5-Apr-06	07-Apr-06	3	0	0	0	Brief torrential rain	2.0	2500	4.2	130 mm of rain in 3 hrs. Occurs every 100 years.

JORDAN

Detailed Locations (Jordan)	Rivers	Began	Ended	Duration in Days	Dead	Displaced	Damage (USD)	Main cause	Severity *	Affected Km^2	Magnitude (M)**	Notes and Comments
Jizza, Umm Joza district		17-Oct-97	19-Oct-97	3	2			Heavy rain	1.0	24510	4.9	
Amman		22-Feb-97	26-Feb-97	5	4			Heavy rain	1.0	1210	3.8	
Mafrak, Zarka, Maan, Madaba	Jordan	1-Nov-94	04-Nov-94	4	21			Heavy rain	1.0	68730	5.4	Torrential rains rare in Jordan.
Al-Bouweidah area - Ramtha		24-Mar-94	26-Mar-94	3	9	300		Heavy rain	1.0	3810	4.1	Farming region - agricultural damage.
Al-balqa, Amman		24-Mar-91	25-Mar-91	2	5			Brief torrential rain	1.0	3680	3.9	Floods uprooted thousands of trees, flushed farm lands, and killed thousands of sheep.

LEBANON

Detailed Locations (Lebanon)	Rivers	Began	Ended	Duration in Days	Dead	Displaced	Damage (USD)	Main cause	Severity*	Affected km^2	Magnitude (M)**	Notes and Comments
Lebanon - Bekaa valley area -Northern Israel - Jordan River	Jordan River	21-Feb-03	24-Feb-03	4				Heavy rain	1.0	6350	4.4	Severe damage. The entire Bekka valley area affected - flooded mountain villages, lots of

Detailed Locations (Lebanon)	Rivers	Began	Ended	Duration in Days	Dead	Displaced	Damage (USD)	Main cause	Severity*	Affected km^2	Magnitude (M)**	Notes and Comments
overflows, Lake Kinneret rises.												cattle swept away, and 80% of crops ruined.
Sidon, Tyre, Akkar, Kesrouan, Eastern Bekaa valley, Hasbaya, Beirut, Nabatieh.	Sayneeq, Litani, Wazzani, Hasbani, Nahr al-Kabir, Al-Ustuwan, Nahr Ibrahim	20-Dec-02	22-Dec-02	3		300		Heavy rain	1.0	4210	4.1	"The rainfall, coupled with exceptionally strong winds, caused power failures in some areas in Lebanon, particularly in the north where rains swept away about 12 homes. Hundreds of others were partly immersed in water, which in some cases reached two-meters high. Civil Defense workers and army troops evacuated people from 50 homes in the remote town of Akkar near the Lebanese-Syrian border"
Beirut, Central Bekaa Valley		23-Dec-91	28-Dec-91	6	1	2,000		Heavy rain	1.0	10180	4.8	
Lebanon - Eastern Bekaa Valley, Al Assi River north of the town of Baalbeck. -- Egypt - Southestern Sinai Penninsula, Sinai a		17-Oct-87	19-Oct-87	3	10	200		Brief torrential rain	2.0	12690	4.9	

Detailed Locations (Lebanon)	Rivers	Began	Ended	Duration in Days	Dead	Displaced	Damage (USD)	Main cause	Severity*	Affected km^2	Magnitude (M)**	Notes and Comments
Suea												

MOROCCO

Detailed Locations (Morocco)	Rivers	Began	Ended	Duration in Days	Dead	Displaced	Damage (USD)	Main cause	Severity *	Affected km^2	Magnitude (M)**	Notes and Comments
Rabat, Agadir, Taza, Casablanca, Marrakesh, Tangiers, Tetouan		25-Dec-09	26-Dec-09	2	5	25		Torrential Rain	1.0	157500	5.5	Heavy rainfall in Morocco struck large swathes of the country, triggering flash floods that took the lives of five people (in the resort of Agadir, the Chichaoua region between Essaouira and Marrakesh, and near Taza in the country's north-east. In Casablanca and Marrakesh, more than a dozen people were injured when their homes were demolished by floods, and entire neighbourhoods in the towns of Tangiers and Tetouan in the country's north also found themselves underwater"
Northern and Central Morocco		1-Feb-09	12-Feb-09	12	24	2,000		Heavy Rain	1.5	188200	6.5	Severe flood waters and storms in Morocco have claimed the lives of at least 24 people. Wwidespread damage to more than 2,500 homes...Large areas of farmland badly hit with the north and central parts of Morocco seeing the worst weather...Moroccan aid agencies have been distributing food and water to those most affected by the flooding with some 2,000 people being evacuated and housed in temporary shelters."
Village of Driouch (500km North		23-Oct-08	03-Nov-08	12	28	1,200		Torrential Rain	2.0	146700	6.5	Eleven people were killed in the village of Driouch, 500km north of Rabat, when 20 homes collapsed in what local authorities

Detailed Locations (Morocco)	Rivers	Began	Ended	Duration in Days	Dead	Displaced	Damage (USD)	Main cause	Severity *	Affected km²	Magnitude (M)**	Notes and Comments
of Rabat), North Eastern Morocco (especially the commune of Driouch in Nador province flooded with wadi Guerti), Tangiers to the west, and the North Eastern city of Taza"												described as the heaviest rains in the area for more than 20 years. Other houses were submerged by floodwaters...Heavy flooding in the wadi of Guerti which swept away 11 people, Rains cut off thousands of workers at an industrial zone in the city of Tangiers Serious material damage has also been caused by the floods in the northeastern city of Taza"
Central areas - Marrakesh, Kalaat Seraghna		26-Feb-08	28-Feb-08	3	4			Heavy rain	1.0	23600	4.9	4 dead. 5 missing. Houses and a bridge destroyed.
Northeastern Morocco - Nador area - valley of Amlah in Ain Zohra, Zaio	0	21-Apr-07	22-Apr-07	2	4	0	0	Heavy rain	1.0	9450	4.3	Three days of heavy rain causes flooding.
Er Rachidia Province	0	26-May-06	28-May-06	3	6	1,100	0	Heavy rain	1.5	33210	5.2	270 houses destroyed. Er Rachidia lies in a semi-arid region and has not seen such rain since the 1970s.
Northeastern Nador region, Beni Bufrah region, Zaio. Rift valley province of Al Hoceima		17-Nov-03	21-Nov-03	5	13			Brief torrential rain	1.0	21190	5.0	Torrential storms dump 100m rain in 12 hours causing flash flooding. "Artificial lakes at the Mohammed V and Machraa Hammadi dams reached maximum capacity of 331 million cubic meters and 180 million cubic meters respectively". 146 homes destroyed in Zaio town in Nador Province. MODIS observation of a sediment plume

Detailed Locations (Morocco)	Rivers	Began	Ended	Duration in Days	Dead	Displaced	Damage (USD)	Main cause	Severity *	Affected km²	Magnitude (M)**	Notes and Comments
												(from flood runoff) off the coast of Saidia, east of Nador
Western Morocco - Provinces: Benslimane, Khouribga. Settat region. Towns: El Gara, Bengueribi, Mohammedia, Berrechid. Moulay Yacoub, near Fez.	Bengueribi, El Maleh.	24-Nov-02	29-Nov-02	6	63			Heavy rain	1.5	40850	5.6	"Heavy rain Sunday and Monday, which came amid a four-year drought in Morocco, caused flooding that left 30 people dead in the rural farming area of Settat," "Flood damage also sparked a fire at the SAMIR oil refinery in the industrial town of Mohammedia, located between Rabat and Casablanca," "the deadliest natural disaster to strike the north African country in seven years." Worst floods in 30 years.
Settat and Essaouira regions - Settat, Berrechid industrial zone. Boumoussa River		23-Dec-01	26-Dec-01	4	15	300	2,200,000	Heavy rain	1.0	6400	4.4	"...record rainfalls of up to 160 mm in 24 hours. Rainfalls of above 200 mm were also reported in northern Morocco." "The rain came after three successive years of drought in the north African country"
Central: El Hajeb, Taza, Khenifra, Marrakesh, Meknes, Imouzzer-Handar, Rommani, Atlas		28-Sep-97	29-Sep-97	2	60			Brief torrential rain	1.0	83480	5.2	Five hours of torrential rain. Flooding and mudslides.

Detailed Locations (Morocco)	Rivers	Began	Ended	Duration in Days	Dead	Displaced	Damage (USD)	Main cause	Severity *	Affected km^2	Magnitude (M)**	Notes and Comments
Mountains.												
Taroudant, Hoceima, Benslimane, Settat		24-Aug-97	26-Aug-97	3	15			Heavy rain	1.0	65150	5.3	
Southeast of Rabat		5-Jan-97	07-Jan-97	3	23			Heavy rain	1.0	9160	4.4	Flooding of normally dry streambeds.
South: Provinces - Essaouira, Azilal, Settat, Taroudant; Region - Chichaoua. North: Provinces - Tangiers, Chefchaouen, Kenitra; Region - Gharb. Center: Provinces - Khemisset, Sidi Kacem, Safi; Region - Casablanca.	Lihoud	21-Jan-96	01-Feb-96	12	23	2,400		Heavy rain	1.0	280200	6.5	Region of Gharb: 90,000 hectares of agricultural land under water, 600 families homeless. El Jadida province: 3,550 hectares of crops submerged. Tetouan province: 17,000 hectares of crops damaged. Sidi Kacem province: 26,000 hectares of farmland flooded. Kenitra province: 36,250 hectares of farmland submerged. Several rivers flooded.
Provinces: Taza, Taounate, Fez		3-Sep-95	06-Sep-95	4	43	228		Heavy rain	1.0	99920	5.6	150 livestock killed.

Detailed Locations (Morocco)	Rivers	Began	Ended	Duration in Days	Dead	Displaced	Damage (USD)	Main cause	Severity *	Affected km^2	Magnitude (M)**	Notes and Comments
Southern Region: Marrakesh, Ouarzazate, Taroudant, Ourika Valley	Gigaya, Ourika, Gamat	17-Aug-95	18-Aug-95	2	166	210	10,000,000	Heavy rain	1.5	132500	5.6	64 vehicles, 52 homes, 53 shops and five adminstrative departments destroyed.

PALESTINE

Detailed Locations	Rivers	Began	Ended	Duration in Days	Dead	Displaced	Damage (USD)	Main cause	Severity *	Affected sq km	Magnitude (M)**	Notes and Comments
Qalquilya, Wadi Kaneh, West Bank		22-Feb-97	26-Feb-97	5	16			Heavy rain	1.0	3610	4.3	-

TUNISIA

Detailed Locations	Rivers	Began	Ended	Duration in Days	Dead	Displaced	Damage (USD)	Main cause	Severity *	Affected sq km	Magnitude (M)**	Notes and Comments
Cap Bon region of northern Tunisia: Tunis, Governorates of Tunis, Ben Arous, Ariana, Zaghouan, Nabeul, Kairouan, Kasserine, Bizerte, Beja, Jeouba		30-Sep-86	03-Oct-86	4	20	500		Brief torrential rain	1.0	4610	4.3	Up to 8 inches of rain.
Sabalet Ben Ammar area.	0	13-Oct-07	16-Oct-07	4	13	0	0	Heavy rain	1.5	11670	4.8	19 inches of rain in 24 hrs in Colombo -

Detailed Locations	Rivers	Began	Ended	Duration in Days	Dead	Displaced	Damage (USD)	Main cause	Severity *	Affected sq km	Magnitude (M)**	Notes and Comments
Bizerte. Tunis area. Ariana, Manouba												new record.
Jandouba, Benzert		12-Dec-03	13-Dec-03	2	7			Heavy rain	1.0	16360	4.5	Floodwater destroyed many fields as well as cotton and vegetable plantations along the river. River flow at 6,000 cubometers of water per second - level not registered in 20 yrs.
Tunis area		16-Sep-03	18-Sep-03	3	4			Heavy rain	1.0	88080	5.4	
Northern Tunisia - Siliana region		25-Jan-03	26-Jan-03	2	2			Heavy rain	1.0	83000	5.2	
Provinces: Kairouan, Sfax, Kasserine, Gafsa, Sidi Bou Zid, Tozeur, Nefta, Gabes		20-Jan-90	01-Feb-90	13	25	152,000	233,000,000	Heavy rain	1.0	48120	5.8	80 villages with a total of 25,000 residential units were completely washed away.
Northern and central Tunisia - Sbeitla province, Le Kef province. Jendouba, Béja, Manouba and	Oued Mejerda.	14-Jan-03	16-Jan-03	3	8	27,000		Heavy rain	1.5	71650	5.5	Called Papua New Guinea's worst ever natural disaster.

Detailed Locations	Rivers	Began	Ended	Duration in Days	Dead	Displaced	Damage (USD)	Main cause	Severity *	Affected sq km	Magnitude (M)**	Notes and Comments
Bizerte. Kasserine, Kairouan, Sidi Bouzid, le Kef and Monastir.												

Source: the Global Active Archive of Large Flood Events; http://www.dartmouth.edu/~floods/Archives/index.html

ANNEX 2: EXISTING DROUGHT AND FLOOD MANAGEMENT FRAMEWORKS:

There are presently two types of frameworks that can be used to improve drought and flood management in the PCs:

1) The first is **built around a general disaster based context**. This includes:

   a. the disaster-risk-reduction (DRR) approach; adopted within the context of the worldwide initiative Hyogo Framework for Action (HFA); **involving** the concepts of "**prevention**", "**mitigation**" and "**preparedness**" in the pre-disaster stages (**See Box 3 for the respective definition**), or

   b. the disaster-risk-management (DRM) approach which combines through a management perspective, the concept of DRR with response (post disaster)(Baas S. et al., 2008, p.7)".

2) The drought and flood specific frameworks offered respectively by:

   a. Ameziane et al. (2007), providing **guidelines for a methodological framework to develop drought management plans** that were developed within the scope of the EU-funded "Mediterranean Drought Preparedness and Mitigation Planning (MEDROPLAN)" under the umbrella of the Mediterranean Regional Programme for Local Water Management (MEDA Water)

   b. The World Meteorological Organisation (WMO) Integrated Flood Management (IFM)[46] approach in developing strategies for coping with floods (WMO, 2009).

1.a) The Hyogo Framework for Action (HFA), which was adopted by the World Conference on Disaster Reduction, held in 2005 in Japan, "emphasises a shift from reactive emergency relief to pro-active disaster risk through the adoption of the following priorities for action":

- Ensuring that disaster risk reduction is a national and a local priority with a strong institutional basis for implementation.
- Identifying, assessing and monitoring disaster risks and enhancing early warning.
- Using knowledge, innovation and education to build a culture of safety and resilience at all levels.
- Reducing the underlying risk factors.
- Strengthening disaster preparedness for effective response at all levels.

1.b) The DRM framework defines 3 core elements for actions as depicted in (Box 3) which combines the pre-disaster measures adopted by HFA with two more elements: response and recovery.

Box 3: Elements of Disaster Risk Management (DRM) framework

I. Pre-disaster: Prevention – Mitigation - Preparedness

On-going development activities – On-going DRM aspects in development programmes
Risk assessment – Diagnostic process to identify the risks that a community faces
Prevention - Activities to avoid the adverse impact of hazards
Mitigation – Structural/non-structural measures undertaken to limit the adverse impact
Preparedness - Activities and measures taken in advance to ensure effective response
Early warning - Provision of timely and effective information to avoid or reduce risk

[46] within Integrated Water Resources Management (IWRM), developed by the Global Water Partnership (GWP), and internationally applied principle

II. Disaster response
Evacuation - temporary mass departure of people and property from threatened locations **Saving people and livelihoods** – Protection of people and livelihoods during emergency **Immediate assistance** – Provision of assistance during or immediately after disaster **Assessing damage and loss** – Information about impact on assets and loss to production
III. Post-disaster (Recovery and Development)
On-going assistance – Continued assistance until a certain level of recovery **Recovery** - Actions taken after a disaster with a view to restoring infrastructure and services **Reconstruction** - Actions taken after a disaster to ensure resettlement/relocation **Economic & social recovery** – Measures taken to normalise the economy and societal living **On-going development activities** – Continued actions of development programmes **Risk assessment** - Diagnostic process to identify new risks that communities may again face

Source: Baas et al. (2008)

2.a) The Drought Management Guidelines developed by Iglesias A. et al. (2007) within the MEDROPLAN, advance four components for drought management:

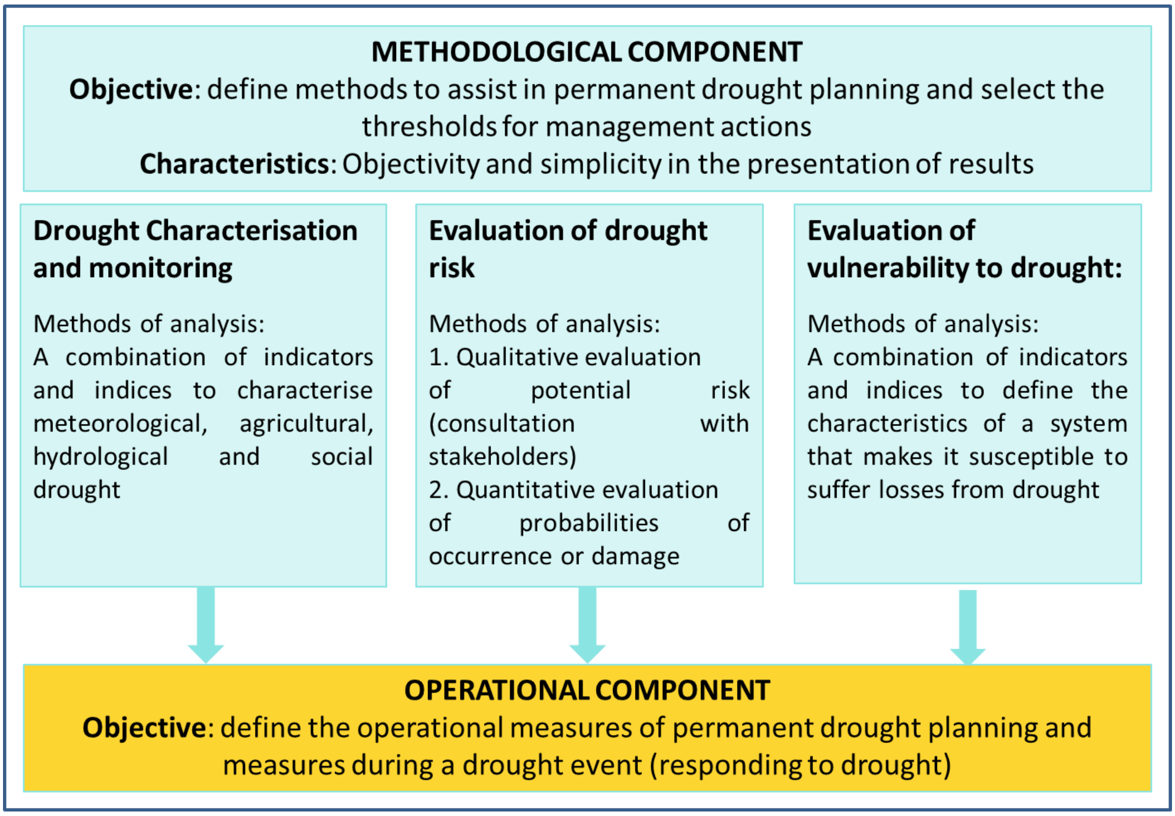
- The ***planning framework:*** aiming at defining the local, regional and national purpose for developing drought planning and establishing a common language among stakeholders by agreeing on a common set of terms and concepts for developing a drought management plan.
- The ***organizational component;*** essential for understanding the institutional and legal framework within which the drought plan will be designed and implemented, and for defining an efficient organizational structure to implement the plan in an efficient manner.
- The ***methodological component;*** comprising a scientific approach to **drought characterisation** (in terms of severity, magnitude and probability of occurrence), **evaluation of the risk associated with the potential consequences of drought in the different** sectors and systems, **and** evaluation of the respective **vulnerabilities** to droughts. **This component forms the basis for the development of any drought plan (See figure 10).**
- The ***operational component*** which defines the long and short term operational measures that can be implemented to “prevent” and “mitigate” drought impacts, which are essential for the creation of a permanent drought plan and subsequent “response” measures during a drought. According to MEDROPLAN, the ***operational component consists*** of the following:
    - Preparedness and early warning (permanent measures)
    - Establishing priorities to be respected during water shortages due to droughts
    - Thresholds defined by drought indices and indicators (physical and social)
    - Defining the actions
    - Evaluating the process to implement the actions
- The ***public review component;*** aiming to revise the application of the previous components when developing a drought plan and suggesting a public multi- stakeholder dialogue and questionnaires to collect feedbacks. Dissemination of information is also essential in this component.

2.b) The WMO (2009) IFM addresses flood management thorough integrated land and water resources development in a river basin, within the context of IWRM, while aiming at maximizing the net benefits from the use of floodplains and minimizing loss of life from flooding. According to WMO, 2009, IFM should address six key elements that follow logically for managing floods in the context of an IWRM approach:

- Managing the water cycle as a whole;
- Integrating land and water management;
- Managing risk and uncertainty;
- Adopting a best mix of strategies;
- Ensuring a participatory approach; and
- Adopting integrated hazard management approaches.

In view of the above, a drought risk management based approach implies a planning effort to determine what measures should be taken before the initiation of a drought event in order to reduce the vulnerability to drought or improve drought preparedness.

Figure 10: Summary of the drought planning "methodological component" and linkages to the "operational component"



Source Iglesias A. et al. (2007)

According to Iglesias A. et al. (2007), a well-designed drought plan would consist of (a) long-term measures oriented to increase the **reliability of water supply systems** to meet future demands under drought conditions through a set of appropriate structural and institutional measures and (b) contingency plan for emergency situation involving suggested actions to be taken after the start of a drought to mitigate its impacts within the existing framework of infrastructures and management policies, and which can be adapted to the on-going drought, if necessary. However for effective drought planning the following elements are essential:

- **Conducting risk assessment to identify** and address the **most vulnerable people and sectors** at the national and sub-national level.

- A **comprehensive drought early warning monitoring system** that include information on the meteorological and hydrologic conditions, as well as on the water supply systems conditions. The system is essential to provide adequate and timely information for drought declaration and to help decision-makers identify the drought warning conditions and the best drought mitigation measures on the basis of a continuous monitoring of the drought evolution (in terms of meteorological and hydrological variables and water resource availability).
- **Adequate institutional arrangements** including effective coordination and cooperation between implicated institutions
- **A policy framework** in support of proactive planning.
- Inclusion of **stakeholders**

Likewise, formulating a flood management plan within the Integrated Flood Management (IFM) approach requires identification of the present and future flood risks based on assessing the magnitude of the flood hazard; expressed in terms of frequency and severity, the exposure of human activities to flooding, and the vulnerability of all the elements at risk, in addition to the development of national and basin flood management policies. Systematic actions in the cycle of preparedness, response and recovery based on the flood risk assessment would help determine distinct targets that articulate how the flood risks would be reduced or managed based on the natural conditions, state of socio economic activities and resultant damages.

Similar to IWRM, putting integrated flood management into practice requires an enabling, environment in terms of policy, legislation and information; clear institutional roles and functions; and management instruments for effective regulation, monitoring and enforcement.

Finally the adoption of proactive approach should be connected to tangible, hands-on activities available through traditional/indigenous practices that have been developed on community level within the PCs. These are complimentary to internationally accepted and widely applied methodological approaches in tackling the multi-dimensional impacts of droughts and floods. Fostering the principle of sustainability, such concerted approach would provide an appropriate level of effectiveness in a decentralized manner while bridging for any institutional short-comings in disaster risk management on governmental level. `

2 CASE STUDIES

2.1 THE CASE STUDY OF JORDAN

2.1.1 WATER RESOURCES SITUATION IN JORDAN

Jordan's renewable natural water resources are estimated to be in the magnitude of 780 MCM/year. To date about 505 MCM/year of surface water resources have been developed. Full development has been impeded by regional political considerations and the high cost to develop and transport the remaining sources of water estimated at 9 U.S. $\$/m^3$. Under normal rainfall conditions, 275 MCM/year are considered sustainable groundwater abstractions. Jordan also possesses limited resources of fossil; non-renewable groundwater in the Disi aquifer in the South, with a yield of 125 MCM/year that can be abstracted for 50 years. In order to meet the increasing demands, transfer of this fossil water to the major urban areas in the country has already started in 2013, and treated wastewater reuse; mostly in agriculture, has increasingly become part of the water balance equation; representing about 12% of the total water supply in 2009.

Due to the semi-arid climate, compounded with high population growth rates, water scarcity in Jordan has become of permanent nature and water resources overstressed. In the year 2009, the annual per capita share of the renewable fresh water resources available in the country was estimated at 130 m^3; about 27% of the internationally recognized limit threshold for water scarcity of 500 m3/capita/year. The situation is expected to worsen with increasing competition between consumers and will become even more alarming when put in the context of climate change, with the expected increase in temperature and evaporation, decrease in precipitation, inland water flows and water yields.

2.1.2 REVIEW AND INVENTORY OF PAST DROUGHT AND FLOOD EPISODES DURING THE PAST TEN YEARS

DROUGHT EPISODES

Despite the consecutive droughts with varying severity within the different basins/regions of the country, drought was never announced during the past decade. The only time that a state of drought was declared nationwide in the history of modern Jordan was in 1998/1999; when the country was hit by extreme drought (with rainfall representing 30% of the annual average) for two consecutive water years until 2000. However, rainfall data maintained at the Ministry of Water and Irrigation reveals that mild to extreme droughts were recorded in the various surface water basins **(Figure 11)** of the country) as per **table 25**.

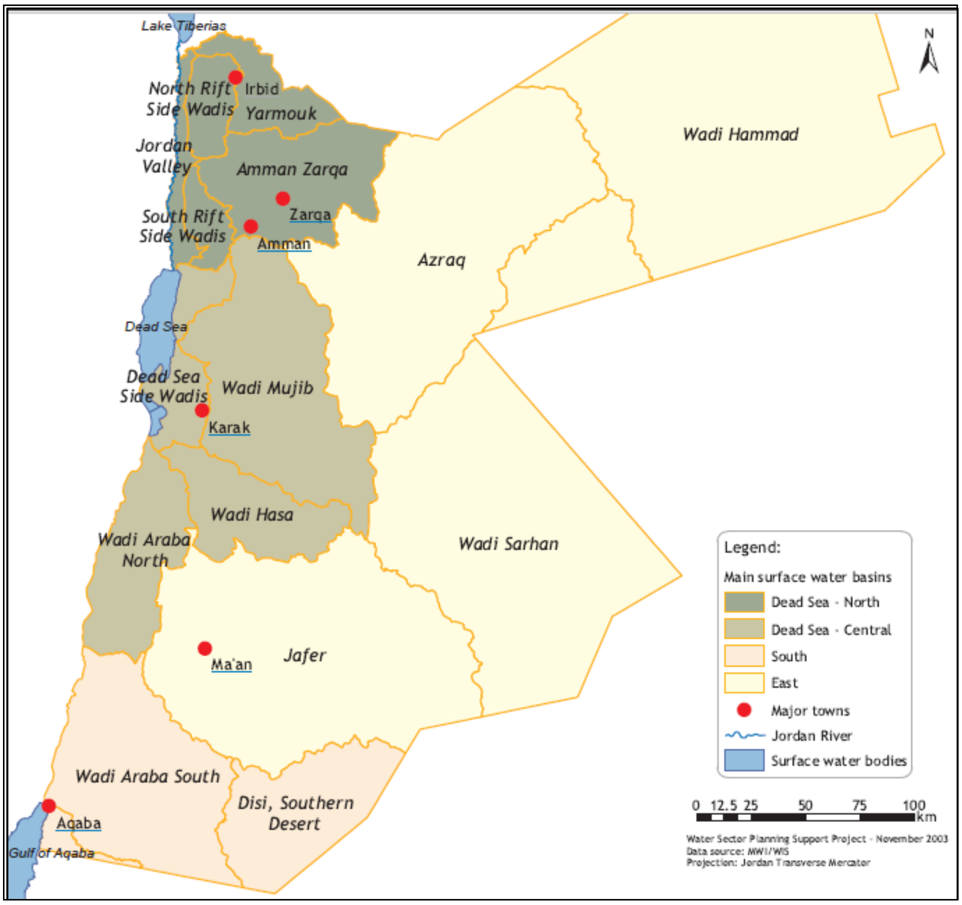
Table 26 shows the number of "severe to extreme" droughts that occurred per basin and nationwide between 2002 and 2011 and the corresponding return period. In nine years, the number of basins that were hit with "three to six" severe to extreme drought is eight out of fifteen. It is not possible however to compare the drought frequency with that of the long term due to lack of consolidated rainfall records per basin. However the Ministry of Water and Irrigation (MWI) keeps such records for "nationwide rainfall amounts" since 1937.

According to MWI, the average precipitation volume over the whole country from 1937 till 2011 is about 8,225 Million Cubic Meters (MCM), with rainfall ranging from a minimum of 2,973 to 17,797 MCM47. Using linear regression for the overall precipitation volume indicates a nationwide reduction rate of 32.85 MCM/year **(Figure 12)**. According to Weibull distribution analysis of rainfall at the national scale, the probability for the precipitation volume to be less than the average (i.e. existence of drought regardless of its severity) is around

[47]Records provided by Mr. Zakaria Haj-Ali, Water Resources Directorate / MWI (2013).

46.6%.However, analysis of country-wide precipitation volumes during the last ten years indicates that drought occurred seven times; i.e. probability of 77 % in a life span of ten years (Table 27).

Figure 11: Main surface water basins in Jordan



Source: Water Sector Planning Support Project, MWI, 2003.

Table 25: Inventory of Droughts in Jordan (Water Years 2002/03 – 2010/11)[48]

Year	Severity[49]	Geographic Extent	Year type at the National Level
2002/03	Extreme	W. Araba North & W. Araba South Basins	Wet
	Severe	W. Hasa, Southern Desert & Jafr Basins	
	Mild	Hammad Basin	
2003/04	Extreme	Northern Ghors, Southern Ghors & Hammad Basins	Moderate drought
	Severe	Zarqa River	
	Moderate	Yarmouk River,Jordan Valley, Dead Sea, W. Mujib & Jafr Basins	
	Mild	W. Hasa & W. Araba North Basins	

[48] The Ministry of Water and irrigation provided the project with annual and rainfall amounts for **only nine water years for each basin** and for 74 years for the whole country.

[49] Severity of drought is expressed in precipitation deficiency. It refers to the per cent of normal (average) precipitation (provided per basin and for the country for the period 1937-2011); whereby extreme drought refers to precipitation <70% of normal, severe: precipitation between 70% and 80% of normal, moderate: precipitation between 80% and 90% of normal, mild: between 90% and 100% of normal precipitation.

Year	Severity[49]	Geographic Extent	Year type at the National Level
2004/05	Severe	W. Araba North Basin	Wet
	Mild	Northern Ghors, Southern Ghors & Zarqa River Basins	
2005/06	Extreme	Azraq and Hammad Basins	Severe Drought
	Severe	Northern Ghors & Zarqa River Basins	
	Moderate	Yarmouk River, W. Hasa, North W. Araba & W. Sirhan Basins	
	Mild	Jordan Valley, W. Mujeb & Jafr Basins	
2006/07	Extreme	Jordan Valley	Mild Drought
	Severe	Yarmouk River, Southern Ghors, Zarqa River & Azraq Basins	
	Moderate	Northern Ghors & W. Sirhan Basins	
	Mild	W. Araba North & Hammad Basins	
2007/08	Extreme	Twelve out of fifteen basins: Yarmouk River, Jordan Valley, Northern Ghors, Southern Ghors, Zarqa River, Dead Sea, W. Mujeb, W. Hasi, W. Araba North, Southern Desert, Azraq & Hammad Basins	Extreme Drought (63% of long term average precipitation)
	Severe	Jafr Basin	
	Mild	W. Sirhan Basin	
2008/09	Extreme	W. Araba South, Southern Desert, Azraq & Hammad Basins	Severe Drought
	Severe	Zarqa River & W. Araba North Basins	
	Moderate	Jordan Valley, Northern Ghors, Southern Ghors & Dead Sea Basins	
	Mild	Yearmouk River Basin	
2009/10	Extreme	Jordan Valley Basin	Wet
	Severe	Northern Ghors & W. Araba North Basins	
	Mild	Yarmouk River, Southern Ghors, & Hammad Basins	
2010/11	Extreme	Jordan Valley, Southern Ghors, Zarqa River, North W. Araba & Southern Desert Basins	Severe Drought
	Severe	Northern Ghors, Dead Sea, W. Mujeb, W. Hasa & Hammad Basins	
	Moderate	Jafr Basin	
	Mild	Azraq Basin	

Source: Author; based on raw data provided by MWI, 2013

Table 26: The number and severity of droughts per surface water basin and the return period of severe to extreme droughts (2002-2011)

Surface Water Basin	Mild	Moderate	Severe	Extreme	Total No. of Droughts in 9 years	severe & extreme Droughts in 9 years	
						Number	Return Period
Yarmouk	2	3	1	1	7	2	5
Jordan Valley	1	2	0	4	7	4	2
Northern Ghors	1	2	3	2	8	5	2
Southern Ghors	3	1	1	3	8	4	2

Surface Water Basin	Mild	Moderate	Severe	Extreme	Total No. of Droughts in 9 years	severe & extreme Droughts in 9 years	
						Number	Return Period
Zarqa	1	0	4	2	7	6	2
Dead Sea	0	2	1	1	4	2	5
W.Mujib	1	1	1	1	4	2	5
Hasa	1	1	2	1	5	3	3
North W.Araba	2	1	3	3	9	6	2
South W.Araba	0	0	0	2	2	2	5
Southern Desert	0	0	1	3	4	4	2
Azraq	1	0	1	3	5	4	2
Sarhan	1	2	0	0	3		
Hammad	3	0	1	4	8	5	2
Jafr	1	2	2	0	5	2	5
Nation	1	1	3	1	6	4	2

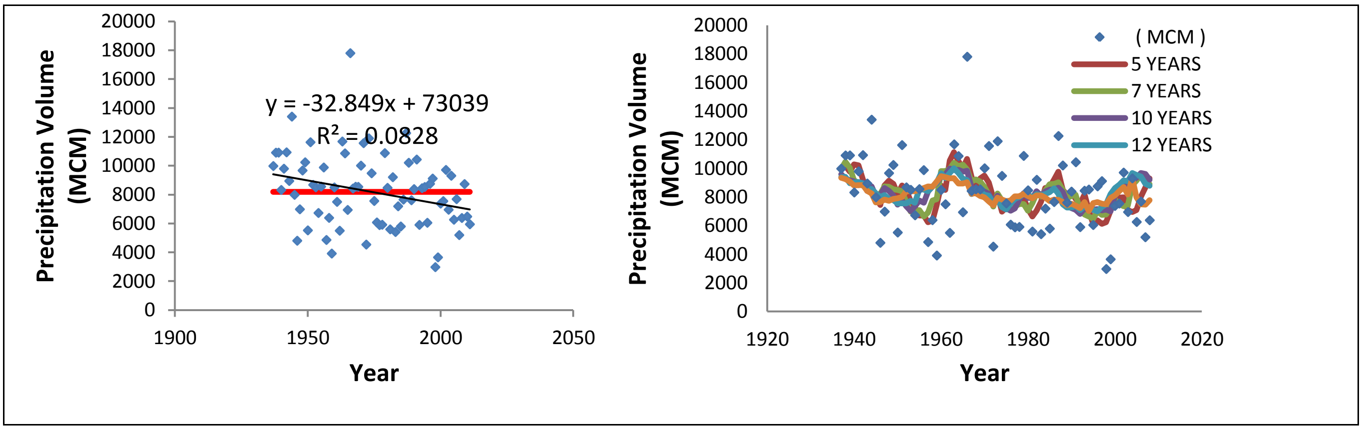
Source: Author; based on raw data provided by MWI, 2013

Table 27: The number and severity of droughts at the national level and the return period of severe to extreme droughts (2002-2011)

Drought Severity	No. of drought		Probability of occurrence	
	1937/38-2010/11	2001/02-2010/11	1937/38-2010/11	2001/02-2010/11
Mild	7	2	9.59%	22.22%
Moderate	6	1	8.22%	11.11%
Severe	7	3	9.59%	33.33%
Extreme	14	1	19.18%	11.11%
Total	**34**	**7**	**46.58%**	**77.77%**

Source: Author; based on raw data provided by MWI, 2013

Figure 12: Trends in precipitation using linear regression and moving average.



Source: Author; based on raw data provided by MWI, 2013

FLOOD EPISODES

Floods do not occur regularly in Jordan. However the Kingdom witnessed recently a sharp increase in flood severity and frequency of occurrence as observed by relevant government officials. Floods are formed on a seasonal basis in some areas of the kingdom either at the beginning or end of the rainy season, during periods of unstable weather conditions. Floods and flash floods remain the main cause of death due to natural disasters in the country; representing around 53% of disaster-related mortality between 1980 and 2012 (UNISDR, 2013)and producing losses in properties, and destruction of infrastructure.

Like in any other arid to semi-arid countries, flash floods pose an important threat to many of the settlements in the country that are located in the low land areas of the mountainous ranges (such as the archaeological city of Petra), or cities located downstream of a catchment area in a flat topography (Ma'an City) or in alluvial fans such as the case of Aqaba city. Despite the large threat posed on some parts of the country by the floods, there is limited documented literature on floods in Jordan. Hence, most of the information cited in this report is based on electronic news, internet publications and few references provided by the recently established disaster reduction unit (DRR) in Aqaba Special Economic Zone Authority (UNDP, unknown date)[50].

One of the wadis ranked with the highest potential for risk and damage in Jordan is W.Yutum; a tributary to the Red Sea at the Gulf of Aqaba notorious for producing extreme flood events that have damaged structures located in the active flood channel. In February 2006, both Aqaba and Ma'an in South Jordan witnessed a large flood in lower W.Yutum and in W.Ouhadah; west of Ma'an city killing eight people[51]. The peak flow reached some 550 m^3/second in W.Yutum (estimated to be between a 10 and 40 year event), and around 320 m^3/second in W.Ouhadah (USAID, 2011). The incidence, which was of regional nature (involving Palestine, Saudi Arabia and Israel) resulted in the destruction of part of the Disi-Aqaba water transmission pipeline; the main water line to Aqaba city, and the disruption of water supply for two weeks and of power supply, and caused scour and erosion that impacted concrete revetments and gabion structures within the Wadis channel. The floods also disrupted Aqaba Wastewater Treatment Plant (WWTP) for several months and Aqaba airport due to water flow and sediments transported to the runway. Property damage to the airport and WWTP alone was estimated at 6 million Jordanian Dinars (JD)[52]. During the floods of 2006, the total amount of compensations paid to damaged farms as a result of flood in the kingdom was in the order of 131 thousands JDs.

In 2007, the floods flowing down the slopes of the steep mountains surrounding Ma'een hot springs area (some 100 km south of the capital), resulted in soil erosion and large boulder deposits, high water levels in addition to landslides, claiming two lives and three casualties in addition to damages to properties (Ministry of Civil Defence (MCD), 2007).

In 2012, the floods which occurred in Wadi T (one of the tributaries of W. Yutum), and the coastal wadis of Shallaleh and Al-jayshiyyeh) in Aqaba city, resulted in two fatalities, damage to infrastructure in addition to inundation of residential areas (ASEZA, 2013).

In 2013, an extreme flood event hit the whole country; in the northern parts (Mafraq, Zarqa, Amman and Yarmouk River), the Jordan Rift Valley (JRV) in the West (including the Dead Sea, and Jordan River) and the southern part in Ma'an and Aqaba. The floods demolished 500 Syrian refugee tents in Mafraq[53], submerged the streets in the main cities of Amman and Zarqa with rainwater that inundated the vehicles, and caused one

[50] An autonomous institution; responsible for the management, regulation, and the development of the Aqaba Special Economic Zone (ASEZ)
[51] Information provided by Mr. Waleed Abdullah from the DRR unit, ASEZA,. 2013.
[52] 1 JD = 1.4 US dollars
[53] http://www.trust.org/item/?map=jordan-readies-its-first-policy-on-climate-change/

death [54]. In the Jordan Rift Valley, about 8,500 acres of agricultural land adjacent to the Jordan River were submerged with water. Floods also destroyed all the plantations affected by heavy runoff and soil erosion - from Adasiyeh in the North of JRV, to Damia in the middle. Fish farms in Manshiyeh and Abu Obaida were also destroyed. In the southern part of the country, the road linking Aqaba to the Dead Sea was closed by eroded sediments, while Aqaba airport was closed for two days.

2.1.3 POTENTIAL LINKAGE OF DROUGHT AND FLOOD EPISODES TO CLIMATE CHANGE

Drought and flood analyses are unfortunately not well-established by the relevant governmental officials.However, trend analysis conducted on the time series of the existing climatological records - as part of the First and Second National Communication Reports (FNCR and SNCR; respectively) to the UNFCCC, in addition to sector specific studies[55], and other climate change research studies -.show an **increasing trend in the maximum temperature and a more remarkable increasing trend in the minimum temperature and consequently the mean temperature**. While the **precipitation exhibits a decreasing trend in the majority of the locations in Jordan**. However**, problems associated with data availability**, **accuracy and reliability**, including the lack of models and tools specifically designed for local conditions, render the predicted climate change impacts on the country **highly uncertain**.

At the **local level**, climate change future scenarios developed for the Jordanian part of the **Yarmouk River Basin** (north of the country) as part of the SNCR, suggest an increase in temperature of less than 2°C, by the year 2050. In a recent study, a **statistical downscaling model was employed to generate site-scale future climate scenarios at several locations in Jordan from the coarse Global Climate Model (GCM) products** for the period 2011 – 2099 (Freiwan and Kadioglu, 2008a). These scenarios reveal an obvious **increase in temperature** ranging from 1 - 4°C and a **decrease in precipitation** ranging from 15 to 60% in the majority of the studied sites (Freiwan and Kadioglu, 2008b; Freiwan and Kadioglu, 2006). Studies mentioned above also indicate that **extreme events** (i.e. flash floods, intense rain, snow storms, drought etc.) **are predicted to be more frequent** and thereby increasing disaster risk potential (UNDP, 2012).

The **potential impacts of climate change on the hydrological** system and water resources were analysed using the Water Evaluation and Planning (WEAP) hydrological model. Analysis at the basin level indicated that the amounts of **surface runoff are expected to decrease** especially in January, February and March. Surface water will be reduced from 20% to 40% under different climate change scenarios (MOE-JO, 2009).**Ground water recharge is also expected to be reduced** by around 32% if temperature does not change. The respective reduction in groundwater recharge if the temperature increases by 3.5◦C is 38.9%.

On the other hand, the **Drought Monitoring Unit (DMU) at the National Centre for Agricultural Research and Extension (NCARE)** is currently identifying drought trends in Jordan on annual and seasonal basis (from 1901 till 2011) along with the affected areas using both SPI and Normalized Difference Vegetation Index(NDVI) indicators; conducted on a 16-days interval obtained from MODIS composite images of 1 Km resolution. The DMU is also establishing future predictions for monthly mean precipitation and thus drought severity and location by implementing the results of SNCR (2010-2040). **Preliminary drought maps delineated the absolute changes in soil moisture**; which would **limit the crops growing period at both ends of the season**. Initial

[54] http://www.disaster-report.com/2013/02/recent-natural-disasters-list-february-2.html

[55] Under the Joint Implementation Program (water, health and food security): Adaptation to Climate Change to Sustain Jordan's MDG Achievements; Submitted by four UN organizations working in Jordan (UNDP, WHO-CEHA, FAO& UNESCO) to the UNDP/Spain MDG Achievement Fund under the MDG-F Environment and Climate Change thematic window. Key national partners in this program include: Ministries of Environment, Health, Agriculture, & Education.

results also indicate that the **vulnerability to large drought events is increasing** with time **in the Badia region and part of the Yarmouk River**.

2.1.4 INSTITUTIONAL, POLICY AND LEGAL ASPECTS

The first institutions that are directly implicated in the management of drought and flood events in Jordan are (1) the Ministry of Water and Irrigation (MWI) with its two sister organisations; the Water Authority of Jordan (WAJ) and the Jordan Valley Authority (JVA) [56] and (2) the Ministry of Agriculture.

MWI is the official body responsible for the overall monitoring of the water sector, water planning and management, formulation of national water strategies and policies, water related information systems and procurement of financial resources. MWI **performs systematic monitoring of water resources quantity and quality as an integral component of its water resources protection strategy** *(By-Law No.16 of 1988).* **WAJ** responsibilities include the **construction, operation and maintenance of public water supply and wastewater services and the overall water resources planning and monitoring** (*Article 3 of Water Authority Law No.18 of 1988*). **The social and economic development of the Jordan Rift Valley (JRV) is assigned to JVA** through "*The Jordan Valley Development Law No. 19 of 1988 and its amendment in 2001*". This includes water resources' development, utilization, protection and conservation in addition to the management and distribution of irrigation water in the JRV.

The **Ministry of Agriculture (MOA)** which is responsible for organizing the agricultural sector and its development is mandated by "*Article 65 of the Provisional Law No. 44 of 2002 - Law of Agriculture* with the responsibility to "**officially announce the fact case of drought**……. **and take the required measures** (in coordination and cooperation with the competent parties**) to mitigate the negative impacts on the agricultural sector** ….. in accordance with the resolutions made by the Council of Ministers in this respect".

According to the *Civil Defence Law No.18 for 1999 and its amendments*, the **Higher Council for the Civil Defence (HCCD)** is mandated to carry out the tasks related to putting a general civil defence policy for facing emergency cases and their potential results, approving the plans to take the necessary procedures in this regard, determining the duties and responsibilities of each formal or domestic authority, and tracking their execution" (MCD, 2008) .The HCCD which is **headed by the Minister of Interior includes members representing all ministries, institutions and organizations (Figure 13)**, that are related to facing and managing disasters and emergency cases which, by law are announced by the Prime Minister.

As part of Jordan's commitment to Hyogo Framework for Action (HFA)[57] (spearheaded by the General Directorate of Civil Defence (GDCD) as a focal point for implementing the five priority areas[58] of HFA (**See also ANNEX 2: EXISTING DROUGHT AND FLOOD MANAGEMENT FRAMEWORKS**), a **National Centre for Security and Crisis Management (NCSCM)** was established in 2006 (European Network of National Platforms (ENNP), 2008). The centre is envisaged to deal with all types of crisis throughout its management cycle (prediction, prevention, mitigation) and to manage coordinated response and recovery across the government departments, private sector and NGOs in addition to international humanitarian aid agencies. The centre is however still not fully operational, due to potential overlap of duties with the HCCD. Being a military institution, **no further information could be obtained regarding the role which the centre will play towards**

[56] The three organisations are linked with the Minister of Water and Irrigation

[57] HFA was adopted by the World Conference on Disaster Reduction, held in 2005 in Japan, "emphasising a shift from reactive emergency relief to pro-active disaster risk".

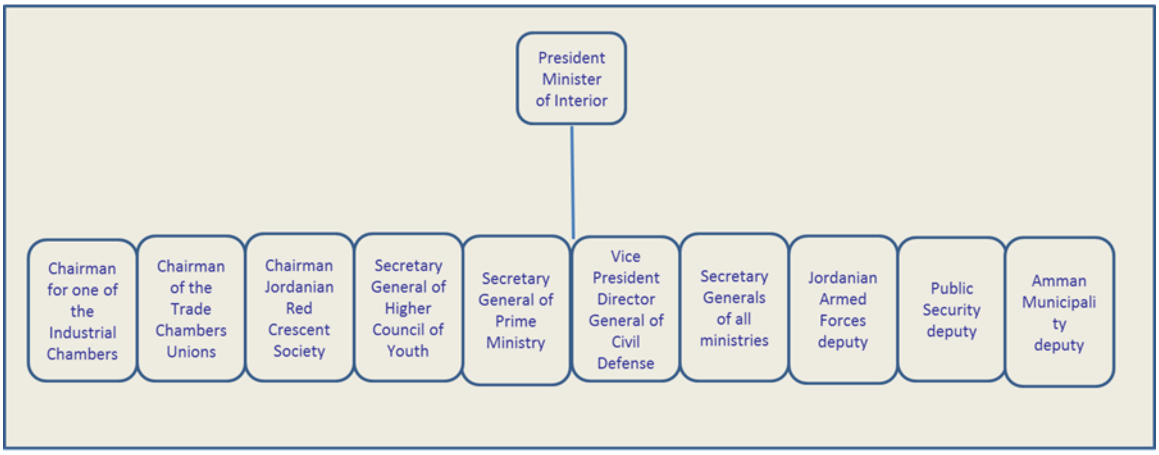
[58] The five priority areas are: (1) Ensuring that disaster risk reduction is a national and a local priority with a strong institutional basis for implementation. (2)Identifying, assessing and monitoring disaster risks and enhancing early warning. (3) Using knowledge, innovation and education to build a culture of safety and resilience at all levels. (4) Reducing the underlying risk factors. (5) Strengthening disaster preparedness for effective response at all levels.

committing the line ministries (including those responsible for drought and flood management) towards preparedness, prevention and mitigation including the preparation of contingency plans.

Within MOA, two units are also concerned with some parts of the flood and/or drought management cycle:

1. The Drought Monitoring Unit (DMU) established in 2008 within NCARE – a centre affiliated with the Ministry of Agriculture; aiming to monitor and predict drought through satellite images. It was indicated that the unit **provided information for decision makers about the status of vegetation during the drought conditions of 2009/2010.**
2. The **Agricultural Risk Management Fund** established according to law no. 5 of 2009, which aims to compensate the farmers during emergencies and natural disaster, in accordance with the criteria and ceilings set by the regulations issued for this purpose. **This fund is still in its early stages** and work is underway to develop the instructions to allow farmers to subscribe and pay subscription fees. A strategy was also prepared for the work of the Fund for the years 2013 – 2015.

Figure 13: Members of the Higher Council for the Civil Defence



Currently, there is **no national strategy for "drought or flood management or preparedness plans that focuses on mitigation to reduce or avoid the impacts of future events of these types** . However, in 2007, MOA in cooperation with the Food and Agricultural Organisation (FAO) prepared a document which is referred to as the "National Strategy and Action Plan for drought management". Despite its name, the document is not a strategy, as it only suggests a detailed road map with a set of recommendations for the development of such a strategy. **Other strategies that address both drought and flood** in the country include:

1) The *updated version of the Water Strategy for 2008 – 2022 "Water for Life"* **(MWI, 2012),** which refers to drought management and adaptation to climate change as a challenge that "will need to be addressed through proper policies and regulations", proposes integrated approach to the sustainable management of Jordan's water resources taking into consideration the impacts of climate change on water resources availability. However, one year later, **the strategy still remains in its draft version, and it is unlikely that actions have been taken to translate the relevant articles of the strategy into policies or action plan**.

2) The *MOA "National Strategy for Agricultural Development (2002-2010)"and "The Agricultural Document for (2009-2014)"*. **The latter was translated into an action plan involving interventions for drought mitigation in the agricultural sector**.

3)The *Jordanian ministry of environment "National Climate Change Policy (2013-2020)*(MOE-JO, 2013)", the *"National Strategy to Combat Desertification"* in 2006 (MOE, 2006), the "*National Biodiversity Strategy and Action Plan"* in 2003, the *"National Environmental Strategy (NES)"*, the *"National Environmental Action Plan*

(NEAP)", the *"Environmental Strategy Implementation Plan (ESIP)"*for (2007-2010) and (2011-2013), and the *"National Capacity Self-Assessment (NCSA)"*in 2007. Several programs to mitigate drought and flood threats were accordingly suggested and implemented.

In addition, a *"National Comprehensive Plan for Emergencies and Disasters (NCPED)"* was developed in 2004 by the HCCD. However, **the plan defines the duties** of each member of the HCCD, including ministries, **with a view to civil defence** related actions to ensure preparedness and effective response and recovery during and post-disasters; respectively, **while the requirements for the preparation stage related to identifying the risk types, size, and their likelihood is spelled out in only one occasion; as part of HCCD requirements – without any reference to the respective role of the ministries including those implicated in drought and flood management**.

Concerning flood, there are **two major institutions involved in flood monitoring**. Both MWI and JVA[59] have monitoring networks with a view to monitor surface water quantity and quality; for the purpose of water resources protection, allocation, development and planning at the national and local level; respectively. **In the case of JVA**, **its additional role as far as flood is concerned** is the construction and operation and maintenance of dams for use either locally in the JRV for irrigation purposes or in the uplands for domestic purposes. **Where wadis (surface water) are not regulated by JVA,** the **role of the Meteorological department, civil defence, and municipalities become prominent** involving awareness-raising and warning the population to avoid potential flood areas, and to undertake evacuation and/or rescue, as necessary**. During the past decade, with the decentralisation of authority in both Aqaba and Petra in the south,** flood control and protection became the responsibility of the respective authorities of "Aqaba Special Economic Zone (ASEZA)" and "Petra Development & Tourism Region Authority. Currently both authorities are supported with the UNDP[60]to increase their coping capacity to address disaster risk reduction (DRR) for natural hazards and climate change adaptation (CCA) as it relates to prevention, mitigation, and preparedness for flash flooding

2.1.5 ANALYSIS OF EXISTING STRUCTURES AND SYSTEMS INCLUDING TECHNICAL CAPACITY AND LINKAGES

Despite the country's awareness of the crucial role of Disaster Risk Reduction (DRR) (including drought and flood risk reduction), it is still not clear how its future will evolve with respect to the shift from the dominating crisis management to Disaster Risk Reduction (DRR) and disaster risk management (DRM) **(See ANNEX 2: EXISTING DROUGHT AND FLOOD MANAGEMENT FRAMEWORKS)**. This is particularly valid given **the absence of a legal framework** which assigns the driver's seat to **one single body** with a strong institutional and technical capacity and clearly **mandates it to initiate, coordinate and follow up the efforts of developing sectorial drought and flood management policies and plans**. The result is fragmented institutional approach, lack of unified vision, and a sectorial approach by the relevant line ministries in addressing drought and flood management challenges; based on the provisions of their respective laws. **The situation is worsened** by the multiplicity of international commitments and donor driven initiatives; that have to deal with different institutions in the absence of a central structure for guidance and permanent institutional linkages - to replace the existing committees established to ensure coordination between the sectors.

To date, there are no official guidelines indicating the criteria for announcing drought and the different levels of drought alerts. This becomes even more obvious with the fact that practically it is the cabinet of the ministers which decides whether to declare a state of drought or not and its reluctance to do so. Instead, the

[59] JVA mandated area is the Yarmouk River in the North to the Red Sea in the South. The Eastern extension of the area is limited by the 300 m above mean sea level (a.m.s.l.) contour line north of the Dead Sea and the 500 m a.m.s.l. contour line south of the Dead Sea. The King Abdallah Canal represents the backbone of the JVA water distribution system north of the Dead Sea

[60] http://www.undp-jordan.org/index.php?page_type=projects&cat=4&page_id=388

government declares drought under different names; water shortage, delay in rainfall, rainfall deficiency. **Several reasons account for this reluctance**, including the potential impact on summer tourism; especially from the Gulf States, absence of a national criterion for drought, and the implications for financial commitments towards the farmers, especially with the country's limited financial resources and the absence of an operational agricultural risk management fund.

In view of the above, the role of the Ministry of Agriculture with respect to the announcement of the fact case of drought, is that of assessment of its severity and evaluation of its socio-economic impacts, discussing the pros and cons of announcing drought, and reporting the findings of a designated committee to the Minister of Agriculture[61] who submits its conclusions to the Cabinet of Minister. Should the latter take the decision to announce drought, a state of drought emergency is declared by the Prime Minister, who instructs to form a national drought committee involving the secretary generals of the Ministries of Agriculture, Water and Irrigation, Health, Finance and Interior under the presidency of the Minister of Interior to coordinate actions between the relevant line ministries during the time of the crisis. Detailed investigation of drought impacts on animal and food production in each district of the country is also carried out and decisions to compensate affected farmers are implemented by the Ministry of Finance. Programs involving relevant line ministries are jointly formulated with the aim to ease the impact of droughts on the agricultural sector and the economy. Aid agencies are also contacted including the Food and Agricultural Organisation to provide technical and advisory assistance for the mitigation of drought impacts. However, recognising the role of prevention and mitigation in the pre-drought phase, and due to recurring droughts during the past 2 decades, the **Ministry of Agriculture developed an action plan around several axes of interventions to promote drought mitigation in the agricultural sector in line with the agricultural document of 2009-2014**.

When floods occur, several local committees are formed (one in each of the thirteen agricultural directorates; representing a total of 35 districts) upon the request of the Minister of Agriculture, in order to identify the affected farmers and assess the associated impact costs. Another temporary committee from the central offices is also formed by the minister to verify the work of the local committees. The findings are reported to the Minister of Agriculture who presents it to the Council of Ministers for further decision and follow-up.

Review of data provided to the project [62] indicates that during the last decade, the Government of Jordan compensated twice the farmers who were affected by floods throughout the kingdom or locally. However, during the 2007, 2012 and 2013 floods, no compensations were dispensed. **In the case of drought, financial aid to farmers is only provided if drought is declared by the Cabinet** - which as indicated above did not take place during the past decade, despite the drought episodes of varying severity. Interviews with the MOA staff indicate **there are certain criteria that make farmers eligible for aid**. For example, farmers are entitled only if their rain-fed agriculture fits the local agro-climatic conditions, as per the recommendations of the Ministry of Agriculture and if surface water or springs, whose flows are negatively affected by drought, are the source of irrigation. However, **these criteria (if documented) were not provided, nor the basis for final decision on compensation by the government**.

The development of alternative measures (drought planning and preparedness) under different scenarios of hydro-climatic conditions or drought levels **is to date not practiced**; neither in the water sector nor in the agricultural sector or any other related sector. **Only when faced with clear indications of meteorological and hydrological drought**, the Ministry of Water and Irrigation forms an emergency committee to develop drought management plans (mostly depending on the already depleted groundwater) for further implementation by

[61]Some references indicate that such findings are reported to the national drought committee. However this was not confirmed during the interviews with the MOA staff.
[62]Country Presentation on Risk Management obtained from Eng. Amjad Khandaqji.

the water sector. **However**, since Jordan is under permanent water shortage**, the country has developed a framework for water allocation that is driven by its sector strategy and policies, and has formulated its water management plans under scarce conditions**. In this context, **plans to face the increasing water scarcity, also serve as drought preparedness and mitigation elements.** This includes inter-alia: the implementation of water demand management policies and programs, promotion grey water reuse and rainwater harvesting in agriculture, in addition to the long history of the country's high dependence on the treated wastewater reuse.

Currently **there is no drought early warning system in operation** in Jordan. **However, there are many drought and floods relevant information systems** that are maintained by several institutions in the country. MWI for example maintains all historical rainfall data and stream flows, **but does not analyse them with a view to characterise flood or drought**, even if there still exists some expertise left in the sector to do so. Although this task is considered very essential for risk assessment and reduction, it is **not considered part of MWI mandate**. Nevertheless, raw data are made available upon request for specific catchment(s), within and without the sector. **Additional data in other institutions include**: (a) data on soils, land use and land cover and agricultural statistics at MOA, (b) Meteorological data at the Meteorological Department, agro-meteorological data at NCARE, wildlife and vegetation including plant/animal species at the Royal Society for the Conservation of Nature; with of lot of the above data processed using GIS and database management systems. All these **efforts are however fragmented and sectorial-based**.

Since the major drinking water pollution[63] outbreak in Amman due to extreme weather conditions in the summer of 1998, and in order to face the possible impacts of deteriorating water quality during periods of droughts and floods, a **real-time water quality monitoring; serving as an early warning system for the protection of public health and the environment was established**. The system is comprised of 13 fully-automated monitoring stations located on selected surface water resources[64] in the JRV that are considered the main sources of municipal and irrigation water supplies in the country and is accessed by both JVA and WAJ.

Despite the several programs and activities related to drought and flood management in the country; **Jordan's capacity to deal with natural hazard risk is still predominantly focused at the response stage**. There is still **shortage of qualified and experienced staff**, especially in the public sector, in drought/flood risk and vulnerability assessment. Moreover, there is an overall **lacking in awareness** amongst the drought/flood implicated sectors about the role of the integrated multi-sectorial approach in drought and flood management.

2.1.6 OFFICIAL WATER SECTOR REACTIONS AND TRADITIONAL RESPONSE BY THE COMMUNITY TO PAST DROUGHT AND FLOOD EPISODES

When faced with drought (whether announced or not), the water sector in Jordan (represented by MWI, WAJ and JVA) and the water utilities, develops an emergency water management program which comprises the following measures:

1) In the domain of water supply for municipal purposes:

- Increased pumping from the groundwater resources; the main source of water supply in the country including drilling of additional wells;

[63]Due to a malfunction of the capital's major drinking water treatment plant as a result of increased algae in the lake of Tiberia; used since the signing of the peace water treaty with Israel in 1994, to store the winter floods of Yarmouk River for further utilisation in summer for municipal purposes in Amman city.

[64] Jordan, Yarmouk, and Zarqa Rivers, King Abdullah Canal and King Talal Reservoir;

- Rationing in water distribution below what is normally practiced of once a week (except for Aqaba city, water supply is intermittent in the country and is distributed once a week);
- Water for municipal purposes is given priority, followed by industrial and touristic.
- Reallocation of water between the irrigation sector and the municipal sector. This includes:
  - Renting of privately owned agricultural wells;
  - Increasing transfer of fresh water resources from the JRV - to meet the municipal demands of the cities of Amman and Irbid (located in the highlands) - which would otherwise be used for irrigation within JVA mandated area.
- Distribution of water by tankers;
- Identification of potential observation wells for use during drought;
- Public awareness campaigns involving all water users for the promotion of water conservation and saving;
- Fining practices that result in the waste of water (Ex: Car washing with hoses, washing of sidewalks, driveways, and streets);

2) In the domain of irrigation water supply:

- Agreement with the water users associations in the JRV on the rationing measures including the reduction in water allocated for irrigation;
- Banning of summer plantations in the Jordan Rift Valley and compensation of farmers;
- Provision of irrigation water for trees to survive and not to produce;
- Mixing of treated wastewater with fresh surface water for the irrigation of the areas in the JRV that are affected by the increased transfer of fresh water to the main cities. The actual mixing ratios would depend on fresh and treated waste water availability, irrigation water quality provisions and types of crops;
- Alert farmers to any degradation in water quality to enable them plan the use of such water for the suitable farming purposes.

Due to imminent water scarcity in the country, recurrent drought and continuous influx of refugees as a result of political instability in the region, the **above measures have become the regular practice**. However, the extent to which these measures are applied – individually or collectively – depends on whether scarcity is exacerbated by one or both of the above conditions.

During flood events, the main concern of JVA is to ensure the safe operation of the dams and optimisation of its operation (including opening the spillway gate) or the diversion of floods beyond the capacity of its main conveyance system, for further storage. During the rainy season, each dam is equipped with an emergency room that is operational 24 hours a day; which relays information to the JVA Control centre, from where actions are controlled and co-ordinated. Whenever spilling is required, special arrangements are made by JVA with the local governor and the Civil defence, to inform communities in the downstream vicinity. However, JVA indicates that due to successive droughts during the past decade, the spilling needs were insignificant in most of the dams, with the exception of W.Mujib and W. Wala Dams (April 2006, and January 2013; respectively).

As indicated previously, the MOA has also a significant role in assisting farmers to reduce the impact of drought on agriculture. These include during severe drought assessing of drought induced damages in agriculture, requesting allocation of emergency funds in the government budget and compensation of farmers, requesting technical and advisory services from the FAO and aid from donors and NGOs. Other measures include:

- Coordination with relevant line ministries to increase imports and emergency storage of grains and fodders.
- Provision of subsidies and soft loans to farmers and livestock breeders, re-scheduling of loans and partial or total exemption of farmers from interest rates on the Agricultural Credit loans.
- Intensification of agricultural extension to the farmers and the promotion of the use of drought tolerant crops and of the best practices to deal with drought-related increase in pests and plant diseases
- Increased environmental awareness campaigns targeting the public
- Provision of free drinking water for livestock breeders,
- Free veterinary services
- Regulation of grazing and protection of the range lands

On the other hand, t**here is a range of indigenous practices that have been traditionally used to cope with drought and floods**. These include the construction **of residential rainwater collection systems** to harvest the **rain for domestic and landscape use**; still practiced (although to less extent than in the older days) especially in the Northern part of the country. **Other water harvesting techniques for enhancing and securing additional water supplies for irrigation uses**; such as pools, hafirs and cisterns have been practiced historically in the country in areas with annual rainfall of 100 mm. **Table 28** highlights the water harvesting technique used in Jordan to capture the different types of water sources according to the end use objective.

Table 28: Water harvesting techniques used in Jordan.

Water Source	Objective	Water Harvesting Technique
Rainfall	• To protect soil from erosion and to conserve water. • To increase rainfall effectiveness.	Terraces, contour-ridge terracing and earth dams
Local runoff	• To collect and store harvested water used for domestic supply.	Micro-catchment techniques and cisterns.
Wadi flow	• To divert water for irrigation	Earth dykes and earth canals

Source: Adapted for Jordan from Nasr, 1999

Local responses to drought events are more effective when they are coupled with adaptation measures. Some of the techniques that have been widely used by farmers in the field of soil and water conservation include: carefully scheduling of irrigation (quantities and frequency), selection of crops (drought tolerance), and enhancing the physical conditions of soil which eventually enhances its water holding capacity (Abu Sharar, 2003).

Water-harvesting techniques, either in the form of micro-catchment or macro-catchment, are also used to halt flash flood. Other local mitigation practices include the usage of dispersion and diversion structures for flood flows. The dispersion structure is comprised of low-level structures, of 2-4 meters high, designed to withstand overtopping, while diversion structures are used for partial flood flows through a channel located in the wadi (Abu Sharar, 2003).

2.1.7 ACHIEVEMENTS, SHORTCOMINGS AND GAPS

Water scarcity that is coupled with recurrent drought has been the business as usual during the past two decades in the country. This led to the adoption of several adaptation policies and measures including:

- Introduction and implementation of water demand management policies (2008) and programs, including the promotion of water saving devices in the municipal and touristic sectors, industrial recycling, grey water reuse and rainwater harvesting in agriculture;
- Adding requirements in the building code for rain water collection systems in the construction of new residential buildings;
- Mobilisation and use of nonconventional water resources including desalination of brackish groundwater for domestic purposes, and treated waste reuse;
- Minimisation of losses (Use of drip system in most of the irrigated areas in the country, implementation of water loss reduction programs in the water supply networks, and the conversion of surface water canals for irrigation into pressurised pipe network);
- Structuring of municipal water tariffs to encourage and motivate efficient water use;
- Metering of irrigation and industrial wells and charging for groundwater abstractions for both purposes;
- Construction of flood protection and retention structures including dams, earth dams and bunds;
- Development and implementation of local mitigation measures to reduce drought associated risks and vulnerability (use of subsoil irrigation, protected agriculture, soil-less culture, soil conservation projects, etc.)

Moreover, **a wealth of know-how and experience has developed in the water sector's resources management** capabilities under different hydro-meteorological conditions **and a set of common practices has emerged**. **Unfortunately** none of that is documented in the form of indicators, or plans to guide the managers as to when and what courses of action should be taken under each hydro-meteorological scenario. This poses dangers on the long term sustainability of knowledge in managing droughts and floods. Likewise contingency plans in the agricultural sector are missing and emergency plans are developed, only when faced with drought.

Because irrigation can contend with the more inferior treated wastewater quality, **an intricate water transfer system was constructed to transfer the fresh surface and ground water from areas dominated by irrigation activities to meet the municipal demands of the urban areas** (mainly in Amman and Irbid cities) in exchange with its treated wastewater. This has helped buffer the impact of drought on all sectors including irrigated agriculture in the Jordan Rift Valley. It is expected that with the increasing amounts of treated wastewater from both cities, an increasingly reliable source of irrigation would be available during droughts for agriculture in the JRV.

Despite the above achievements, **Jordan still faces unresolved shortcomings and gaps in its current approach to drought and flood management**. These are summarised below.

- Even with on-going international efforts and technical assistance, awareness of DRM frameworks is not yet institutionalised in the relevant sectors at the national, regional, or local levels.

- To date, a legal framework for DRM in general and drought and flood risk management in particular is absent. Moreover, there is no national drought and flood strategy/policy and vision to guide the development of sectorial, regional and local strategies and plans, or initiate the shift from a reactive approach towards short and long term drought and flood risk prevention, mitigation and preparedness within the context of sustainable development
- There is significant overlapping in the organisational mandates and structures without specific and/or clear roles and responsibilities of the institutions implicated in the different phases of drought and flood risk management. Furthermore, it is not clear till date, which institution is practically responsible for coordinating the drought and flood management efforts in the country (GDCD, HCCD, NCSCM, MOE, MOA, etc.). This results in fragmentation of efforts and lack of a unified vision.
- To date, no drought or flood formal guidelines with criteria and triggers to declare various mitigation and response activities are established.
- So far, there is no methodological framework in place to systematically prevent or minimise the impacts of droughts and floods hazards or to reduce vulnerability (biophysical, social and economic).
- There is a general decline in staff resources and limited technical capacities to characterise drought and floods and evaluate associated risks. This is aggravated by fragmentation of data banking, and problems associated with hydro-meteorological data's quality and availability (too short time series, missing data at some stations, data inconsistency, and validation problems, etc.). The lack of organised documentation of the impact of drought and flood events on the socio-economy and the insufficient measurement of their impacts on biodiversity and ecosystems are not conducive to conducting vulnerability assessments in the various sectors.
- Lack of financial resources and access to sufficient funds that would support the shift from reactive to risk based approach.
- Absence of national insurance fund aimed at protecting/compensating farmers and livestock production from drought and flood-related damage to crops and production losses.
- Weak linkages between research and policy making.

2.1.8 LESSONS LEARNT AND POTENTIAL INDIGENOUS BEST PRACTICES

The following is an overview of the most important lessons learnt from the Jordanian experience in drought and flood management.

The **use of treated wastewater helps relieve agricultural drought in the country**, especially in the Jordan Rift Valley, where increasing developed areas are getting irrigated with treated effluent. Together with the available transfer systems, treated wastewater reuse allows more flexibility in water allocation between various uses under scarce condition in general and under drought conditions in particular.

Despite the financial constraints, the amount of exemption from interest on loans that was born by the government due to agricultural disasters (including drought and flood) between 1985 and 2005 was in the order 44 Million JDs. **The absence of national drought and flood insurance programs, not only increases the financial burden on the state budget during such disasters and affects national economy, it also increases the vulnerability of the affected people and the most susceptible sector (agriculture) to the direct and indirect impact of drought and flood events** (damage to the farm, the crops and/or loss in production, loss of livelihood, etc.). There are various kinds of crop insurance that can be applied during such events, including those assumed by the public sector and increasingly by the private sector. Adequate funds to mitigate drought in advance can also reduce the spilling effects before a drought.

Among many other factors, the introduction of **intensive irrigation systems**, and **the crisis/reactive-oriented programs to provide assistance to affected people** (provision of subsidies to farmers and livestock breeders, provision of supplementary feeds, etc.), **have led to the abandonment of indigenous and local community strategies in drought and flood management over the decades and to the increasing dependence of the communities and farmers on the government assistance**. In order to encourage indigenous drought and flood coping techniques, the government initiated several programs for soil and moisture conservationincluding investment in cisterns, hafirs and other water harvesting systems in micro and macro catchment scale.

Cisterns, hafirs and dams are indigenous methods widely used in arid and semi-arid areas for runoff water harvesting. A large number of cisterns existing in the region are linked with the Roman period. **Cisterns** are underground structures excavated in the frail rock to provide a water storing capacity that could range from 100 m3 to 3000 m3 (ICRISAT, 1999). The structure consists of channels to collect rainwater, excavated main reservoir, settling basin to receive runoff water and to allow the settling of suspended material before it is moved to the main reservoir to pump out the stored water. **Hafirs** are used for rainwater collection in areas with gradual slopes and in absence of drainage channels. They could provide a water storing capacity of 5,000 m^3 to over 1.0 million m^3 (ICRISAT, 1999) and are constructed through excavation and reallocation of the spoils as a bund around its varying geometrical forms to protect it from contamination from nearby activities (Olokesusi, 2006). Compared to cisterns, their structure is rather complex; entailing additional structure of water inlet and outlet pipelines for water conveyance (ICRISAT, 1999). **Apart from storing water for various end-uses, cisterns and hafirs benefit groundwater table recharge through percolation** (Olokesusi, 2006).

Some of the earliest water harvesting methods in the Edom Mountains in southern Jordan - believed to date back to over 9000 years ago - (Nasr, 1999) are applied in areas **where rainfall is insufficient to ensure sustainable production of crop and pasture** through the **collection and storage of runoff water within the soil's profile for productive use** (Nasr, 1999). Stored water is utilized to rehabilitate and restore land productivity, provide drinking water, recharge ground water, and eventually, reduce the risks in drought prone areas. **Amongst the commonly practiced micro-catchment water harvesting techniques** are contour ridges, which are small ridges with an upslope furrow that accommodates runoff between ridges (ICARDA, 2012). Runoff is then stored within the vicinity of the soil profile and near the plant's roots (UNEP[65]). Some practices used in response to contouring difficulties involved semi-circular and trapezoidal bunds (ICARDA, 2012).

Macro-catchment methods were practiced by the early **Nabateans** who relied heavily on sustaining run-off water stored in bedrock constructed plastered cisterns. They lived largely off cisterns for human use since large pools were subject to high rates of evaporation, pollution by surrounding domestic animals, and

[65]Accessible at: http://www.unep.or.jp/ietc/publications/techpublications/techpub-8a/tied.asp.

intrusion by plants. **Among the water harvesting techniques still visible are run-off collection fields, wadi barriers and agricultural terraces** (Oleson, 2003).

2.1.9 ASSESSMENT OF SOCIO-ECONOMIC AND ENVIRONMENTAL IMPACTS OF DROUGHTS AND FLOODS

The population that is most affected by natural hazards are the urban population of Aqaba city (ALEFCON LLC & GC, 2012), and farmers due to repeated droughts and unpredictable rainfall. Over the past 30 years**, 86% of the recorded damages that occurred to houses were due to climate related risks** (MOE, 2013).According to UNISDR statistics for disaster-related human and economic losses reported for Jordan between 1980 and 2012[66], **flash floods and floods represented the highest percentage of disaster related mortality (52.7%)** while **drought almost represented the only factor affecting Jordanian people** (98.2 % of the people reported to be affected by disasters are due to droughts). The respective percentages for flood and flash floods related **injuries**, **missing people and destroyed houses** are about 27%, 43% and 19%, while those of **evacuations** and damages in the roads were in the order of 22%. At the same time and according to the same source, the **economic losses due to droughts represent 15.4% of the reported losses compared to 1.7% for floods and flash floods.** It should be noted that, in the absence of structured and consolidated national statistics, the **percentages provided by the UNISDR should be regarded as indicative of the order of impact** of the two phenomenae on the Jordanian population.

Review of FAO / Food World Program (FWP) Crop and Food Supply Assessment report during their mission in April/May 1999 provided by the Ministry of Agriculture, and available ESCWA report on the Vulnerability of the ESCWA region to socio-economic drought (ESCWA, 2005), point to the **following impacts of droughts on the agricultural secto**r as concluded from the 1998/1999 and 1999/2000 consecutive drought seasons (involving only 30% of the country's total rainfall):

1) Drop in the water levels of the dams reducing agricultural production.
2) Reduction in agricultural yields and production especially of wheat and barley (drought reduced their production in 1999 by 88%). The estimated total production loss alone for the 2000 drought according to FAO was $160 million.28% of the cultivated area during the previous years
3) Decreased income of the rural populations dependent on the agricultural sector, and subsequent liquidation of assets
4) Loss of livestock herds to disease, malnutrition, premature slaughter and distress sales.
5) Decreased domestic production of red meat and milk
6) Increased dependence on imported fodder (barley and straw) for herds
7) Increased import of wheat for the drought-affected people including small holders, small scale herders and landless rural households
8) Increased import of the shortfall for agricultural production

The main effect of drought on water resources is the reduction in the availability of surface water, drying of springs, and increased burden on the already overexploited ground water resources, resulting in depletion of water tables, further loss of fresh water due to increased salinity and the subsequent increase in pumping and treatment costs. This, together with the reduced agricultural production is translated into **increased pressure on the urban population, in the form of increased cost of living and dependence and pressure on water**

[66] http://www.desinventar.net/

distributed by tankers. **Sanitary conditions** in households are also affected. The situation could also be exacerbated by increased deterioration in the quality of the country's water resources. The water pollution outbreak during 1998 extreme weather condition offers a good example in this regard, which resulted in several incidences of diarrhoea in the capital Amman, as a result of high algae loads entering the water treatment plant serving the city.

The **decreases in the hydraulic loads to the wastewater treatment plants** ensuing from drought results in inefficient wastewater treatment and subsequent deterioration in the effluent quality (including increased salinity) that **affect downstream irrigation reuse areas**. Loss of production due to increased salinity and crop failures become major threats for irrigated agriculture.

One of the main concerns of prolonged droughts is the **degradation of the vegetative coverage** within the Badia region. According to historical data, the degradation of rangeland into marginal steppe has been estimated at approximately one million hectares in the Eastern Badia. The drought incident in 2006 alone, recorded a production of rangeland that covered only 20-25 per cent of the animal needs over a period of 3-4 months (ICARDA, 2012). A study based on meteorological data for over four decades revealed cycles of two years of drought occurring every 10 years in the South Badia . This has a serious implication on the carrying capacity of rangeland desired to meet the requirements of grazing animals, particularly those owned by smallholders. An evaluation mission conducted by the International Fund for Agricultural Development in Jordan identified that the majority of the smallholders in the southern Badia have lost part, or most, of their animals in the past 10 years as a result of drought and overgrazing (International Fund for Agricultural Development (IFAD), 2012), thus impacting the livelihood of small herders, food security and accessibility, and hindering progress..

Depending on the location and intensity of the flood, observed **impacts** during the last decades in the country vary from loss of life, human injuries and loss of agricultural lands or products (including livestock and fishery production). Other damages include destruction of existing infrastructure (communication, transportation, aviation, business and commerce), disruption in infrastructure services, disruption of water and power supplies, decrease in water quality and increased turbidity in fresh water systems, damages to recreation and tourism properties, in addition to substantial hardships for the affected population as a result of evacuation and resettlement.

To date, **the direct impact of drought and flood events on Jordan's biodiversity and ecosystems are not documented or measured**. **However**, **historical meteorological information** on the shift in rainfall patterns, warmer seasons and recurrence of drought **anticipate a cumulative impact on the vegetative cover and fauna's habitat** (MOE-JO, 2001).**Habitat fragmentation/degradation** in the country as a result of the compounded effect of urbanization, overgrazing, deforestation, drought and flash floods, etc. has led to a dramatic decline in biodiversity and a reduction in genetic diversity. This has **isolated many species** and made them vulnerable of a high risk of **extinction**; influencing some 200 and 250 plant species that are nationally rare and 100 to 150 species that are nationally threatened

Due to water shortage compounded with the effect of over pumping from aquifers and drought, the **Azraq Oasis;** declared in 1977 by the Ramsar Convention as **a strategic station for migratory birds** on the African Eurasian route[67]**decreased significantly in size** (National Center for Research and Development (NCRD), 2011). Despite national efforts, the country has only managed to restore it to less than 5 per cent of its previous state. This has severely impacted the number of migratory birds, which is still witnessing a decline in numbers. Moreover, the wetland's rich biodiversity has posed a threat to numerous aquatic and terrestrial species, for

[67] http://rscn.org.jo/orgsite/RSCN/HelpingNature/ProtectedAreas/AzraqWetlandReserve/tabid/98/Default.aspx

example, an endemic vertebrate species of Jordan, Killfish, has been identified as critically endangered by the International Union for Nature Conservation (IUCN). It is expected that the situation will worsen with the predicted fluctuations and severity of precipitation and temperature as a result of climate change which will have serious implications on the flora's growing season and fauna's favourable conditions.

2.1.10 OPPORTUNITIES

The recurrence of droughts and floods in several parts of the kingdom has resulted in a growing need to increase drought and flood preparedness. Moreover, the on-going efforts within the HFA framework in Jordan has mobilised attention to the concept of disaster risk reduction and management as a way to reduce the vulnerability of the country to natural hazards. However, with the DRR being led by the Civil defence, and with the establishment of the NCSM expected to deal with all types of crisis including natural disasters, it is imperative in order to avoid duplication of efforts, that an adequate legal framework is established; involving clear definition of roles and responsibilities of institutions at the national, regional and local levels and mandating one designated body/institution to initiate the development of sectorial disaster risk management policies and plans (including those of drought and flood), and coordinate and follow up their implementation.

There are several drought and floods relevant information systems in place, in addition to a reasonable number of automated weather and agro-climatic stations operating in Jordan. Progress has been made on networking some of these stations (for example at NCARE), while MWI is currently extending its Telemetric Water Resources Observation Network (TeWaRON) including hydro-meteorological network - which should offer an opportunity to establish drought/flood monitoring and early warning system. However, in the case of drought, special efforts should be put forth to agree on a national definition of drought, the development of sound indicators and criteria for announcing and ending it. This could be revised as more information on drought impacts becomes available and/or organised and consolidated.

If operationalized, the "Agricultural Risk Management Fund" established by MOA would contribute to improved management of agriculture-related disasters including drought and flood. Linking compensations with risk reduction practices would certainly promote the development and application of techniques to mitigate their impacts on the famers. Efforts to expedite the resolution of pending issues (legal, institutional) and to build the capacity of the relevant staff in insurance and risk management should be intensified.

There is a wealth of guidelines produced by regional and international organisations that provide good foundation for drought and flood management and reduction of related risks (See ANNEX 2: EXISTING DROUGHT AND FLOOD MANAGEMENT FRAMEWORKS). Use of these guidelines can help enable stakeholders/authorities at all levels address relevant aspects of drought and flood management

The micro and macro catchment inherited knowledge and conservation practices from pervious civilizations in the region should provide farmers and users including local communities, with sustainable management tools to deal with drought and flood events. These should be systematically revived in the country through demonstration sites that can be implemented at the local level under the responsibility of the NCARE and MOA staff, and perhaps with the assistance of the increasing presence of NGOs and community based organisations (CBOs). Both NGOs and CBOs can also be used within coordinated campaigns to increase awareness of the local communities on drought and flood recurrence and mitigation and tap the knowledge of the elders.

Last but not least, since drought and flood risk reduction greatly overlap with climate change adaptation, there is ample opportunity for synergy and learning between these two communities of practice. Advancements made in the climate change adaptation agenda in the country can provide a good source of tools and approaches that are common to both practices (vulnerability assessments, sector and national planning, capacity building and response strategies) and that are directly supportive of DRR.

REFERENCES

1. Abu-Sharar T., 2003. The Challenges of Land and Water Degradation Resources Degradation in Jordan: Diagnosis and Solutions. Proceedings of the NATO Mediterranean Dialogue Workshop on Desertification in the Mediterranean Region. Springer, 2003; 201-226.
2. ALEFCON LLC & GC, 2012. Climate Change – Assessment of Potential Adaptation Measures and Fields of Intervention for the Water Sector of Jordan, Vol. I + II, pp. 86, Amman (unpubl. consulting report).
3. ASEZA, 2013. Flood reports –DRR unit
4. Badia, 2011. Azraq oasis restoration project final technical report. Available at http://www.badia.gov.jo/themes/water/azraq_oasis_restoration_project__final_technical_report_2011.pdf
5. ESCWA, 2005. Economic And Social Commission For Western Asia. ESCWA Water Development Report 1. Vulnerability of The Region to Socio-Economic Drought. United Nations, New York, 2005
6. ENNP, 2008. Workshop on National Platforms at the International Disaster and Risk Conference (IDRC) in Davos- Switzerland, Disaster Risk Reduction National Coordinating Mechanisms in Jordan. 23 – 29 August 2008, available at: http://www.ennp.eu/080823_IDRC_Davos/080823-Jordan.pdf
7. Freiwan, M. and Kadioglu, M., 2006. Contemporary Climate Change in Jordan. 1st International Conference on Climate Change and the Middle East: Past, Present and Future 20-23 November 2006, Istanbul Technical University, Istanbul, Turkey.
8. Freiwan, M. and Kadioglu, M., 2008a. Climate variability in Jordan. Int. J. Climatol. 28, p. 69 – 89.
9. Freiwan M. and Kadioglu M., 2008b. Spatial and temporal analysis of climatology in Jordan. Int. J. Climatol., 28, 521 - 535.
10. IFAD, 2012. The Hashemite Kingdom of Jordan National Programme for Rangeland Rehabilitation and Development
11. ICARDA, 2012. Oasis Country Report 1. Land Degradation in Jordan - Review of Knowledge Resources.
12. International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), 1999. Efficient soil water use: the key to sustainable crop production in the dry areas of West Asia, and North and Sub-Saharan Africa. Andhra Pradesh, India.
13. MOA, 2007. National Strategy and Action Plan for Drought Management. Draft Report .
14. Ministry of Civil Defence (MCD), 2007. Flood report, Disaster Management Unit, Jordan.
15. Ministry of Civil Defence (MCD), 2008. Analytical Study on Legislations effective in the Hashemite Kingdom of Jordan Related to Disasters & Disaster Management. Support to Building National Capacities for Earthquake Risk Reduction at Amman Municipality in Jordan" Project, Jordanian Civil Defence, 2008.
16. MOE-JO, 2001. Conservation and sustainable use of biological diversity in Jordan, 2001.
17. MOE-JO, 2006. National Strategy and Action Plan to Combat Desertification. 2006. Ministry of Environment, Hashemite Kingdom of Jordan.

18. MOE-JO, 2009. Jordan's Second National Communication to the United Nations Framework Convention on Climate Change (UNFCCC).

19. MOE-JO, 2013. The National Climate Change Policy of the Hashemite Kingdom of Jordan (2013-2020). Ministry of Environment, Hashemite Kingdom of Jordan.

20. MWI, 2012. Final Discussion Draft 2012 Update to Water for Life: Jordan's Water Strategy 2008 – 2022.

21. Nasr M., 1999. Assessing Desertification and Water Harvesting in the Middle East and North Africa: Number 10 - Policy Implications, ZEF – Discussion Papers on Development Policy, Rheinische Friedrich-Wilhelms-Universität Bonn, Bonn.

22. NCRD, 2011. Development of a Decision Support System (DSS) for Azraq Oasis, Final Technical Report, June 2011. Azraq Oasis Restoration Project. Available at http://www.badia.gov.jo/themes/water/azraq_oasis_restoration_project__final_technical_report_2011.pdf.

23. Olokesusi F., 2006. Survey of Indigenous Water Management and Coping Mechanisms in Africa: Implications for Knowledge and Technology Policy. African Technology Policy Studies Network (ATPS) Special Paper Series No. 25. ATPS, Nairobi, Kenya.

24. Oleson J, 2003. Nabataean Water Supply. Pp. 39-42, 55-60 in R. Rosenthal-Heginbottom, ed.,The Nabataeans in the Negev. Haifa: Hecht Museum, 2003.

25. UNDP, 2012. Strengthening Synergies between Governance of Disaster Risk Reduction and Climate Change Adaptation in Jordan with a View to Reduce Poverty. Jordan Civil Defense Department. UNDP supported Program. Draft Report on Institutional Analysis "Mapping and assessing the existing and potential linkages between CCR and DRR in Jordan". September 2012.

26. UNEP. Technical Publications. Sourcebook of Alternative Technologies for Freshwater Augmentation in Africa -Tied Contour Ridges. Accessible at: http://www.unep.or.jp/ietc/publications/techpublications/techpub-8a/tied.asp.

27. UNISDR, 2013. The United Nation Office for Disaster Risk Reduction, Country Disaster Statistics.http://www.desinventar.net/DesInventar/profiletab.jsp?countrycode=jo

28. UNISDR,2005. Hyogo Framework for Action 2005 - 2015; Building the Resilience of Nations and Communities to Disasters. World Conference on Disaster Reduction 18-22 January 2005, Kobe, Hyogo, Japan.

29. UNDP, unknown date. "Disaster Risk Reduction program in the country (Amman, Petra and Aqaba with the aim to improve governance and strengthen Jordanian institutional coping mechanisms to address disaster risk reduction (DRR) for natural hazards and climate change adaptation (CCA) as it relates to prevention, mitigation, and preparedness for flash flooding, ASEZA Report on Floods. DRR unit, 2013.. Available at http://www.undp-jordan.org/index.php?page_type=projects&cat=4&page_id=388

30. USAID, 2011. Improved Drainage and Flood Control for the Aqaba Special Economic Zone Authority (ASEZA), Volume 1: Final Flood Protection Master Plan for Wadi Yutum and Adjacent Coastal Wadis, December 2011.Study implemented by CDM International, Inc.

Websites consulted:

31. www.desinventar.net/

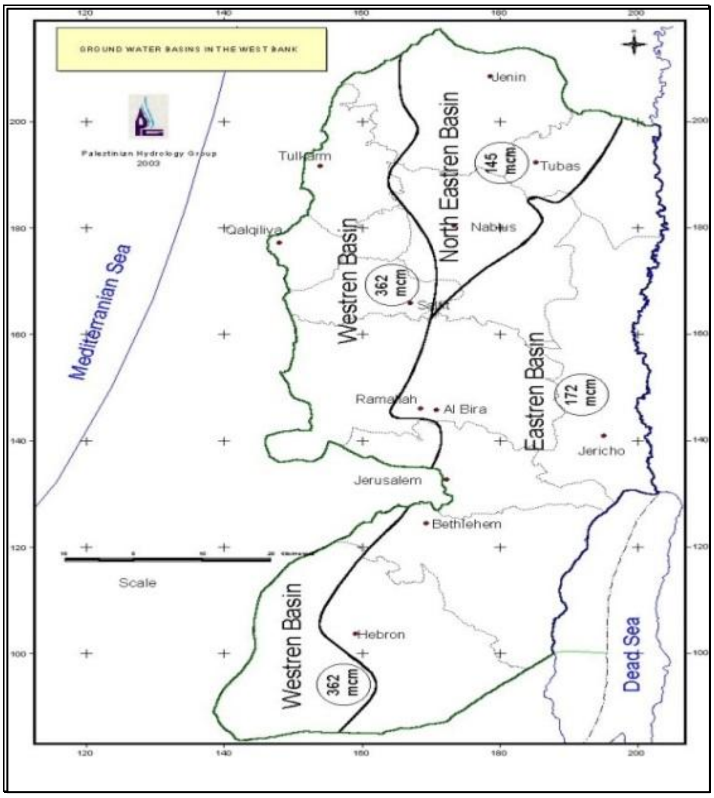
32. http://rscn.org.jo/orgsite/RSCN/HelpingNature/ProtectedAreas/AzraqWetlandReserve/tabid/98/Default.aspx
33. http://www.disaster-report.com/2013/02/recent-natural-disasters-list-february-2.html
34. http://www.trust.org/item/?map=jordan-readies-its-first-policy-on-climate-change/

2.2 THE CASE STUDY OF PALESTINE

2.2.1 WATER RESOURCES SITUATION IN PALESTINE

Precipitation is the only source of water resources replenishment in Palestine. Its annual average varies from 537mm in the West Bank to 358.5 mm in Gaza (PMD, 2012).The long term groundwater replenishment in the West Bank as reported by the (World Bank, 2009) varies from 679- 709.2 Million Cubic Meters (MCM)/year; distributed in three major basins: Western, North-eastern and Eastern basins as follows; 362 MCM, 145 MCM and 172 MCM per year; respectively **(figure 14)**. While the long term replenishment of the coastal aquifer in Gaza was estimated at 55–60 MCM/year, (Palestinian Water Authority (PWA), 2011).

Figure 14: Groundwater Basins in the West Bank



Source: Palestine Hydrology Group.

The surface water, represented mainly by the Jordan River, is no longer accessible to the Palestinians. The historic discharge of the river to the Dead Sea which was nearly 1400 MCM/year has been decreased substantially, mainly due to major upstream diversion of its head waters; especially by Israel(nearly 500 MCM/year are diverted through the Israeli National Water Carrier(PWA, 2011).

Of the total annual renewable groundwater resources in the West Bank and Gaza**, estimated at 734MCM, the country is allowed to use 118.5 MCM/year** (53 MCM purchased from the Israeli Water Company Mekorot and 65.5 MCM pumped from wells by the Palestinian government)**,in addition to the variable quantities discharged by springs in the West Bank**(actual quantities depend on annual rainfall). The long term average spring discharge is estimated at 54 MCM/year. However in 2011, the recorded discharge was only 21 MCM, with the reduction being attributed to drought on the one hand and over pumping of groundwater by Israel; to serve its settlements in the West Bank, on the other hand(PWA, 2011).Over-pumping of the aquifer in Gaza strip (estimated to be four times more than the average annual replenishment from rainfall), in addition to the absence of lateral flows as a result of groundwater pumping by Israel in the northern and eastern border of the Strip, have both led to saline water intrusion and deterioration of the aquifer's water quality. The total groundwater abstracted for Municipal use in Gaza is estimated at 92.8 MCM and nearly 86 MCM for agricultural use, (PWA, 2011). According to PWA, 2012, out of the total water quantity pumped from the ground water in Gaza, only 5% is suitable for drinking purposes.

As a result of the restrictions imposed by Israel, the average per capita water use for domestic purposes amounts to70 l/c/d in the urban centres, including 40% of water losses due to leaks. The per capita water use in the rural areas is much less, where access to water is still limited to rainwater collection and purchase of water from water tankers. According to Palestinian Hydrology Group (PHG), 2004, the per capita daily water use for all domestic uses (including all losses) ranges between less than 15and 30litres per capita per day (l/c/d)in some of these communities.

2.2.2 REVIEW AND INVENTORY OF PAST DROUGHT AND FLOOD EPISODES DURING THE PAST TEN YEARS

DROUGHT EPISODES

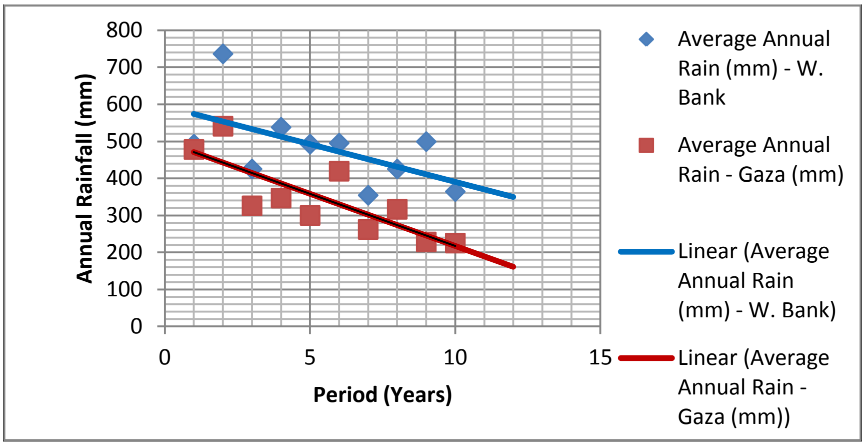
Over the past ten years, Palestine experienced lower than average annual precipitation resulting in consecutive meteorological drought events **(Figure 15).** Although drought occurrence is random with no fixed return period, whereby the occurrence of two or more consecutive meteorological drought events can occur with equal probability (Rabi et al, 2003), the drought occurrence phenomenon has neither been studied in depth nor continuously monitored to understand the subsequent impact of hydrological and agricultural droughts on the water resources and the agricultural sector (both rain-fed and irrigated agriculture).

For a region characterized by a semi-arid climate, natural water scarcity, shared water resources, conflicting demands and a complex hydro-political situation such as in Palestine, the need to monitor and assess drought onset, duration, severity and areal extent is highly crucial in order to better factor it in the national water management and agricultural plans and to develop proper mitigation measures.

The most severe drought that was recorded in Palestine over 60 years of available records was that of 1998/1999, when total rainfall reached 37% of the long term average. Since then, Palestine was hit by extreme to mild droughts with the total annual rainfall ranging from 60 to nearly 100% of the long term average as shown in **Figure 16a and 16b**. Extreme drought occurred in Gaza Strip (GS) in 2009/10 **(Figure 16a)**, while it hit the West Bank in 2007/08 and2010/11 **(Figure 16b)** with the total rainfall representing nearly 60% of the long term average. The drought severity for the remaining years can be considered mild to moderate with the exception of the wet year in 2002/2003. It should be noted that the geographic extent of the drought varies within the country, such that a year of drought in one part, could be wet in another, as can be noticed in 2001/02 and 2006/07 characterised as moderate droughts in the West Bank and wet years in Gaza Strip.

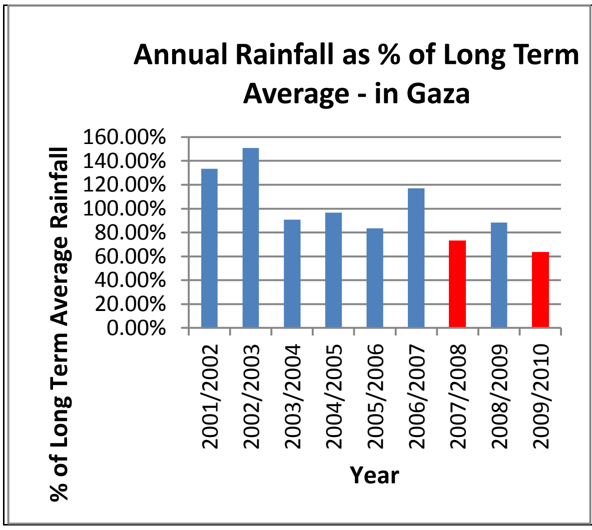
Although the analysis of average rainfall over the entire West Bank and Gaza provides a useful indicator about the severity of drought at national scale, the spatial analysis of rainfall would provide much more useful information about the impact of drought at a local scale. **Figure 17** shows that Hebron; the southern part of the West Bank, is by far the region most affected by severe drought over the period2007/2008 - 2010/2011; even during the wet year of 2009/2010. This is followed by Salfeet in the middle part and Nablus in the northern part of West Bank, which witnessed severe to moderate droughts for four consecutive years.

Figure 15: Trends of Annual Rainfall

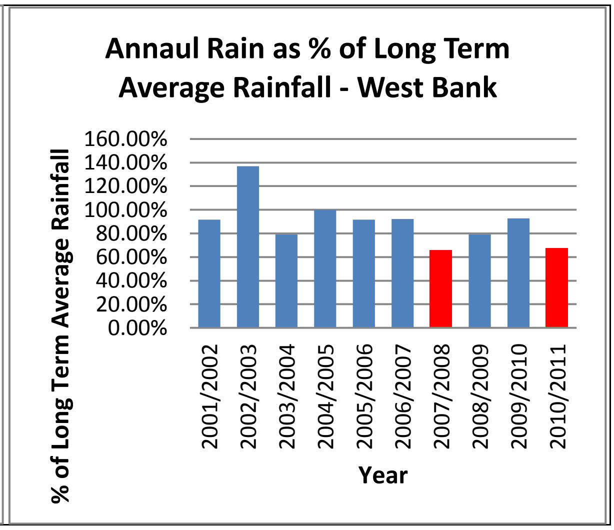


Source: Author

Figure 16: Annual Rainfall as Percentage of the Long Term Average Rainfall in West Bank and Gaza



(a)



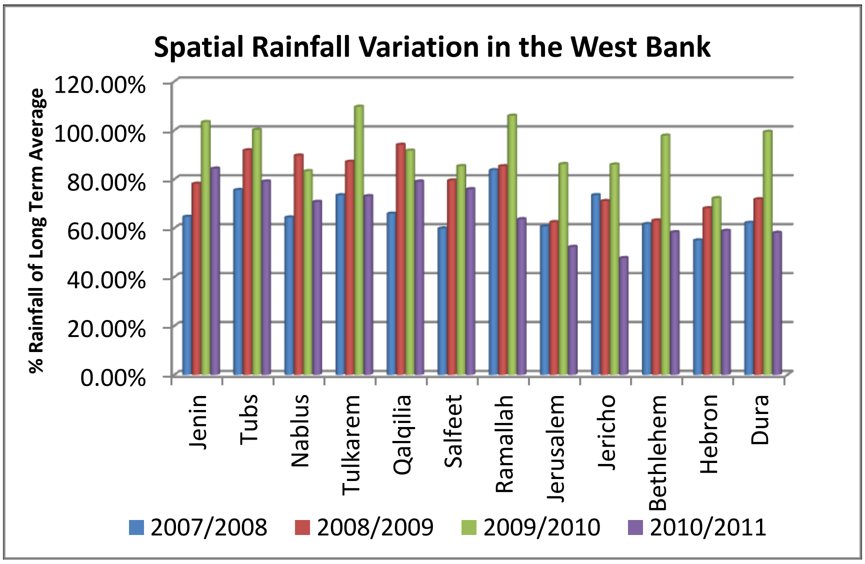
(b)

FLOOD EPISODES

Flood events in Palestine are generally less frequent than drought. Their occurrence can also be considered random; whereby the likelihood of occurrence of two consecutive flood events is 50%.In addition, flood may occur in one area and not necessarily in the entire country. An example of this is the flood event of April 2006 which affected the Jordan Valley area and that of October 2008 which affected both the Jordan Valley and Gaza. Flood events in the form of flash floods, also occur when rainfall intensity is high and the duration is short. They may occur even during drought years. One of the areas that has been flooded almost on a yearly basis during the past ten years, is the area of Marj Sanour in the northern part of the West Bank, where several wadis discharge their flows into its plane resulting in water accumulation that may last for a few months during normal years, and throughout the entire year during wet years. A pronounced case of this occurred in 1992, when nearly 20 MCM of ponded water remained for the whole year (International Union for the Conservation of Nature (IUCN) - PHG, 2009).

Analysis of available records over the past ten years shows four major flood episodes which affected the entire country; with the last two occurring in 2012 and 2013; the first during28 February – 1March, 2012 and the second and most extreme during 4-10 January 2013; reaching its peak on 7th January. The total rainfall during this storm accounted for nearly 30% of the long term annual average, with more than100mmor 50% of the rainfall occurring on 7th January 2013.

Figure 17: Spatial Rainfall Variation in the West Bank



2.2.3 POTENTIAL LINKAGE OF DROUGHT AND FLOOD EPISODES TO CLIMATE CHANGE

Climate change forecasts for the eastern Mediterranean using high-resolution regional climate models give clear scientific backing to the Intergovernmental Panel on Climate Change (IPCC) projections for the region. In its Fourth Assessment Report, the IPCC predicts that, for the southern and eastern Mediterranean, warming over the 21st century will be larger than global annual mean warming – between 2.2 and 5.1^{o}C; based on a realistic emissions scenario (Scenario A1B). Annual precipitation rates are also likely to fall – decreasing 10% by 2020 and 20% by 2050 – with an increased risk of summer drought (Christensen et al, 2007).

Moreover, the GLOWA MM5 model run between 1958-1996 and 2007-2045 forecasts a mid-century decrease in precipitation by 100 to 200mm in northern Palestine (above 31ºN), and a shift in the rainfall season into March and April (Khatib, 2009).

Accordingly, it is highly likely that the current drought and flood episodes are linked with climate change whereby (a) rainfall deficit by 10 - 20% is more frequently occurring as indicated in the previous analysis **(See chapter 2.2)**, (b) there is a delay in the start of the rainfall season; beyond the month of October when the hydrological year normally starts, and (c) rainfall occurs in shorter periods as witnessed during the last storm of January 2013;whennearly 30% of long term average rainfall occurred in a couple of days. Accordingly, business as usual planning is no longer an option and more dynamic plans that factor in these changes are needed.

2.2.4 INSTITUTIONAL, POLICY AND LEGAL ASPECTS

The legal and institutional setup related to droughts and floods is not well developed in Palestine. There are no specific laws or regulations or dedicated distinct policies or strategies addressing this issue clearly, rather they are generally encountered or broadly referred to, within overall strategies such as environmental sector strategy, Climate Change Adaptation Strategy and Program for Action, National Strategy on Combating

Desertification, Water Sector and Agricultural Strategies. For example, the Water Strategy calls for the formulation of specific practical plans to alleviate the adverse impact of climate change, mainly the impact of floods and droughts. The plans should include the necessary measures to minimize flood risks, preserve available water resources and prevent its depletion and ensure the sustainability of livelihood of local communities. Moreover, **there is no specific government agency clearly charged with the responsibility of addressing or monitoring and managing these events**. A good example in this regard is offered by Article 78 of the environmental law. According to the interpretation of this article, the task of preparing emergency plans to deal with environmental disasters is mandated to the Environment Quality Authority (EQA). Yet, there is no clear mention of the drought or flood in the definition of environmental disasters. According to the environmental law, the broad definition of environmental disasters as “the accident that results from nature or human act which causes severe damage to the environment” leaves room for a lot of interpretation and provides no clear mandate to the EQA to deal with the subject.

At the same time, the tasks of the **Civil Defence Directorate General** as stipulated in the Civil Defence Law no 3 for 1998, include preparedness to, combat of and providing post disaster relief. The law gives example on the natural disasters and lists droughts as part of these disasters. On the other hand, the role of **Meteorology Department** is to monitor, record and forecast weather conditions and to warn people as well as relevant government agencies on the potential consequences expected from any extreme weather condition to enable them to take the necessary precautions. On the other end, the **Water Authority** whose role includes collecting information on water quantity and quality, measures only winter flows in the major wadis[68]during flood periods, while the **Ministry of Agriculture (MOA)** focuses on alerting farmers and assessing the damage to the agricultural sector. Together with PWA, the Ministry of Agriculture tries to leverage compensation programs - through the support of various local and international agencies - to the communities affected by floods or droughts. One of the existing mechanisms is to distribute water via tankers to the most vulnerable communities affected by drought especially during the summer period. Several local and international agencies who deal with water and sanitation in Palestine form ad hoc committees such as drought or water scarcity committees to assess the impact and propose proper mitigation responses for the vulnerable groups.

Overall, the existing structure which addresses disasters is **theoretically the Higher Civil Defence Council**, defined under Civil Defence Law #3 of 1998, which is **headed by the Minister of Interior** with the membership of 15 different ministries, the police, national security, etc. as shown in **figure 18**.

However, the Palestinian National progress report to Hyogo Framework 2011 - 2013 indicated that some more institutions have been added to the council such as the Red Crescent Society, Engineers Union, Union of Palestinian Contractors, and any other body that can be seen relevant. In addition to the higher civil defence council, the law provides for the establishment of local civil defence committee at each governorate headed by the governor as shown in **figure 19**.

It should be noted that neither the Higher Civil Defence Council nor the local civil defence committee structures include the ministries and authorities that are most relevant to drought and flood, namely; the ministry of Agriculture, the Palestinian Water Authority and the Palestinian Environment Quality Authority. The meteorology department, however, is represented because it is part of the Ministry of Transport.

Although the council is not functional on the ground, the local civil defence committees are more practical and they are activated in emergency conditions and during the times of expected natural disasters, especially floods. The committees are generally composed of the structure mentioned under **figure 19**, and include volunteers from the public (who have been trained by the Civil Defence - Department of Disasters), the Red

[68]There are no perennial streams in Palestine

Crescent as well as representatives from other institutions.

The most formal committee which was established by a ministerial decree is the national climate change committee which comprises 21 different government and non-government institutions and is tasked to monitor the climate change impact on various sectors[69].

Figure 18: Structure of Higher Civil Defence Council as stipulated in the Civil Defence Law #3 of 1998

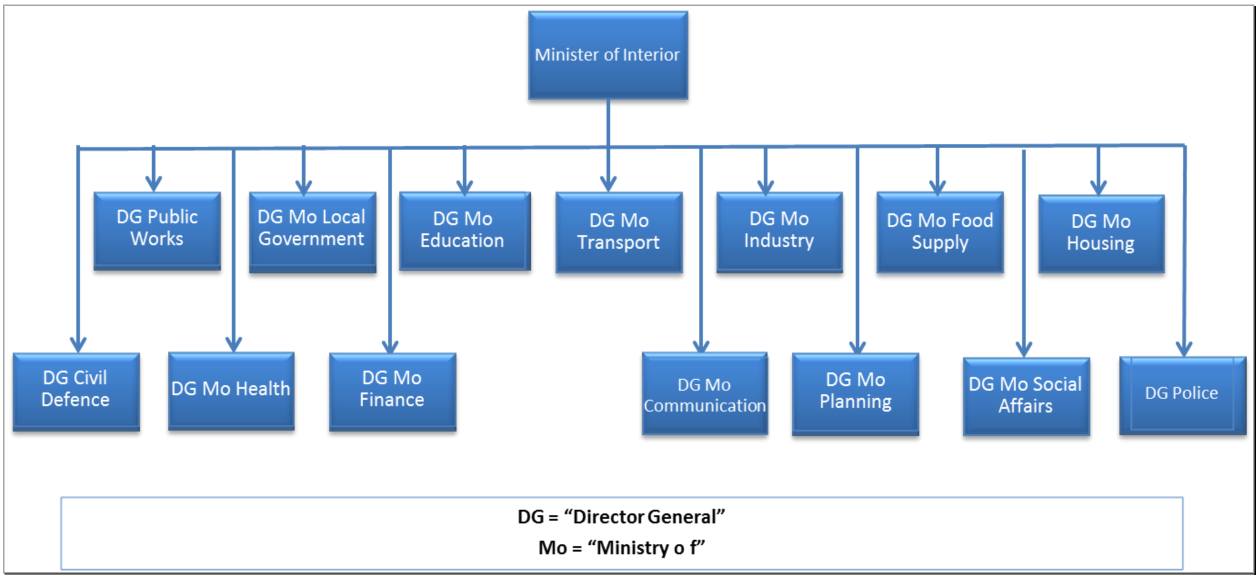
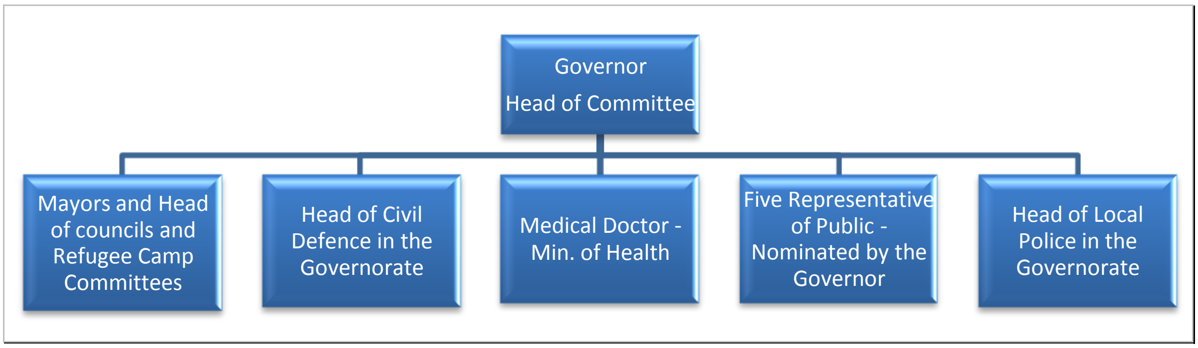


Figure 19: Structure of Local Civil Defence Committee as stipulated in the Civil Defence Law #3 of 1998



2.2.5 ANALYSIS OF EXISTING STRUCTURES AND SYSTEMS INCLUDING TECHNICAL CAPACITY AND LINKAGES

Based on the preceding section, it is evident that **no clear mandate** is given to any specific government agency to deal with the two types of natural disasters. Moreover, there is **no clear provision in the existing relevant laws** that allows for a **more formal coordination among the various implicated agencies**, which leaves the **efforts** scattered and **coordination** voluntary rather than mandatory. According to the Climate Change Adaptation Strategy (United Nations Development Program - Program of Assistance to the Palestinian People (UNDP – PAPP), 2009), available **data** is also **scattered**, and collected by different institutions without adequate coordination. The **data related to climate change**, **including flood and drought, is not always effectively processed, screened and evaluated**. Moreover, **there is no central hub or 'clearing house'** within this dispersed climate information infrastructure. This has also been confirmed by the country's National Progress Report to the Hyogo Framework 2011 – 2013 and the various meetings held with the relevant

[69] Personal interview with Mr. Ahmad abu Thaher and Mr. Nedal Katbeh of EQA

ministries and authorities and evidenced by the lack of integration in the use of existing capacity and infrastructure. For example, the **weather stations are scattered between multiple institutions;** the Meteorology Department, the MOA and the PWA; each of which runs its own stations with minimum coordination. All the interviewed people from these agencies acknowledge the **importance of unifying the monitoring efforts and the information sources in order to avoid duplication and contradiction in the data provided. Moreover, they identified important areas for immediate cooperation between the Meteorology Department and the Ministry of Agriculture in the implementation of an Early Drought Monitoring System** (Abu Asaad, 2013).

Presently, the **only early warning system that is in place** in the country is related to flood forecasting, established by the Meteorology Department before a storm strikes the area. The Department announces the likely impact that is expected and the likely areas to be affected and coordinates with relevant government agencies; especially the Civil Defense Directorate, MOA and local authorities to take the necessary precautionary measures[70].

Recently, the Ministry of Agriculture got support the from Food and Agriculture Organization (FAO) to join the "data base project" on the documentation of disasters over the past thirty years currently being implemented by Civil Defense - Department of Disasters in cooperation with the United Nations Office for Disaster Risk Reduction (UNISDR). In the meantime MOA is currently developing its own data base for documenting the impacts resulting from natural and manmade disasters, quantify their monetary value, define affected people and prepare compensation claims and submit it to the Palestinian Council Of Ministers for actions. However, the relevant staff of MOA still needs **capacity building in drought and flood "risk assessment" and "planning", in addition to monitoring and management of both events**[71].

So far the government's approach to drought and flood management is reactive and is confined to the formation of committees as the need arises including those for the assessment of damages ensuing from disasters. For example, when a flood event occurs[72], the MOA forms a higher committee headed by the Minister to assess the damages resulting from the flood. The committee dispatches a team of expert to the areas affected, to assemble a report on the damages within 48 - 72 hours. Such a report is then presented to the Council of Ministers for further decision and follow-up. A higher committee for follow up (comprising the Deputy Minister and the Directors general of various departments within MOA) is formed to assess the damages. The higher committee is supported with subcommittees which are formed at the local level to assess the detailed damages and to estimate the amount of the compensation needed in each affected area. Each committee produces a report which is then sent to the Ministry - Extension Directorate - Department of Vegetables and Flowers for approval, and thereafter sent for the Ministry of Finance to assist in compensation.

It is worth mentioning that there is **no specific budget allocation for disasters within the government budget**. However, the council of ministers may decide to allocate some budget for compensating some affected people from any disaster following the recommendations of relevant committees such as the committee to assess agricultural damage or that of the civil defense committee at the governorate level.

EQA[73]has received some funding to implement a project to assess the gaps and capacities needed to mainstream climate change in the national policies in Palestine. **The project aims at enhancing the capacities of the Palestinian Authority to mainstream and address the challenges of climate change in the areas of**

[70] Personal interview with Mr. Yousef Abu Assad, Director General of Meteorology Department

[71] Personal interview with Mr. Isam Nofal - Director General of Soil and Irrigation Department and Mr. Nazih Abu Fkhaithah; Disaster Department Director within the Ministry of Agriculture

[72] Meeting with Mr. Sae'ed Ellahham - Vegetable and Flowers Department- Extension Directorate - Ministry of Agriculture

[73] Meeting with Mr. Ahmad Abu Thaher Director General of international relations and projects of EQA and Mr. Nedal Katbeh - Climate Change Department of EQA

reporting, mitigation and adaptation. It will also contribute to the achievement of the Millennium Development Goal related to ensuring environmental sustainability. However, **one of the most important constraints preventing access to dedicated funds** is the fact that Palestine is not yet a full member in the various international agreements and conventions related to climate change. On the other hand, the Climate Change Adaptation Strategy (UNDP - PAPP, 2009) recommended developing a unified national assessment system, supported by technical capacity-building on electronic information management tools and services, which would be the most efficient means of identifying a clear hub of up-to-date climate information.

Furthermore, according to the **Department of Disasters within the Civil Defense Directorate**[74], the latter still lacks the required capacity to face and deal with natural disasters including floods and droughts. They also lack a central emergency operation room at the national and governorates' levels. The fact that there is no disaster and risk reduction strategy and that the draft national civil defense plan is still not finalized while the membership of the various agencies (government and non-government) is not fully defined in the plan makes their work even harder.

Finally, and as indicated by the Climate Change Adaptation Strategy, (UNDP - PAPP, 2009), the **adaptive capacity at the national level is directly compromised by movement restrictions as well as insecure, insufficient water and land resources**. Some of the best agricultural land is taken by Israeli settlements in the Jordan Rift Valley, while 20% of arable land in the Gaza Strip is off-limits to farmers because it falls within the Israeli security zone adjoining the border. Similarly, Israeli restrictions prevent both bulk imports of clean water in the Gaza Strip and the development of irrigation in the West Bank. The Palestinian National Progress Report to HYOGO Framework also considers the restrictions imposed by the Israeli occupation as the main obstacle that restricts Palestinian Institutions from addressing disasters properly. Accordingly, **any plans to develop capacity to reduce climate vulnerability must be grounded in the current political reality of Palestinian Institutions with limited jurisdiction and weak authority over land and natural resources**.

2.2.6 OFFICIAL WATER SECTOR REACTIONS AND TRADITIONAL RESPONSE BY THE COMMUNITY TO PAST DROUGHT AND FLOOD EPISODES

The climate change adaptation strategy describes the official response to the flood and drought events as reactive rather than proactive where the government agencies in charge, be it the PWA, the MOA or others, are generally responding to the event after its occurrence; providing the necessary relief to those who are affected by the event (UNDP - PAPP, 2009).

For example, following any drought event, **PWA identifies a number of potential water sources and points for water tankers to fill from**, and **organizes water delivery** to the affected communities through tankers, which is carried out by both government and non-government agencies following a unified coupon system to deliver water at subsidized prices. PWA also **ensures that the water is of good quality**, for both the source and the delivered water through water quality tests implemented by the relevant bodies upon PWA request.

Given the constraint related to the Israeli Occupation previously mentioned, **PWA has no authority or control over the entire water resources which makes its ability to respond very limited**. The fact that nearly 54% of drinking water is purchased from the Israeli Company - Mekorot, makes the situation even more difficult, especially **during drought**, when the **Israeli Company reduces this amount by 30 - 50 %,** (PHG, 2008), (PWA, 2009).

In order to alleviate the impact of droughts and floods as they relate to climate change, the national water

[74] Meeting Mr. Ammar Salameh of the Department of Disasters - Civil Defence Directorate

strategy of Palestine (PWA, 2012), advanced the some recommendations which include:

1. Promoting efficient use of existing water resources by imposing water conservation measures.
2. Developing a protection program against flash flood risks.

In addition, the Climate Change Adaptation Strategy and Program of Action for Palestinian Authority recommended several adaptation measures that include:

1. Development of flood contingency plans
2. Increasing the local capacity of rainfall interception
3. Increasing the use of treated wastewater
4. Selection of crops which are more tolerant to droughts

In response to both drought and flood events**, various traditional adaptation measures were developed by the communities** over time. They range from rain water harvesting, to the prevention of soil erosion and preserving soil moisture through building terraces, as well as other practices, etc. Based on (PHG - IUCN, 2012), the main adaptation measures taken by the community to cope with both flood and drought are summarized in **Table 29**.

Table 29: Summary Impact of both Flood and Drought and Community Adaptation Measures

Risk	Impacts	Coping measure
Flood	Soil erosion	Planting trees Building stone retaining walls Avoiding plowing steep lands Reverse plowing
	Flooding of agricultural lands and inability to cultivate	Not cultivating low lands and pumping the water to adjacent lands and cultivating it
	Crop damage	Re-cultivating the lands with summer crops
	Infrastructure damage	Preventive maintenance and Rehabilitation of retention structures, sewer systems, etc. to make sure that they are well maintained and prepared to accommodate floods so that flood risks are avoided.
	Spread of weed seeds	Removal of weeds using deep plowing
Drought	Decline of groundwater level Increase salinity of ground water	Decrease areas of irrigated lands Cultivate crops with low water requirement as well as salt tolerant plants
	Decrease in water harvesting quantities	Increase catchment areas to collect rain Purchase water from other sources via tankers
	Decline in rangeland productivity and loss of some plant species	Manage rangeland properly, restrict grazing areas by dividing it into various zones some of which protected and left to be regenerated while some open for herders.

Source: Modified from (PHG - IUCN 2012).

2.2.7 ACHIEVEMENTS, SHORTCOMINGS AND GAPS

Although the development of some databases for documenting the impact of disasters at some institutions such as the “Disaster Departments” of the “Civil Defense Directorate and the Ministry of Agriculture” can be considered important achievements, yet much still needs to be done in order to improve planning and management of these important natural phenomenae. **Clear mandates** need to be assigned to the relevant institutions and a **proper legal framework** needs to be clearly delineated. Moreover, **coordination** among the various actors needs to be more formal and scattered efforts and available **infrastructure** needs to be unified. In this regards, the country would also benefit from designating **one single body** to coordinate drought and flood risk management efforts among all sectors, and ensure that adequate **sectorial contingency plans** are prepared based on **vulnerability assessments and impact analysis**. A **clear budget allocation** for disaster response and management is still urgently needed as clearly indicated by the Climate Change adaptation strategy (UNDP - PAPP, 2009) and the Palestinian National Progress Report to the Hyogo Framework 2011 - 2013.

Al-Dabbeek, 2008 quoted in the Climate Change adaptation strategy (UNDP - PAPP, 2009)- also summarized the main weaknesses related to the disaster risk reduction (DRR) in Palestine as follows:

- Limited legal frameworks for disaster risk reduction, which are response-led rather than preventive
- Underdevelopment of policies for disaster preparedness, mitigation, and emergency response
- Weak capacity in disaster management and rescue operations
- Lack of capacity and training in disaster risk management and policy implementation at government level(national and local)
- Lack of coordination between central and the local level authorities in disaster management activities

2.2.8 LESSONS LEARNT AND POTENTIAL INDIGENOUS BEST PRACTICES

The main lessons learnt are those related to the mechanisms adapted by the communities to cope with both flood and drought events. Reducing overland flow or winter runoff, preventing soil erosion and maximizing soil moisture content through building stone terraces, maximizing water availability through various rain water harvesting techniques and preventive maintenance to the infrastructure can be among these practices.

2.2.9 ASSESSMENT OF SOCIO-ECONOMIC AND ENVIRONMENTAL IMPACTS OF DROUGHTS AND FLOODS

Flood events often causes severe damage to infrastructure (roads, water systems, culverts, etc.) and may sadly result in loss of lives. Moreover, floods may cause serious soil erosion and loss of land fertility both in the high and low lands resulting in loss of biodiversity and lowered plant productivity in general. Floods particularly cause severe damage to agricultural crops cultivated in the low land and plane agricultural areas. However, to avoid such detrimental impacts of flood events, proper precautions should be taken to safeguard the lives and livelihood of people while at the same time transforming flood events into more useful water through the construction of various structures for drainage, embankments and storage.

Water resources as well as rainfed agriculture are the two most vulnerable and affected sectors from drought. However, while floods may cause damages to some crops, it can be considered a good potential for increasing available surface water if captured and stored properly.

Although the Ministry of agriculture keeps records of the damages resulting from flood and drought, the information collected is not centralized nor included in one data base. Its retrieval takes time and effort and depends very much on the person involved. However, based on the information available so far, some estimates for flood and drought events have been obtained from the MOA - Department of Vegetable and Flowers for two flood events.

The flood event which took placeduring26 - 29 October 2008 caused substantial damage to agriculture, mainly cultivated areas with vegetables in the Jordan Valley and Gaza, with an estimated cost of 1.98 Million (M) New Israeli shekel (NIS) or nearly 0.5 M US $. While the last flood event of January 2013, has left more severe damage since it was by far larger in magnitude and affected the entire country. The total estimated damage caused by this incident is estimated by MOA 2013 at 57 Million NIS or nearly 15 Million U.S. $.

The damage afflicted by the drought episode which hit the West Bank during the 2007-2008 season (rain fall reached 67% of the annual average), caused direct losses in plant production of rain-fed agriculture estimated at more than 113.5 M US$ based on farm gate prices as reported by (Abdo, 2009). The indirect losses were estimated at more than 250 M US$ and more than 200,000 small ruminants were affected.

On the other hand (FAO -Gruppo Di Volontaria to Civile[75] (GVC) - PHG - Union of Agricultural Work Committees (UAWC), 2008) have reported that many farmers in the eastern - south eastern part of the West Bank and in the Jordan Valley have suddenly found their crops short of irrigation water and were thus forced either to reduce the areas of their cultivated land or to abandon it at once. This has caused some farmers to switch their professions to other sectors in a desperate attempt to acquire jobs that provide the bare minimum wages to support their families. In addition, raising livestock, which constitutes over 75% of the annual income of many of these communities, has been slashed to over half its value following the shortage in water and in food grown in the area. Most importantly, some families have migrated from the area to live in larger towns or cities to be able to adequately maintain their lives.

2.2.10 OPPORTUNITIES

Although opportunities are limited, yet it is important to adopt the recommendations of Hyogo Framework for Action to build the resilience of Palestinian communities to disaster. In this respect, it is important for the State of Palestine to **promote the integration of risk reduction** associated with existing climate variability and future climate change into strategies for the reduction of risk disaster and adaptation to climate change; ensure that the management of these risks is fully taken into account in disaster risk reduction programmes at various levels. One of the **good opportunities** here is the funds provided to EQA to mainstream climate change variability into national policies and strategies discussed earlier. It is also important to benefit from all possible funding opportunities provided to EQA, MOA and other related institutions to unify their efforts and to harmonize their data and data bases to manage both flood and drought properly and upgrade their capacities to establish proper early warning systems to enable better preparedness to climate induced disasters. Seeking technical assistance is also warranted to help Palestine develop **drought preparedness plan**, - within the context of the hydro-political situation in the country –that **builds on available information**, and **leverages the indigenousadaptation measures presently adopted to mitigate the impacts of droughts and floods, including rainwater harvesting for both drought and flood purposes.**

REFERENCES

1. Abdo K., 2009. Agricultural Drought: Changing Perception of Planning and Management. Paper submitted to the 2nd International Conference on the Palestinian Environment, Annajah National University, Nablus - Palestine.
2. Abu Asaad, Y., 2013. Current Status and Priority Needs of Climate Monitoring in Palestine - A presentation to Regional Workshop on Climate Monitoring Including the Implementation of Climate Watch Systems for Arab Countries in West Asia, Amman, Jordan.
3. Al-DabbeekJ., 2008. An Assessment of Disaster Risk Reduction in the Occupied Palestinian Territory,

[75] Civil Volunteer Group

Jerusalem: UNDP/PAPP

4. Applied Research Institute – Jerusalem (ARIJ), 2011. Conducting a Survey and Needs Assessment for a National Meteorological Station and the implementation of an Early Drought Monitoring System. Bethlehem, Palestine.
5. Bachmat Y. & Khaled A., 2000. Drought impact on water resources in the Jordan River Basin, Jerusalem (unpublished report).
6. Christensen, J.H., B. Hewitson, A. Busuioc, A. Chen, X. Gao, I. Held, R. Jones, R.K. Kolli, W.-T. Kwon, R. Laprise, V. Magaña Rueda, L. Mearns, C.G. Menéndez, J. Räisänen, A. Rinke, A. Sarr and P. Whetton, 2007. Regional Climate Projections. In: Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.
7. FAO, GVC, PHG and UAWC, 2008. Increase of water availability and access in areas vulnerable to drought in the Palestinian Territories", report prepared for FAO.
8. IUCN - PHG - UAWC, 2010. Watershed Management at Marj Sanour - Water Resources Assessment. Ramallah, Palestine.
9. IUCN - PHG, 2012. Social, Ecological and Agricultural Resilience in the Face of Climate Change (SEARCH) - Vulnerability assessment of MarjSanour. Ramallah - Palestine.
10. Khatib I., 2009. GLOWA-Jordan River – Project 3, Final Report: Regional Climate Scenarios. Jerusalem, Palestine Academy for Science & Technology.
11. MOA, 2008. Records of Ministry of agriculture. Not published.
12. Palestinian Hydrology Group (PHG), 2004. Water for Life - WASH Monitoring Program, Ramallah, Palestine.
13. Palestinian Hydrology Group (PHG), 2008. Water for Life - WASH Monitoring Program. Ramallah, Palestine.
14. Palestinian Meteorology Department (PMD), 2012. Rainfall Records, Data Base.
15. Palestinian Water Authority (PWA) , 2011. Status of water Resources in Palestine. Ramallah, Palestine.
16. Palestinian Water Authority (PWA), 2012. National Water Strategy of Palestine. Ramallah, Palestine.
17. Rabi A., Khaled A. and Carmi, N., 2003. Drought occurrence and impact on the Eastern Groundwater Basin West Bank/Palestine. Hydrology of the Mediterranean and Semiarid Regions (Proceedings of an international symposium held at Montpellier, April 2003, edited by Servat, E. et al. IAHS Publ. no. 278.
18. United Nations Development Program - Program of Assistance to the Palestinian People (UNDP-PAPP), 2009. Climate Change Adaptation Strategy and Program of Action for the Palestinian Authority. Ramallah, Palestine.
19. World Bank, 2009. Assessment of Restrictions on Palestinian Water resources Development. Sector Note, Middle East and North Africa Region, Sustainable Development, Washington DC.

Websites consulted:

20. http://scholar.najah.edu/sites/default/files/conference-paper/agricultural-drought-changing-perception-planning-and-management.pdf
21. http://www.wmo.int/HttpErrorCodes/index_en_404_en.html

2.3 CAS DE LA TUNISIE

2.3.1 SITUATION DES RESSOURCES EN EAU EN TUNISIE

La Tunisie demeure un pays aride à semi-aride sur les ¾ de son territoire. Elle se caractérise par la rareté de ses ressources en eau et par une variabilité accentuée du climat dans l'espace et dans le temps. L'eau constitue un bien précieux en Tunisie, un facteur essentiel pour le développement du secteur agricole (et des autres secteurs). Le maintien de la croissance économique reste tributaire du facteur eau qui est cependant un facteur limitant et limité.

La Tunisie est placée dans la catégorie des pays les moins dotés en ressources en eau dans le bassin méditerranéen. En effet, pour une population de 10,777 Millions d'habitants (Institut National des Statistiques (INS) au 1 juillet 2012), la dotation pour l'année 2012 est estimée à environ 450 m^3 par habitant et par an. Selon des études prospectives, ce chiffre est appelé à diminuer progressivement pour atteindre 315 m3 par habitant en l'an 2030 pour une population estimée à 12 millions d'habitants.

En effet, les ressources en eau potentielles sont estimées actuellement à 4840 Mm3. Toutefois, elles ne se prêtent pas toutes à l'exploitation. Le volume d'eau exploitable (mobilisable) atteint 4640 Mm3 ; mais le volume effectivement mobilisé est de 4300 Mm3, soit 92,7% du total des ressources exploitables et 88% du total des ressources potentielles (Observatoire Tunisien de l'Environnement et du Développement Durable (OTEDD) et Coopération Technique Allemande(GTZ), 2008). De plus, une forte réduction des apports a été observée sur certains bassins durant les 15 dernières années ce qui est de nature à réduire les volumes d'eau futurs disponibles.

Les richesses hydriques renouvelables, sont étroitement tributaires du climat. Cette dépendance est donc un facteur supplémentaire de vulnérabilité. Les eaux mobilisables sont à 56% des eaux de surface qui sont très variables dans l'espace et dans le temps. Le reste provient des nappes souterraines, profondes ou phréatiques (rechargeables). Pour les eaux des nappes profondes, outre leur faible qualité par endroit, elles représentent des ressources épuisables ne pouvant être rechargées à court terme.

La Tunisie est un pays à vocation agricole puisque 55% de sa superficie est destinée à l'agriculture (9 millions d'ha dont 5 millions d'ha labourables). La contribution du secteur dans le produit intérieur brut (PIB) national est de 10% environ. Ce secteur emploie 20% de la population active et contribue à hauteur de 8% des exportations. Ce secteur présente une vulnérabilité assez forte aux aléas climatiques (sécheresse, inondations, grêles, température élevée, etc.) et consomme 82% des ressources en eau potentielles.

L'analyse des données pluviométriques sur la période de 1872-1998 a permis de déduire que la Tunisie est emmenée à vivre deux années singulières sèches tous les dix ans, une année sèche très sévère une fois tous les 20 ans, un cycle de deux années successives sèches une fois tous les 30 ans et enfin la succession de trois années sèches une fois par siècle (MA, 1999).

2.3.2 INVENTAIRE DES SECHERESSES ET DES INONDATIONS SUR LA PERIODE DE 2002-2012

L'identification des évènements de sècheresses et des inondations a été relativement difficile dans le sens où les caractéristiques des évènements sont à recueillir auprès de différentes directions générales du Ministère de l'Agriculture (MA) et du Ministère de l'Equipement et de l'Environnement ainsi qu'auprès de l'Institut National de Météorologie et de l'Office National de la Protection Civile. Il n'existe pas de document global qui documente chaque évènement et permet une évaluation et un suivi des mesures d'atténuation des effets des évènements.

Pour atténuer les conséquences des impacts des inondations, des plans de protection des villes contre les inondations sont initiés. Par contre, pour les sècheresses, mis à part le guide de gestion de la sècheresse, nous estimons que les conséquences de la sècheresse n'ont pas à ce jour alimenté les réflexions pour améliorer la politique et les plans d'action pour une gestion proactive de ces évènements.

LES SECHERESSES

Dans le cadre du projet "Mise en place d'un système d'alerte précoce à la sécheresse dans les trois pays de la rive sud de la Méditerranée : Algérie, Maroc, Tunisie" (Observatoire du Sahara et du Sahel(OSS), 2006), une typologie de la sècheresse en Tunisie est fournie en identifiant trois intensités de sècheresse en fonction de l'étendue spatiale, la durée et l'importance du déficit hydrique[76] **(tableau 30)**. C'est sur cette base que les sècheresses ont été répertoriées ci-dessous pour la période 2002-2012.

Tableau 30. Typologie des sècheresses en Tunisie (OSS, 2006)

Catégories d'intensités	Extension spatiale	Durée	Importance du déficit hydrique
Sècheresse modérée	Locale ou régionale	Un mois à une saison	Faible (déficit de 20 à 40%)
Sècheresse intense	Région à plusieurs régions	Saisons critiques à une année	Déficit important (40 à 60%)
Sècheresse très intense	Plusieurs régions à toutes les régions	pluriannuelles	Très important (déficit > 60%)

Source: OSS, 2006

La décade 2002-2012 a connu trois sècheresses. L'année 2001-2002 est une année de sècheresse générale qui a suivi à trois années de sècheresse (1998-2001). Cette année a connu un déficit hydrique de 50% dans le Nord ; 52,5% dans le centre et 55% dans le Sud. Depuis deux sècheresses localisées ont été signalées 2007-2008 et 2009-2010 **(cf. tableau 31)**.

Tableau 31. Inventaires des périodes de sècheresse en Tunisie sur la période de 2002-2012

Date	Caractéristiques de l'évènement	Impacts socio-économiques et environnemental
2001-2002	**Sévérité : très sévère** (Déficit hydrique variant de 24% à 51% selon les régions) **Fréquence:** **Durée : pluriannuelle** sècheresse successive à trois années de sècheresse 1998-1999, 1999-2000, 2000-2001) **Etendue géographique:** Sécheresse générale sur tout le pays (décret n°2002-1699 du 23 Juillet 2002)	- La production céréalière a connu un recul d'environ 62% par rapport à la campagne précédente (forte baisse des rendements à l'hectare) - Pertes de 75% de la production d'huile d'olive (30 mille tonnes contre 115 mille tonnes l'année précédente) - Augmentation de l'importation des huiles végétales - Régression de 40% de la production d'amandes en coques sèches - Réduction de 50% de la production de l'alfa dans le centre du pays - Augmentation des prix des produits alimentaires de 3,7% en 2002 contre 1,7% l'année précédente, - Hausse des prix à la consommation de 2,8%

[76] Le déficit hydrique utilisé par l'Institut National Météorologique se réfère au déficit par rapport à la normale pluviométrique selon la formule suivante: RaN = Xi / Xn (%); RaN= rapport à la normale, Xi = précipitations de l'année considérée , Xn = la normale pluviométrique annuelle

Date	Caractéristiques de l'évènement	Impacts socio-économiques et environnemental
		- Agriculture, pêche et industrie agroalimentaire : baisse des exportations de 10,7 % et augmentation de 21,7% des importations. **Réaction à la sècheresse** - Rééchelonnement des crédits des céréaliculteurs affectés par la sécheresse (durée maximale 5 ans). Les intérêts générés par le rééchelonnement étaient pris en charge par le Fonds national de Garantie à l'exception des intérêts générés par le rééchelonnement de la 2ème tranche des crédits rééchelonnés en 2000 et la 1ère tranche des ceux rééchelonnés en 2001 ont été pris en charge par le budget de l'Etat.
2007-2008	**Sévérité :** **modérée** **Fréquence**: **Durée:** **Avril et mai 2008** **Etendue géographique:** **Zones des grandes cultures dans le Nord et le Centre du pays**(décret n°2008-3172 du 6 octobre 2008)	- **Pour les gouvernorats du centre : Sousse, Gafsa, Kairouan, Kasserine et Sidi Bouzid:** les superficies sinistrées ont été à 100% des superficies des grandes cultures (toutes les délégations et toutes les imadas). - **Les gouvernorats du Nord : Beja, El Kef, Jendouba, Siliana, Zaghouan** sont affectées à des pourcentages divers selon les Imada. Le déficit hydrique enregistré à la fin du mois de mars, avril et mai 2008, a été à l'origine d'une production céréalière de 40% en moins par rapport à la campagne de 2007. L'effectif du cheptel de reproduction des principales espèces animales a régressé de 8,6% en 2008 (La sécheresse ayant marqué certaines périodes de l'année et la hausse sans précédent des coûts de production des aliments de bétail ont favorisé le phénomène d'abattage du cheptel reproductif) **Réaction à la sècheresse :** Pour faire face à cette situation, il a été décidé de vendre le fourrage concentré à des prix subventionnés, de réduire les tarifs douaniers sur certains aliments de bétail importés, d'étendre les superficies réservées aux cultures fourragères d'été, d'inciter les agriculteurs à s'orienter vers les cultures de fourrages de substitution et de maîtriser les techniques de production des nouvelles variétés. Les Banques ont été autorisées à rééchelonner les crédits octroyés aux céréaliculteurs touchés par la sécheresse au titre de la campagne 2007-2008 ainsi que les crédits d'investissement en liaison avec la céréaliculture
2009-2010[77]	**Sévérité :** **sévère** **Fréquence**: **Durée:** **mars à mai 2010**	Les gouvernorats du Nord et du Centre affectés partiellement sont : Tunis, Ariana, Mannouba, Ben Arous, Nabeul, Bizerte, Zaghouan, Beja, Jendouba, El Kef et Siliana. Les gouvernorats affectés totalement avec 100 % des superficies des grandes

[77]Cette sècheresse a coïncidé avec la mauvaise récolte de blé enregistrée en Russie due à la sècheresse et aux incendies.

Date	Caractéristiques de l'évènement	Impacts socio-économiques et environnemental
	Etendue géographique : Zones de grandes cultures dans le Nord et le Centre du Pays (Décret no 2010-1901 du 06/08/2010)	cultures sinistrées sont : Sousse, Mahdia, Kairouan, Kasserine et Sidi Bouzid. **Réaction à la sècheresse :** L'importation du blé a été de 50% supérieure à celle de 2009[78]

Source: Banque centrale de Tunisie (BCT) 2002, 2008 et 2010 et compilation de l'auteur

L'analyse des événements de sècheresse pendant la période de 2002-2012 confirme les prévisions fournies dans le guide pratique de gestion de la sècheresse (MA, 1999) avec un enregistrement de deux années singulières sèches et une succession de trois années sèches.

LES INONDATIONS

Les dix dernières années (2002-2012) ont été très riches en évènements pluvieux exceptionnels et des inondations dévastatrices aussi bien en milieu rural qu'en milieu urbain **(tableau 32).**La sévérité des inondations est reconnue quand les dégâts et les pertes humaines sont importants. Il n'existe cependant pas d'indicateurs de catégorisation de la sévérité des inondations. Seule la période de retour des inondations est documentée. Dans le cas des inondations de la Medjerda, la rivière la plus importante en Tunisie, **(figure 20),** un suivi des débits de la rivière en plusieurs stations de jaugeage est assuré par la Direction Générale des Ressources en Eau au Ministère de l'Agriculture (DGRE) mais on ne dispose pas d'échelle de classement de la sévérité des évènements. Pour la période 2002-2012, il a été seulement indiqué dans la note de la DGRE de 2012 que les crues sur la Medjerda de 2003, 2004, 2009 et 2012 sont des crues exceptionnelles.

L'année 2003 a été une année exceptionnelle avec des inondations au début de l'année et à la fin de l'année sur le bassin versant de la Medjerda et des inondations dévastatrices sur le Grand Tunis en septembre de la même année.

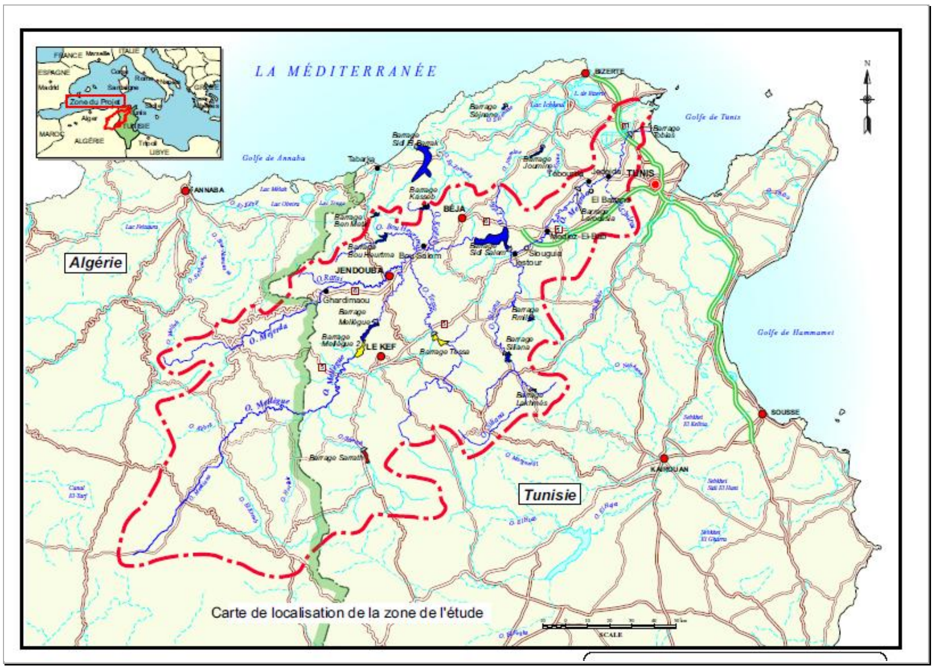
Les crues sont provoquées par des averses de fortes intensités sur des courtes périodes. A titre d'exemple, la crue de septembre de 2003 vécue par le Grand Tunis a été provoquée par les pluies du 16 au 17 septembre survenues sous forme de six averses successives ayant provoqué la saturation des sols et celles du 17 au 18 septembre avec une hauteur cumulée de 186 mm sur 24 heures. Cette pluie a rempli et fait déborder tous les bassins de rétention provoquant la rupture de deux d'entre eux (un à Mnihla ouest au nord-ouest de Tunis et l'autre sur le Bardo amont à l'ouest de Tunis). La journée du 24 septembre a enregistré en deux heures une pluie de 98 mm avec des intensités maximales ayant atteint 136 mm/h sur 15 mn et 114 mm/h sur 30 mn. Cette pluie de deux heures correspond à une crue centennale en termes de débits instantanés.

La crue de Sebbelet Ben Ammar au nord de la capitale Tunis survenue en 2007 a été causée par une pluviométrie de forte intensité (150 mm en moins de deux heures) et d'une période de retour de plus de 100 ans qui s'est abattue sur des bassins versants caractérisés par de fortes pentes (6 à 8%) et s'est aggravée par une rupture en cascade des travaux de conservation des eaux et du sol (banquettes). Cette crue a causé la mort de 17 personnes emportées dans leurs véhicules.

En septembre 2009, c'est la ville de Redayef située au Centre du pays qui a été inondée par une pluie de 150 mm en une heure causant la mort de 17 personnes.

[78]http://faostat.fao.org (5 septembre 2013)

Figure 20. Carte de bassin versant de la Medjerda Source



Source: Japan International Cooperation Agency (JICA), 2009

Tableau 32. Inventaires des inondations en Tunisie sur la période de 2002-2012

Date	Caractéristiques de l'évènement	Impacts socio-économique et environnemental
10 janvier-10 Février2003[79] (Crue du 11-12 Janvier, Crue du 13 janvier au 9 février),	**Sévérité : Non informée** **Fréquence**: 32 à 170 ans selon les stations pluviométriques (DGRE, 2003) **Durée : janvier- Février** **Etendue géographique:** Basse vallée de la Medjerda	* Inondations sur environ 492 Km^2 au niveau de la moyenne et de la basse vallée de la Medjerda : 4,2 km^2 entre barrage Sidi Salem et Slouguia, 42 Km^2 entre Slouguia et El Herri, 17 Km^2 entre El Herri et Laaroussia, 63 Km^2 entre Laaroussia et Jedeida, 189 Km^2 entre Jedeida et Pont Route Nationale (RN) 8 et 177 Km^2 entre RN8 et la Mer. Submersion de la RN 8 sur environ 4 km séparant le pont de la Medjerda et le village Zhana, accumulation des eaux de part et d'autre de l'autoroute * 28 000 sans abris* destructions des habitations et des ouvrages et installations agricoles Au niveau du gouvernorat de l'Ariana, les dégâts ont été estimés à 3 825 000 Dinars Tunisiens (DT)[80] (490 victimes, 4 900 ha endommagés, 40 km de routes rurales affectées, 60 km de canaux de drainage affectés, 16,5 km de réseau d'irrigation affectés, stations de pompage endommagés et petits barrages.

[79] Crue à pointes multiples, donc de longue durée
[80]DT = 0.6 US $

Date	Caractéristiques de l'évènement	Impacts socio-économique et environnemental
Septembre[81] 2003	**Sévérité : Non informée** **Fréquence**: centennale ou plus **Durée: quelques heures** **Etendue géographique:** Inondations sur l'ensemble du Grand Tunis.	Les pertes ont été évaluées à 506 MDT réparties comme suit : -dégâts estimés par enquêtes directes : 20 MDT -pertes de production sur 2 journées : 100 MDT -dépréciation des logements septembre 2003 : 386 MDT -perte moyenne annuelle : 87,6 MDT Une étude pour la protection contre les inondations du grand Tunis a estimé le coût des ouvrages de protection à 600 MDT répartis entre : -ouvrages de protection éloignée (lacs collinaires) : 30 MDT - protection rapprochée : 370 MDT (trois tranches définies sur la base du degré de vulnérabilité vis-à-vis des inondations) -évacuation des eaux pluviales : 200 MDT
Décembre 2003- janvier 2004	**Sévérité : Non informée** **Fréquence**: de 19 à 140 ans selon les stations de mesure **Durée: quelques jours** **Etendue géographique:** Bassin versant (BV) de la Medjerda au niveau de Jendouba, Bousalem et Manouba	Inondations des terres agricoles, au niveau de Djedeida Les dommages liés aux inondations pour le gouvernorat de l'Ariana ont été estimés à 3 417 900 Dinars pour : -218 victimes, - 1 035 ha endommagé - 41 km de routes rurales affectées -72 km de canaux de drainage affectés Et des coûts pour la gestion des effluents, les petits barrages, le dragage des oueds, les routes forestières, la reforestation, et des parcs et zones vertes urbaines
Septembre/Octobre2007 (2ème jour de la fête de l'Aid El Fitr)	**Sévérité : Non informée** **Fréquence**: 100 ans **Duration**: **quelques heures** **Etendue géographique**: Zone nord de la Tunisie et la région de Tunis sur une ligne reliant Bizerte au cap Bon (150 mm en moins de deux heures à Djebel Ennahli et Djebel Ammar)	17 morts (11 morts confirmés par la protection civile). La majorité des disparus sont déclarés à Sabalet Ben Ammar au nord-ouest de la capitale et ont été emportés par les eaux de l'oued El Khlij en crue au volant de leurs véhicules sur la nationale 8 reliant Tunis à Bizerte. Interruption de la circulation à Tunis et sur plusieurs routes. Ces intempéries ont causé des dégâts matériels mais aucune évaluation détaillée n'est disponible
Septembre2009	**Sévérité : Non informée** **Fréquence**:	17 Morts à Redayef, 8 blessés et plusieurs disparus dans les intempéries

[81] Source : Document Direction de l'Hydraulique Urbaine au Ministère de l'Equipement et de l'Environnement

Date	Caractéristiques de l'évènement	Impacts socio-économique et environnemental
	Durée: quelques heures **Etendue géographique:** Gafsa, Redayef au Centre de la Tunisie (crue de l'oued Oum Larayes) 150 mm en une heure à Redayef Et des régions, notamment du centre et du littoral	
Janvier-Février2009[82]	**Sévérité : Non informé** **Fréquence**: **Duration:** **Etendue géographique:** Bizerte au nord de Tunis	Les dégâts ont été évalués à 8 661 750 Dinars
13 Avril2009[83]	**Sévérité : Non informée** **Fréquence**: de 70 à plus de 200 ans selon les stations **Duration: quelques jours (2-5, 8-9, 11-13 et 18-22 avril)** **Etendue géographique:** Dans la basse vallée de la Medjerda : Tunis, Manouba, Bizerte, Beja, cap bon	Les dommages liés aux inondations d'avril 2009 dans le gouvernorat de Manouba ont été estimés à 2 003 800 Dinars. Ces pertes sont au niveau de l'agriculture, les routes rurales, les systèmes de drainage, les installations d'irrigations, les petits barrages et l'érosion sur les terres agricoles.
Février 2012[84]	**Sévérité : Non informée** **Fréquence**: **Duration: plusieurs jours** **Etendue géographique:** Nord et Nord-ouest (BV de la Medjerda)	La ville de Bou Salem dans le gouvernorat de Jendouba : des quartiers entiers et de vastes terres agricoles ont été envahis par les eaux qui ont détruit l'infrastructure locale et les équipements collectifs. Les superficies agricoles endommagées par les dernières inondations, ont atteint 22 mille hectares, dont 14 mille hectares de grandes cultures, 5 mille hectares de fourrages, mille hectares de légumes et mille hectares d'arbres fruitiers, estiment les services du Ministère de l'Agriculture (MA). A mateur dans le gouvernorat de Bizerte, on dénombre quatre victimes. En dégâts matériels, l'infrastructure et les équipements de base ont subi d'importants dommages. Parmi les équipements publics, il y a lieu de signaler les ravages subis par l'Institut Supérieur des Sciences Appliquées et de la Technologie (ISSAT) de Mateur. Situé aux abords de l'Oued El-Khlij, une zone à risques, l'établissement a été immergé par 1,5 mètre d'eau. Les flots ont détérioré tous les

[82] Source: document JICA survey report (mars 2010, chapitre 3)
[83] pluies exceptionnelles et neige sur les hauteurs
[84] Classée crue exceptionnelle comme 2003, 2004 et 2009

Date	Caractéristiques de l'évènement	Impacts socio-économique et environnemental
		équipements électroniques ainsi que les appareils informatiques, outre la détérioration de la majeure partie des ouvrages de la bibliothèque. Les dommages sont estimés de 1,5 à 2 millions de dinars. Les dégâts des glissements de terrain causés par les dernières inondations ont été évalués à 60 millions de dinars (annonce M.Ghazi Cherif, Directeur des Ponts et Chaussées au ministère de l'Equipement et de l'Environnement) et pourraient atteindre 100 millions de dinars.

2.3.3 LIEN POTENTIEL DES SECHERESSES ET DES INONDATIONS AU CHANGEMENT CLIMATIQUE

L'étude des phénomènes de sécheresse et d'abondance pluviométrique en Tunisie au cours des cinq dernières décennies a permis de distinguer deux périodes, 1950-1975 et 1976- 2004. Si la première est caractérisée par une stabilisation ou un léger refroidissement, la seconde est marquée par un réchauffement dépassant 1°C dans certaines régions. La période 1976-2004 est également caractérisée par une plus forte variabilité des températures et un nombre plus important (70% des cas) des extrêmes absolus (Tmin et Tmax). Selon Daoud, 2012, l'occurrence des évènements thermiques exceptionnels a sensiblement augmenté (augmentation de 7 à 10 j/an du phénomène du sirocco[85]).

L'analyse sommaire de la pluviométrie dévoile une baisse ainsi qu'une plus forte variabilité de la pluviométrie moyenne annuelle durant la période 1975-2005 que lors de la période 1950-1974. Toutefois, les tests statistiques ne permettent pas de conclure à une variation significative des précipitations. Aucune extrapolation n'est donc possible pour les stations étudiées.

Par contre et sur la base de l'inventaire des périodes extrêmes sur les dix dernières années, on retient que le nombre d'événements extrêmes (sécheresse – inondations) a fortement augmenté durant la dernière décennie avec au total 11 évènements constituant la période la plus chargée en évènements. Aussi, ce sont surtout les inondations qui se sont avérées plus fréquentes, suggérant une fréquence et une intensité de pluies inconnues auparavant (150 mm en une heure à Redayef en 2009, 150 mm en moins de deux heures à Sebbel et Ben Ammar au nord de la capitale).

Seule l'année 2002 a été une année de sècheresse généralisée sur tout le pays avec un déficit hydrique de plus de 50%.En 2010 (Fin Août), le déficit des apports au niveau des barrages a été de 1500 millions de m^3. Les sécheresses constituent un phénomène préoccupant et récurrent en Tunisie. Leur nombre est important (20 Sécheresses sur le dernier siècle) bien qu'aucune tendance à la hausse ne soit constatée.

2.3.4 ASPECTS INSTITUTIONNELS ET JURIDIQUES

Lorsqu'on évoque la sècheresse ou l'inondation, on évoque la pluie et par conséquent les ressources en eau dont la gestion est assurée par le Ministère de l'Agriculture (MA). En effet, selon le décret n°2001-419 du 13 Février 2001, le Ministère de l'Agriculture est chargé en collaboration avec les autres ministères d'exécuter la politique de l'Etat dans le domaine agricole et la pêche et de veiller à la promotion de ce secteur. Pour cela, il est chargé d'assurer la mobilisation de toutes les ressources naturelles disponibles et la réalisation de tous les

[85] Un vent méditerranéen qui vient du Sahara et atteint des vitesses ouragan en Afrique du Nord et l'Europe du Sud

travaux d'infrastructures de base. Il est aussi chargé de l'élaboration des plans et des programmes de mobilisation des ressources en eaux et leurs utilisations pour les besoins du pays et le développement des ressources hydrauliques non conventionnelles et l'économie de l'eau. Mais compte tenu de la complexité du système hydraulique, plusieurs institutions sont impliquées comme indiqué en **annexe 1.**

Les lois et décrets règlementant la gestion des inondations et des sècheresses

Les sècheresses et les inondations sont gérées par des commissions différentes et des textes de loi différents. Il n'y a cependant aucune loi qui règlemente la gestion de la sècheresse à l'exception des décrets qui fixent les zones de grandes cultures sinistrées par la sècheresse et qui feront l'objet de l'intervention du fonds national de garantie pour la prise en charge des intérêts découlant du rééchelonnement des crédits. En plus du code des eaux, les seuls textes réglementaires en liaison directe avec les sècheresses et les inondations sont les suivants :

1. **Loi n°86-106 du 31 décembre 1986** portant loi de finances pour la gestion 1987 et des articles 52 à 56 portant **création d'un fonds de mutualité** pour l'indemnisation des dommages agricoles dus aux calamités naturelles.
2. **Décret n°88-948 du 21 Mai 1988** fixant à partir de la campagne agricole de 1988-1989 le champ d'intervention, le montant de la contribution et le taux d'indemnisation des agriculteurs relatifs aux fonds de mutualités pour l'indemnisation des dommages agricoles dus aux calamités naturelles.
3. **Décret n°88-949 du 21 Mai 1988** fixant les modalités et les conditions d'intervention et de gestion du fonds de mutualité pour l'indemnisation des dommages dus aux calamités naturelles.
4. **La loi 91-39 du 8 juin 1991** relative à la lutte contre les calamités, à leur prévention et à l'organisation des secours et les mesures nécessaires pour prévenir les calamités et pour y faire face avec tous les moyens disponibles et leur prise en charge dans le cadre d'un plan national et des plans régionaux. Cette loi définit les calamités naturelles comme les incendies, les inondations, les tremblements de terre, les tempêtes et d'une façon générale tout fléau d'origine terrestre, maritime ou aérienne dont la gravité et les séquelles dépassent les moyens ordinaires disponibles pour y faire face sur le plan régional et national. La loi crée aussi la commission nationale permanente et les commissions régionales et définit l'autorité responsable de ces commissions.
5. **Le décret 2004-2723 du 21 Décembre 2004** qui modifie le décret 942-93 du 26 Avril 1993 et qui fixe les modalités d'élaboration et d'application du plan national et des plans régionaux de lutte contre les calamités, de leur prévention et de l'organisation des secours ainsi que la composition de la commission nationale permanente et des commissions régionales et leurs modalités de fonctionnement. Il s'agit du décret d'application de la loi de 1991 qui nomme les différents membres représentants des différents organismes/département et ministères qui forment la commission nationale permanente et celles régionales **(cf. figure 21 et 22)**
6. **Décret n° 2002-1699 du 23/07/2002 qui fixe** les zones de grandes cultures sinistrées par la sécheresse pour la campagne agricole 2001-2002
7. **Décret n° 2008-3172 du 6 octobre 2008 qui fixe** les zones de grandes cultures sinistrées par la sécheresse pour la campagne agricole 2007/2008.
8. **Décret no 2010-1901 du 06/08/2010 qui fixe** les zones de grandes cultures sinistrées par la sécheresse pour la campagne agricole 2009/2010.

Commissions chargées de la gestion des inondations

Selon la loi du 8 juin 1991, les inondations sont classées en tant que calamités. **Les sècheresses ne sont pas classées comme calamités.** Cependant, les feux de forêts qui peuvent avoir différentes origines y compris les sècheresses sont classés comme des calamités. Les commissions permanentes ainsi formées n'interviennent pas dans la gestion des sècheresses.

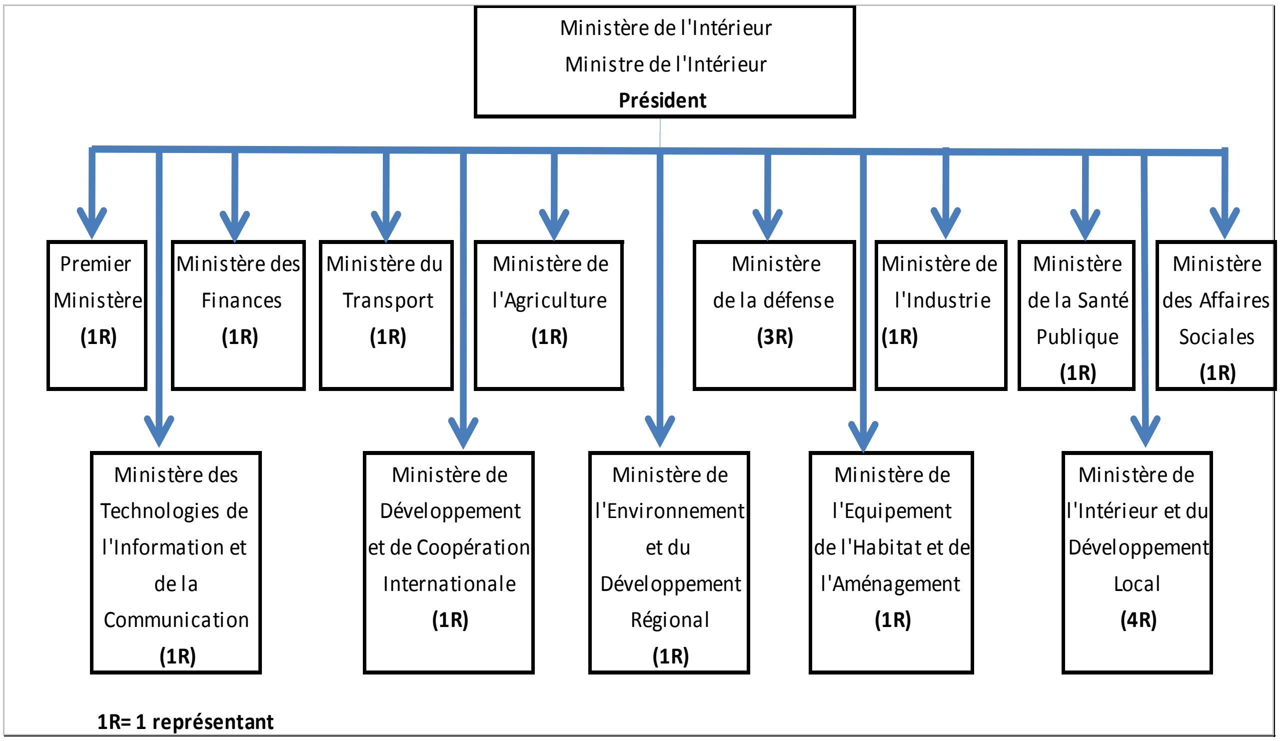
La commission nationale permanente d'élaboration et de suivi d'application du plan national de lutte contre les calamités, de leur prévention et de l'organisation des secours est chargée d'élaborer le plan national de lutte contre les calamités (y compris les inondations), d'organiser les secours et de suivre sa mise en application du plan national. Elle est composée des représentants de 14 ministères comme désignée sur la **figure 21** suivante. La commission est présidée par le Ministre de l'Intérieur ou son représentant. Elle se réunit au Ministère de l'intérieur en présence du Ministre de l'intérieur ou à l'Office National de la protection civile en présence d'un représentant du Ministre de l'intérieur.

Des commissions régionales sont chargées d'élaborer le plan régional du gouvernorat et de suivre sa mise en application. Ces commissions sont présidées par le Gouverneur et comprennent des représentants de tous les ministères impliqués dans la commission nationale en plus du chef du secteur régional de la Garde Nationale, du chef de secteur régional de la Police Nationale, du chef de l'unité régionale de la Protection Civile, un représentant régional de la Société Nationale d'Electricité et de Gaz (STEG), un représentant régional de la Société Nationale d'Exploitation et de Distribution des Eaux (SONEDE) et un représentant régional de l'Office National de l'Assainissement (ONAS)- **(Figure 22)**.

La commission nationale et celles régionales se réunissent deux fois dans l'année : avant la saison hivernale et avant la saison estivale. En cas de crise, la commission nationale peut se réunir tous les jours si besoin y est.

Lors des périodes d'inondations, différentes commissions sectorielles sont créées au niveau de Ministère de l'Agriculture (au cabinet, à la Direction Générale des Barrages et des Grands Travaux Hydrauliques (DG/BGTH), à la Direction Générale des Ressources en Eaux (DG/RE)) pour suivre le déroulement de l'évènement et fournir à la commission nationale permanente les informations nécessaires pour ses interventions.

Figure 21. Structure de la commission nationale de lutte contre les calamités, de leur prévention et de l'organisation des secours (inondations seulement)

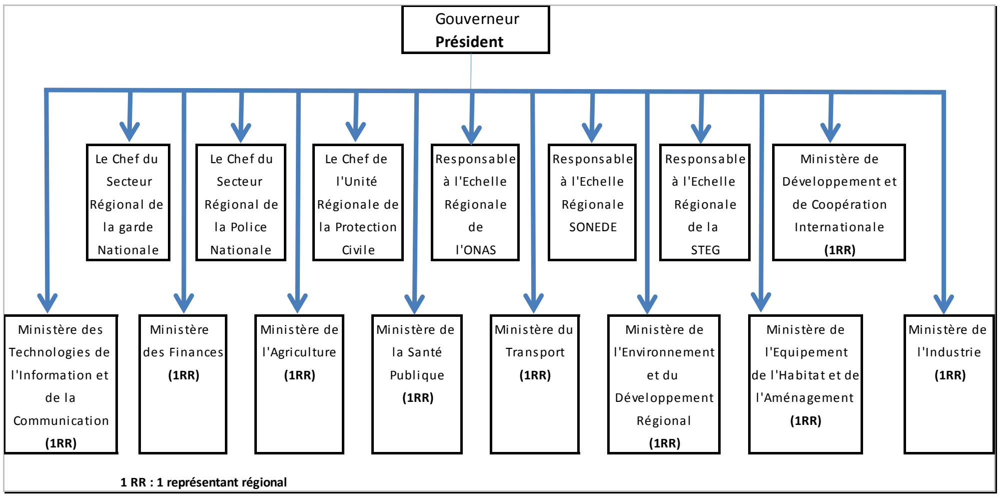


Source: l'auteur sur la base du décret 2004-2723 du 21 Décembre 2004

Commissions chargées de la gestion des sècheresses

La Tunisie ne dispose pas de plan national de gestion de la sècheresse. La commission nationale permanente et celles régionales citées ci-dessus concernent seulement la gestion des inondations classées comme calamités naturelles. Pour atténuer les effets négatifs de la sécheresse en Tunisie qui se manifeste deux à trois fois toutes les dix années, un système de déclenchement du mécanisme de gestion de la sécheresse a été développé et utilisé lors des sécheresses de 1987/1989 et 1993/1995. Aussi, l'étude de la gestion des périodes de sècheresse (CNEA, 1996) a été à l'origine de l'élaboration **d'un guide de gestion de la sècheresse** établi en 1999 et qui a servi à la gestion des quatre années sèches vécues par le pays entre 1998 et 2002. Le guide reprend en détail les effets de sècheresses sévères de 1987-1989 et 1993-1995 que la Tunisie a connu, définit le système pour le déclenchement du mécanisme de gestion de la sècheresse et fournit les mesures qui ont été prises pour surmonter les effets de ces sècheresses. Le guide a été établi que le système de gestion de la sècheresse a compris trois phases successives lors des deux sècheresses de 1987-1989 et 1993-1995 : alerte et annonce de la sècheresse, exécution et évaluation des actions du plan de gestion de la sècheresse. Il s'agit comme suit:

Figure 22. Commission régionale de lutte contre les calamités, de leur prévention et de l'organisation des secours (inondations seulement)



Source: l'auteur sur la base du décret 2004-2723 du 21 Décembre 2004

Commissions chargées de la gestion des sècheresses

La Tunisie ne dispose pas de plan national de gestion de la sècheresse. La commission nationale permanente et celles régionales citées ci-dessus concernent seulement la gestion des inondations classées comme calamités naturelles. Pour atténuer les effets négatifs de la sécheresse en Tunisie qui se manifeste deux à trois fois toutes les dix années, un système de déclenchement du mécanisme de gestion de la sécheresse a été développé et utilisé lors des sécheresses de 1987/1989 et 1993/1995. Aussi, l'étude de la gestion des périodes de sècheresse (CNEA, 1996) a été à l'origine de l'élaboration **d'un guide de gestion de la sècheresse** établi en 1999 et qui a servi à la gestion des quatre années sèches vécues par le pays entre 1998 et 2002. Le guide reprend en détail les effets de sècheresses sévères de 1987-1989 et 1993-1995 que la Tunisie a connu, définit le système pour le déclenchement du mécanisme de gestion de la sècheresse et fournit les mesures qui ont été prises pour surmonter les effets de ces sècheresses. Le guide a été établi que le système de gestion de la sècheresse a compris trois phases successives lors des deux sècheresses de 1987-1989 et 1993-1995 : alerte et annonce de la sècheresse, exécution et évaluation des actions du plan de gestion de la sècheresse. Il s'agit comme suit:

1. La première phase correspond à la **déclaration de la sécheresse** par une note de conjoncture établie par les services agricoles, économiques et hydrologiques du Ministère de l'Agriculture et cela en se référant à des indicateurs pluviométriques, hydrologiques et agricoles observés et constatés dans les différentes régions. Les constats sont signalés lors des réunions mensuelles des Commissariat Régionaux au Développement Agricole (CRDA) et des Directions Générales du MA. Cette alerte est transmise au Ministre de l'Agriculture qui crée par décision ministérielle une commission nationale ad-hoc[86] qui sera chargée d'élaborer un plan d'opérations pour la gestion de la sècheresse. La commission est composée de décideurs et des représentants d'agriculteurs **(figure 23 ci-dessous).**
2. Cette commission non permanente, supervise ensuite **l'exécution de tous les plans d'opérations** durant toute la période de sécheresse en étroite collaboration avec des comités régionaux et sectoriels. Si la sécheresse se poursuit au cours de l'année suivante, les plans d'actions seront maintenus et reconduits. A l'achèvement de la sécheresse, un autre plan d'action pour le démarrage de la période **post sécheresse**

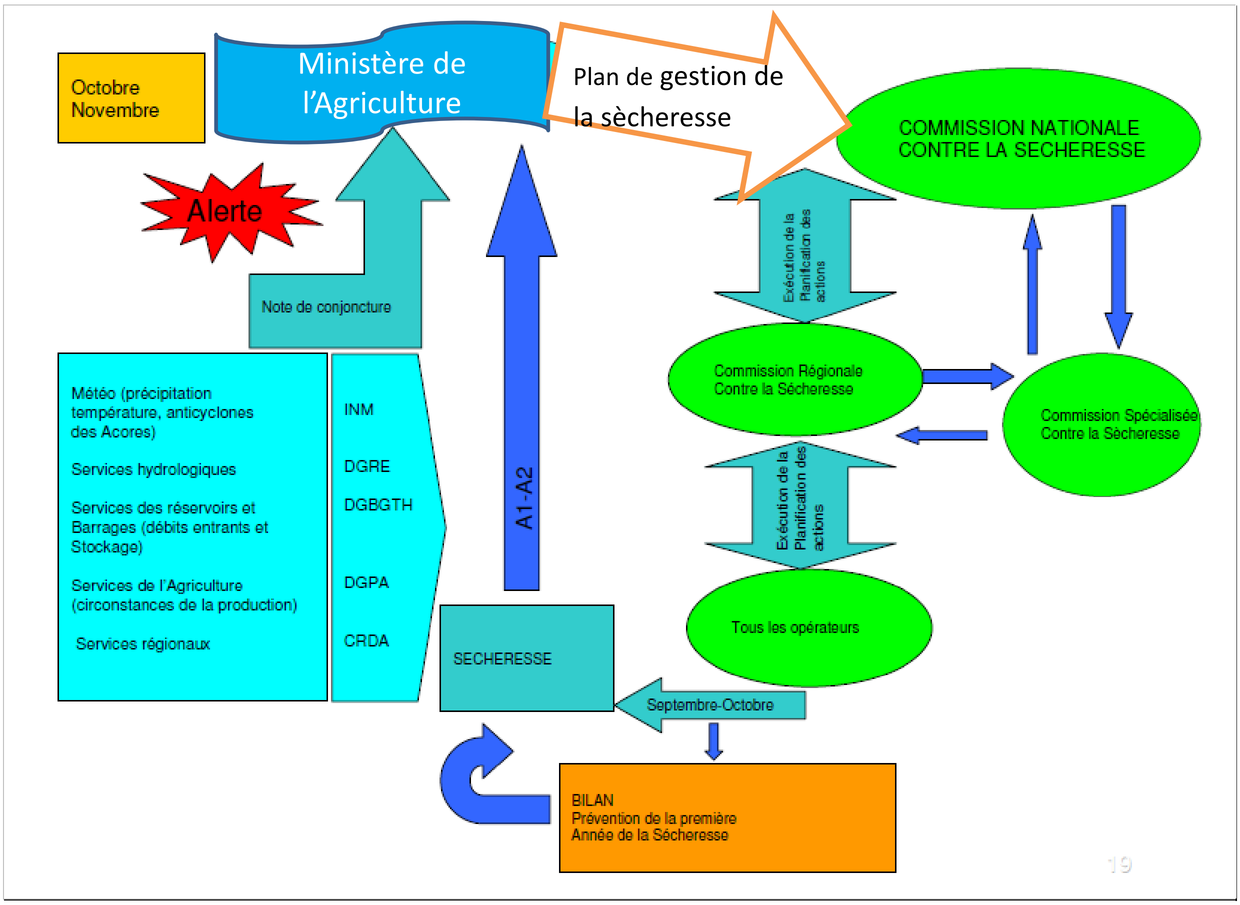
[86] Absence de texte de loi pour la création et la composition de cette commission nationale

supervisé par la même Commission Nationale ad-hoc est mis en place. Des mesures spécifiques sont prises pour une valorisation maximale des conditions favorables.

3. Enfin, **après la sécheresse**, un bilan d'évaluation est réalisé pour dégager les points forts et les points faibles du plan d'action adopté pour gérer la sécheresse. Cette évaluation permet d'enrichir l'approche adoptée pour une meilleure gestion des prochaines périodes sèches.

Les principaux acteurs dans la gestion de la sécheresse sont **(indiqués sur la figure 23)**: les services hydrologiques de la DGRE, les services des barrages (DG/BGTH), les services de l'Institut National de Météorologie (INM), les services agricoles (Direction Générale de la Production Agricole (DGPA), etc.), les services régionaux (CRDA). L'Union Tunisienne de l'Agriculture et de la Pêche (UTAP) est également impliquée en tant que représentant des agriculteurs.

Figure 23. Mécanismes et institutions pour la gestion de la sècheresse



Source: Frigui, 2010

Fonds d'indemnisation pour les inondations et les sècheresses

L'Etat a tenté de mettre en place dès les années 80 un système structuré d'indemnisation des agriculteurs suite à la survenance de calamités naturelles dont la sécheresse. Ce système est composé de deux fonds complémentaires:

- Fonds National de Garantie (FNG) ;
- Fonds de Mutualité pour l'Indemnisation des Dommages Agricoles dus aux Calamités Naturelles (FMIDACN).

Le FNG est destiné à garantir le dénouement de certaines catégories de prêts consentis par les banques sur leurs ressources ordinaires ou d'emprunt en faveur des petites et moyennes unités économiques par le refinancement des impayés et la prise en charge dans certaines proportions des prêts irrécouvrables. Ce fonds n'est pas spécifique à l'agriculture mais couvre les crédits à court terme d'exploitation et les prêts à moyen et long terme consentis en faveur des petits et moyens agriculteurs et pêcheurs.

2.3.5 ANALYSE DES STRUCTURES ET DES SYSTEMES EXISTANTS

Pour la gestion de la sècheresse

Une fois la sècheresse est déclarée, une commission nationale ad-hoc ainsi que des commissions régionales sont créées par le Ministre de l'Agriculture. La commission nationale est chargée de proposer les mesures qui s'imposent et du plan d'opération (qui fait quoi et comment) en fonction de l'avancement de la campagne en s'appuyant sur les informations et les propositions venant des régions (principalement les CRDA). Les commissions régionales sont chargées du suivi de la campagne et de la mise en application des mesures selon le plan d'opération préparé par la Commission Nationale.

Les mesures d'allègement de l'effet de la sècheresse et d'indemnisation sont prises par plusieurs conseils ministériels restreints et conseils interministériels tenus périodiquement par le gouvernement pour examiner la situation du secteur au fur et à mesure de l'avancement de la campagne. Des rapports périodiques sont préparés par le Ministère de l'Agriculture pour renseigner ces conseils interministériels sur la base des avis et recommandations des différentes commissions de gestion de la sècheresse (nationale et sectorielles).

La commission nationale créée de manière ad-hoc pour gérer les évènements de sècheresse[87] est conduite généralement par la Direction Générale de la Production Agricole (DG/PA) et regroupe plusieurs intervenants : l'Office de l'Elevage et du Pâturage (OEP), l'Office des Céréales (OC), la Direction Générale de la Santé Animale (DG/SA), la Direction Générale des Forêts(DG/F), la Direction Générale du Financement, des Investissements et des Organismes Professionnels (DG/FIOP), l'UTAP, l'Union Tunisienne de l'Industrie, du Commerce et de l'Artisanat (UTICA) et le Ministère du Développement et de la Coopération Internationale.

La collaboration entre les différents intervenants qui sont regroupés dans plusieurs structures de suivi et de prise de décision demeure fragile puisqu'il n'existe aucun texte de loi définissant les rôles respectifs des uns et des autres et les procédures à suivre. En d'autres termes, les procédures ne sont pas institutionnalisées, et il n'existe pas de traces écrites sur les actions engagées pour la gestion des sècheresses précédentes. Cette fragilité institutionnelle impacte négativement le fonctionnement de ces structures en conduisant à une confusion dans les rôles, une absence d'une autorité de coordination et un risque de duplication des efforts.

Les structures aussi bien nationales que régionales ou sectorielles (à l'instar du comité de gestion des ressources en eau, comité de sauvegarde du cheptel, comité de gestion du secteur céréalier, comité de gestion du secteur arboricole) sont constituées de manière ad-hoc pour gérer des crises conjecturelles. Paradoxalement, il est assigné à ces structures un objectif de préparation des différents scénarios de gestion de la sècheresse en temps opportun. Cet objectif de nature plutôt stratégique ne peut être rempli sans que ces commissions ne soient permanentes.

A notre connaissance, aucune évaluation de l'efficacité des mesures entreprises pour alléger les effets de la sècheresse n'a été effectuée.

[87] Nous n'avons trouvé aucun document officiel concernant la création et la désignation des différents membres de cette commission

Pour la gestion des inondations

La gestion des inondations est du ressort de la commission nationale de lutte contre les calamités qui est bien structurée mais dont la présidence et la composition mérite d'être revue et actualisée. En effet, la commission est présidée actuellement par le Ministre de l'intérieur qui ne peut pas engager des décisions pour les autres ministères. Une réflexion est en cours pour examiner la possible désignation du Premier Ministre à la présidence de la commission nationale. Par ailleurs, d'autres ministères doivent être impliqués à l'instar du Ministère de la Défense Nationale et du Ministère des Affaires Sociales qui disposent des aires de dépôts pour organiser les aides en cas de sinistre. Aussi, il conviendra d'impliquer la société civile dans cette commission.

La commission qui a été chargée de l'évaluation de la gestion des barrages et des infrastructures hydrauliques lors des inondations de février 2012[88] a relevé dans son rapport plusieurs lacunes et insuffisances liées à la capacité du personnel, à la maintenance des équipements de mesure, etc. Le rapport fournit certaines recommandations dont la plus importante à notre avis concerne la révision profonde de la méthode et des processus d'utilisation et d'exploitation des données météorologiques. Afin que ces dernières constituent un des piliers pour la protection contre les inondations, la commission propose de créer, une cellule spécialisée dans l'alerte précoce des inondations au sein de l'INM et l'instauration d'un système d'alerte précoce (SAP) dans le but d'améliorer fondamentalement la gestion avant et pendant les inondations. Ce Système d'Alerte Précoce ne doit pas omettre la coordination avec l'Algérie pour la gestion des inondations de la Medjerda, la plus importante rivière de Tunisie (33% de la superficie du bassin versant de la Medjerda est située en Algérie).

2.3.6 REACTIONS OFFICIELLES DU SECTEUR DE L'EAU ET LES REPONSES AUX EVENEMENTS EXTREMES

Durant les périodes de sècheresse

Lors des sècheresses, le déficit en eau réduit considérablement les volumes d'eau s'écoulant dans les réseaux hydrographiques et les volumes collectés par les ouvrages de stockage. Les problèmes quantitatifs sont accompagnés de problèmes de qualité. En effet la salinité augmente dans les eaux des barrages. Aussi, la diminution de la quantité d'eau est à l'origine de l'augmentation de la turbidité de l'eau dans les réservoirs d'eau. Cette forte turbidité engendre le colmatage des conduites et des canaux d'adduction et l'augmentation des coûts de production de l'eau potable par le recours aux eaux souterraines ou à l'apport d'eau d'autres barrages moins salés.

La gestion des ressources en eau au cours des années sèches se caractérise principalement par des dispositions spécifiques au niveau des allocations. En effet, les besoins du secteur agricole ne pouvant être satisfaits, des restrictions sont ordonnées dans les zones affectées. Les restrictions peuvent toucher l'eau potable aussi en cas d'acuité de la sècheresse. Quant aux usagers d'eau, en premier lieu les agriculteurs, ils se rabattent sur les nappes pendant les périodes sèches, pour compenser une partie de la demande en en eau non satisfaite avec toutes les répercussions négatives de surexploitation des nappes que cela puisse engendrer.

D'autres types mesures ont été également prises dans le passé pendant des périodes de sècheresse afin de réduire leur impact sur certaines filières agricoles. Par exemple, une réduction du prix de l'eau destinée à l'irrigation des céréales a été accordée lors de l'épisode de sécheresse de quatre années successives 1998-2002. Aussi, pour le secteur arboricole et surtout l'olivier, l'arrosage des jeunes plantations en sec était assuré par des citernes d'eau sur la charge des CRDA. Toutefois, ces mesures ne sont pas systématiques. Leur instauration dépend de la gravité de la sècheresse, des risques (des fois irréversibles) encourus et surtout de la disponibilité de l'eau.

[88] http://www.onagri.nat.tn/

Durant les périodes d'inondation

Lors des évènements pluvieux intenses, le souci majeur de la DG/BGTH est la sécurité des barrages. Ainsi, des lâchures d'eau sont rendues nécessaires par temps de crue ce qui aggrave pour certains évènements pluvieux les inondations à l'aval des ouvrages. En préparation des saisons humides, la DG/BGTH opère à des transferts d'eau entre différents barrages grâce au réseau d'interconnexion reliant quasiment tous les barrages du Nord. Toutefois, ce transfert gagnerait en optimisation avec une utilisation améliorée des prévisions météorologiques dans le cadre d'un système d'alerte précoce aux inondations. De manière plus stratégique, une meilleure valorisation des eaux excédentaires serait envisageable moyennant des ouvrages de transfert d'eau de la zone la plus arrosée vers les zones intérieures du pays et une gestion conjuguée eaux de surface/eaux souterraines.

2.3.7 REALISATIONS, INSUFFISANCES ET LACUNES

Etant confrontée à vivre des sècheresses deux à trois fois toutes les 10 années, la Tunisie a mis en place différentes mesures et techniques pour affronter et atténuer l'effet de la sècheresse :

1. Les techniques traditionnelles hydro-agricoles (tabias, jessours **(figure 24)**, meskats, mgouds, mejels ou citernes), diversification des activités et nomadisme (Voir section VIII pour plus de détails).
2. La mobilisation des eaux (29 grands barrages, barrages collinaires, puits et sondages)
3. La régulation et le transfert (interconnexion des barrages et transfert vers les zones de développement par canaux et conduites).
4. La recharge artificielle des nappes ;
5. Les techniques de conservation des eaux et des sols (structures d'épandage des eaux des crues, banquettes, cordons en pierres sèches **(figure 25)**, reboisement, etc.)
6. L'économie de l'eau (détection des fuites, nouvelles technologies, choix des techniques et des équipements d'irrigation appropriées, choix des espèces culturales…etc.)
7. Et le recours au ressources non conventionnelles (réutilisation des eaux usées traitées, dessalement d'eau)

Toutefois, ces mesures sont plutôt de nature à gérer une ressource en eau rare dans un contexte climatique aride et pourraient se confondre à des mesures de gestion d'évènements extrêmes. Néanmoins, il n'existe pas de mesures distinctes engagées spécifiquement pour se préparer en avance à des évènements de sècheresse ou d'inondation. Dans la plupart de cas, les institutions publiques agissent de manière « réactive » et non «proactive» face aux effets des événements extrêmes et opèrent donc une gestion de crise et non une gestion de risque.

Après l'avènement inondations et des sècheresses, la mesure la plus pratiquée concerne la distribution d'aides directes aux petits exploitants en compensation des pertes et dommages occasionnés. Ces aides, généralement en nature (semences, engrais, aliment de bétail, etc.) sont accordées dans une logique « d'urgence sociale » et non pas dans une logique d'amélioration structurelle du système de production. Par ailleurs ces aides ne sont pas systématiques et les conditions de leur attribution (critères, montant, etc.) restent souvent arbitraires. Avec le risque d'augmentation de l'intensité et de l'occurrence du phénomène de sècheresse à cause changement climatique (Verner, 2013), la vulnérabilité des systèmes de production doit être examinée afin de prendre des mesures structurelles intégrant les impacts du changement climatique.

Le secteur agricole étant le plus touché par la sècheresse et l'inondation, les réactions d'adaptation au plan macro semblent être efficaces par leurs mesures d'intervention conjoncturelles mais méritent d'être révisées et renforcées sur le plan structurel dans le sens d'une meilleure prévision de ces événements (système d'alerte) et gestion des risques (assurance) et de leur intégration dans les plans de développement nationaux. Pour cela, il est utile de mener des études d'évaluation de la vulnérabilité et des risques liés aux évènements extrêmes.

Jusqu'à présent, la gestion des inondations s'est limitée à la protection des ouvrages, des structures et surtout des vies humaines. Un plan de gestion permettant la valorisation des eaux des périodes extrêmes doit être envisagé.

Les efforts consentis par le gouvernement tunisien pour lutter contre la sècheresse et les inondations se sont focalisés sur le développement des infrastructures. Le rôle que peuvent jouer les écosystèmes est largement négligé. D'ailleurs, très peu d'information est disponible concernant les écosystèmes et tout particulièrement les zones humides du Centre et encore moins celles du Sud du pays. Les milieux naturels des sebkhas et en particulier les chotts, leur biodiversité, leurs valeurs, leur fonctionnement et leur potentiel contributif à l'atténuation des évènements extrêmes sont encore peu connus. D'un autre côté, l'évaluation des impacts des événements extrêmes (sécheresses ou inondations) se limite en général à des suivis des ouvrages hydrauliques et des constats de dégâts plus ou moins chiffrés, alors que les impacts sur les écosystèmes, en particulier sur les zones humides sont rarement discutés.

D'autres lacunes et faiblesses méritent également d'être mentionnés telles que :

- Le manque de personnel qualifié pouvant prendre des décisions pour le suivi des ouvrages de stockage et d'évacuation des eaux ;
- La difficulté d'estimer les dommages et les pertes occasionnés par les sècheresses et les inondations sur tous les secteurs et sous-secteurs ainsi que sur les écosystèmes et l'environnement socio-économique en général. Cette difficulté d'évaluer les risques des évènements extrêmes rend difficile sa gestion de façon proactive ;
- L'absence de méthodes normalisées d'évaluation des impacts des sècheresses et des inondations ;
- La non application des décrets relatifs aux fonds de mutualité pour l'indemnisation des dommages agricoles dus aux calamités naturelles mentionnés par les décrets no 88-948 et 88-949 du 21 mai 1988.
- Le redémarrage après une période de sècheresse nécessite des moyens financiers assez lourds pour permettre aux agriculteurs de surmonter leurs difficultés engendrées par la sécheresse antérieure. En absence de système d'assurance adéquat, ces moyens demeurent très limités.
- Le non-respect du plan d'aménagement et d'extension urbaine dans certaines zones à risques d'inondation (lit d'oued, limite d'une sebkha, etc.)

L'impact de sécheresse et des inondations risquent d'être de plus en plus sévères avec le changement climatique et une politique nationale de gestion intégrée de la sècheresse et des inondations est nécessaire y compris le développement d'un système d'alerte précoce et le renforcement des capacités institutionnelles.

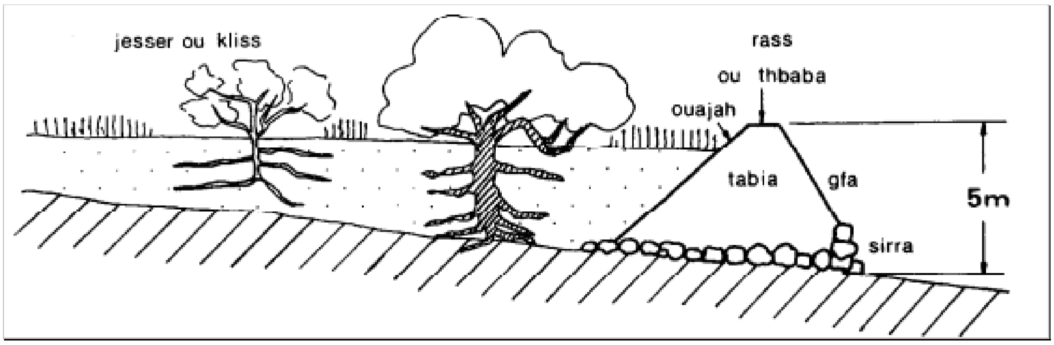
2.3.8 LES LEÇONS APPRISES ET LES MEILLEURES PRATIQUES POSSIBLES INDIGENES

Le phénomène de la sècheresse étant un phénomène récurrent en Tunisie, l'homme perçoit l'érosion et l'aridité des sols comme un processus naturel. Mais il admet que son accélération sous l'effet de ses activités (le surpâturage, les cultures dans des zones fragiles, les techniques culturales inadaptées, la réduction de la jachère, etc.) a entraîné la disparition de la végétation suivie par la dégradation des sols. Au cours des temps, l'homme est parvenu à mettre au point des techniques traditionnelles qui lui permettent de maîtriser son environnement et de s'adapter à son milieu. L'adaptation de l'homme à la sécheresse et à l'aridité se perçoit à travers son savoir-faire en matière d'utilisation des eaux pluviales et de techniques d'aridoculture.

A défaut de sources d'eau sécurisées (nappes phréatiques, etc.), et afin de satisfaire ses besoins domestiques et assurer l'abreuvement de son bétail, l'Homme emmagasine l'eau des pluies dans des réservoirs souterrains (ou citernes), dits ''majel'' ou ''Fesguya''dont la contenance va de quelques dizaines à quelques centaines de mètres cubes.

Pour ses cultures, et depuis l'époque berbère, l'Homme a développé la technique des ''Jessour (pluriel de Jesr) qui consiste à établir à travers les thalwegs, une série de petits barrages en terre, derrière lesquels s'accumule l'eau et les éléments fins du sol, lui permettant de faire pousser oliviers, palmiers, figuiers et vignes selon la superficie dont il dispose. Dans les zones de piedmont, par dérivation ou par établissement de « tabias » établies en quinconce, il procède à l'épandage des eaux. Dans la région de Médenine-Tataouine au sud de la Tunisie, pour conserver l'humidité du sol aux oliviers qu'il plante, sa technique consiste à percer la croûte calcaire ou gypso-calcaire, juste pour les trous de plantation, la croûte restant en place continue à jouer son rôle de mulch pour le paléosol qu'elle couvre.

Figure 24: Profil d'une tabia et de son Jesser



Source: Bonvallot, 1986

Figure 25: Cordon de pierres sèches comme mesure de conservation des eaux et du sol

Source: Frigui, 2010

Dans la région sfaxienne, celles de Zarzis, de Bengardane et de la presqu'île du Jorf (Dakhla) au sud-est du pays, où la pluviométrie est faible, l'évapotranspiration forte, les sols plats, profonds et meubles, les arbres, généralement des oliviers, sont plantés avec un écartement de près de 20 mètres. La concurrence de la végétation herbacée, notamment le chiendent, est éliminée, l'ascension de l'eau par capillarité et l'évaporation du sol sont coupées tout au long de l'année par de fréquents labours légers. L'eau est ainsi retenue là où elle tombe.

Dans le Sahel de Sousse, région de collines, les oliviers sont plantés dans les dépressions à sol profond, où l'eau de ruissellement des coteaux environnants est dirigée par des fossés vers les oliviers. Cette technique, dite des « Meskats », est pratiquée depuis des temps immémoriaux. En milieu aride la création de périmètres irrigués et principalement d'Oasis constitue une des meilleures façons d'adaptations de l'homme aux conditions d'aridité climatique. La production agricole en trois étages dans les oasis (palmiers, arbres fruitiers, cultures fourragères, céréales, légumes, etc.) est de 10 à 25 fois celle de la végétation spontanée suivant les situations. En matière d'élevage, les éleveurs utilisent des animaux rustiques comme les chameaux, les chèvres et les moutons qui sont capables de valoriser la production végétale des terrains de parcours des zones arides. En année sèche, l'éleveur est contraint à envoyer son troupeau dans les régions où la pluviosité a été favorable et à réduire généralement l'effectif en vendant une partie de ses animaux. Ainsi le troupeau réduit est sauvé et sera reconstitué durant les années pluvieuses. Ces exemples montrent bien comment l'homme s'est adapté aux conditions arides, par un nomadisme de type pastoral, soutenu par la production régulière des oasis, et le développement d'une petite hydraulique de surface permettant d'avoir des apports supplémentaires en eau pour la culture sans aucune pression sur le milieu naturel.

Ce savoir-faire et ces bonnes pratiques indigènes méritent d'être revalorisés et d'être intégrés à leur juste valeur dans la politique de gestions des évènements extrêmes.

2.3.9 L'EVALUATION DES IMPACTS SOCIO-ECONOMIQUES ET ENVIRONNEMENTAUX DE LA SECHERESSE ET DES INONDATIONS EN TUNISIE

A notre connaissance, il n'existe pas de rapport d'évaluation des impacts socio-économique liés directement ou indirectement aux évènements de sècheresse et d'inondations ni de rapport d'évaluation de l'efficacité des mesures mises en place pour atténuer les effets de ces évènements. La seule étude qui a tenté d'identifier et d'évaluer les impacts socio-économiques liés à ces évènements est celle réalisée dans le cadre du projet SWIM-SM sur le bassin versant de la Medjerda. Ces impacts sont examinés à travers les composantes de dégradation des ressources en eau engendrés par ces évènements tels que l'envasement des barrages suites aux inondations, la surexploitation des nappes suites aux sècheresses, etc. Les résultats de cette étude fournissent un ordre de grandeur de la valeur de ces impacts et peuvent être considérés comme première évaluation globale pour orienter la recherche des solutions pour une meilleure gestion de ces évènements.

Ceci étant, il est manifeste que les pertes engendrées par les évènements extrêmes se traduisent par une baisse de la contribution de l'agriculture au PIB, à la valeur ajoutée, à l'emploi et à la couverture de la balance commerciale. Sur le plan environnemental, les dommages qui en découlent concernent la dégradation des ressources naturelles (eau, sol, couvert végétal). Sur le plan économique et social, les pertes portent principalement sur le dysfonctionnement de certaines infrastructures agricoles de base et la perte d'une part du marché. A l'échelle de l'exploitation, on assiste à une perte du niveau de la production des spéculations agricoles et du revenu de l'exploitant, à un accroissement des coûts des facteurs de production, à une décapitalisation du cheptel et à l'abandon de l'activité agricole au niveau de l'exploitation au profit d'autres métiers ou activité en dehors de l'exploitation.

Bien que comme mentionné ci-dessus, il n'y a pas eu à notre connaissance d'évaluation des impacts socio-économiques des évènements de sècheresse, certaines observations génériques peuvent être partagées. En même temps, il nous semble utile de partager des informations sur les effets cumulatifs de ces évènements et leur contribution à la dégradation des ressources en eau. L'étude récente réalisée dans le cadre du programme SWIM-SM a permis d'évaluer le coût de la Dégradation des Ressources en Eau du Bassin de la Medjerda (Sherif Arif et Fadi Doumani, SWIM-SM 2012). Nous avons relevé de cette étude les évaluations de la dégradation qui est engendrée et/ou largement aggravée par les sècheresses et les inondations.

La sècheresse

Le déficit hydrique engendré par les sècheresses a conduit à une réduction des volumes d'eau s'écoulant dans les réseaux hydrographiques et les volumes collectés par les ouvrages de stockage. Les perturbations quantitatives sont accompagnées de perturbations qualitatives. En effet, la salinité a augmenté dans les eaux des barrages augmentant ainsi le risque d'augmentation de la salinité dans les sols irrigués et par conséquent la diminution des rendements agricoles. La turbidité de l'eau dans les barrages a également augmenté provoquant le colmatage des conduites et des canaux d'adduction et par la suite l'augmentation des coûts de production de l'eau potable à cause des réparations engendrées.

Les sécheresses ont eu également des répercussions négatives sur le débit des sources thermales perturbant ainsi l'activité médicale thérapeutique du secteur du thermalisme.

Dans les zones rurales, les sécheresses ont aussi affecté les nappes phréatiques par la baisse du niveau piézométrique et l'assèchement des puits et des sources. Il en résulte un manque au niveau de l'alimentation en eau potable rurale et de l'irrigation.

La sécheresse se manifeste encore par la disparition de l'artésianisme et l'épuisement des réserves pour les forages qui captent les petits aquifères à ressources limitées.

En période de sècheresse, le recours à l'usage de l'eau souterraine peut provoquer ou aggraver la surexploitation et la dégradation de la qualité de l'eau. La surexploitation est à l'origine d'un rabattement conséquent du niveau piézométrique et donc de l'augmentation des coûts supplémentaires pour le pompage de l'eau (0,004 litres de diesel/m de profondeur et par m^3 d'eau). Ce coût supplémentaire a été estimé sur le bassin versant de la Medjerda en 2010 à 0,45 Millions de DT (Sherif Arif et Fadi Doumani, SWIM-SM 2012).

Au cours des années de sècheresse, la perte de la production hydroélectrique du nord de la Tunisie est compensée par une production à base de gaz ou fuel. Sur la base de la moyenne sur 11 ans, la perte d'hydroélectricité a été de 5,97 millions de Kilo Watt/Heure en 2010. Le coût de la dégradation est estimé par conséquent à 0,76 million de DT avec 0,66 million de DT comme coût de substitution pour produire l'électricité en utilisant de l'énergie fossile et 99 987 DT pour l'équivalent d'émissions carbones en 2010 du fait de la fluctuation des flux hydriques (Sherif Arif et Fadi Doumani, SWIM-SM 2012). L'année 2008 semble avoir été l'année la plus sèche de la décade avec une perte de production hydroélectrique de 58,4 millions de kW/h et un coût de la dégradation de presque 7,5 millions de DT (dont 6,5 millions de DT représentant le coût de substitution). L'année 2003, considérée humide a permis au contraire des gains hydroélectriques par rapport à la moyenne avec un coût négatif de la dégradation de 9,9 millions de DT (dont -8,6 millions de DT représentent le coût de substitution) aux prix de 2010 (Sherif Arif et Fadi Doumani, SWIM-SM 2012).

Il est admis qu'une période de sécheresse accrue avec vague de chaleur augmente l'inflammabilité de la masse combustible – et naturellement le risque d'incendie. Mais sans «masse combustible», même avec augmentation de la sécheresse et de chaleur, le risque d'incendie est zéro (les zones désertiques et pré-désertiques ne connaissent pas de feu de forêt parce que la forêt (= masse combustible) est absente). En contrepartie, une augmentation des précipitations au nord de la Tunisie pourrait considérablement augmenter le risque de feu de forêt avec le développement de masse combustible. Il existe donc une interaction complexe entre les évènements extrêmes et les feux de forêts. La dégradation des bassins versants par les feux de forêts engendre une augmentation de la sédimentation des barrages et par la suite une diminution des stocks de l'eau.

Une répercussion concrète sur les zones humides des années extrêmement sèches n'est pas repérée. D'une manière générale, en dehors de la pression humaine, les grandes sécheresses entraînent une atténuation du fonctionnement des écosystèmes. Les périodes entre les apports d'eau douce sont prolongées, la production végétale est diminuée et le processus de la désertification avec toutes ses conséquences se met en place. Les sebkhas en proximité des villes risquent de devenir un cloaque des eaux usées et des décharges comme il est rapporté pour la sebkha Séjoumi à Tunis Ouest. Une forte perturbation du Lac Ichkeul a été signalée pendant les années sèches 1988, 1993 et 2002. Le manque d'apport d'eau douce avec l'interruption transfert du volume d'eau réservé à ce lac a augmenté la salinité de l'eau du lac à plus de 80 g/l.

En milieu aride et saharien, l'absence de végétation raréfiée par un surpâturage excessif augmente la vulnérabilité du sol à l'érosion éolienne en période de sécheresse et à l'érosion hydrique au moindre orage.

Les inondations

Les inondations génèrent une érosion très importante surtout dans les zones à fortes pentes, voir même des glissements de terrain. Les pertes sont estimées à 14,5 tonnes par ha le long de la dorsale[89] (Sherif Arif et Fadi Doumani, SWIM-SM 2012). Les barrages, barrages collinaires et lacs collinaires subissent ces érosions, ce qui est à l'origine d'une diminution de leurs capacités de stockage et une détérioration de la qualité de l'eau qui se répercute sur le coût de traitement pour la production de l'eau potable et l'infrastructure d'irrigation en mode goutte à goutte.

L'érosion est à l'origine de la dégradation de la qualité des sols. La perte de la valeur nutritive des sols est compensée par des engrais augmentant par conséquent les coûts de production. Sur la base d'une superficie cultivée d'environ un millions d'hectares (1 090 570 Ha) dans le bassin de la Medjerda et d'un coût moyen des engrais de 27,1 DT par ha, le coût de la dégradation est estimé à 7,4 millions de DT avec une variation de 3,7 à 14,8 millions de DT en 2010 (Sherif Arif et Fadi Doumani, SWIM-SM, 2012).

L'envasement peut conduire à la réduction de la disponibilité en eau pour les usagers. L'impact de l'envasement sur l'agriculture irriguée peut être évalué en suivant le changement de production. En considérant une consommation de 5 000 m^3/ha pour l'irrigation intensive, un manque à gagner serait la différence entre la valeur ajoutée de la production agricole entre l'irrigation intensive et non-intensive. Tous les autres facteurs restant constants, un manque à gagner de 2007 DT/ha toutes cultures confondues a été retenu Sherif Arif et Fadi Doumani, SWIM-SM 2012). Pour le bassin de la Medjerda, le coût de la dégradation s'élève ainsi à 4,3 millions de DT avec une variation de 3,9 à 4,8 millions de DT en 2010 (Sherif Arif et Fadi Doumani, SWIM-SM 2012).

Le coût de la perte de volumes de stockage dans les barrages est estimé à 0,006 DT/m^3 en se basant sur les coûts réels correspondant aux travaux de surélévation de la digue du barrage de Mellègue dans le nord-ouest de la Tunisie. Dans le cas de remplacement des barrages envasés par des nouveaux barrages, le coût s'élèverait à 1,31 DT/m3. Ainsi, le coût dû à l'envasement des barrages s'élèverait à 7,1 millions de DT avec une variation de 0,1 à 14,1 millions de DT en 2010 (Sherif Arif et Fadi Doumani, SWIM-SM 2012).

[89] C'est un ensemble d'alignement montagneux qui est le prolongement de l'atlas saharien. Il s'étend des monts de Tébessa, à la frontière avec l'Algérie, jusqu'aux hauteurs du cap Bon

Les inondations qui entraînent l'asphyxie des sols dans les plaines et une détérioration de la structure du sol (création de croûtes limono argileuses imperméables tapissant la surface des terres arables) contribuent à la salinisation des sols après évaporation des eaux de ruissellement qui sont généralement bien chargées en sel.

La dégradation de la qualité de l'eau par l'augmentation de la salinité aura un impact sur la production agricole ainsi que sur la consommation en eau potable. Le recours à l'usage de l'eau en bouteille dans le bassin de la Medjerda et du Grand Tunis peut être chiffré en tant que coût économique relatif à la dégradation de la qualité. Ce coût est évalué à 19,3 Millions de Dinars par an (Sherif Arif et Fadi Doumani, SWIM-SM 2012).

Par ailleurs, l'ampleur des dégâts et la gravité des impacts des inondations ont produit chez les habitants du Grand Tunis en général et ceux des zones Nord et Est en particulier, un sentiment d'insécurité induit par les séquelles des inondations est à même de freiner les différents aspects du développement de la ville.

2.3.10 LES OPPORTUNITES

Le contexte actuel de la Tunisie peut être saisi comme une opportunité pour une révision et une amélioration de la gestion des évènements extrêmes. En effet, l'intégration de la composante de changement climatique dans la gestion des évènements extrêmes oblige le recours à une nouvelle forme de gestion et de planification. Les périodes extrêmes vécues par la Tunisie au cours des 25 dernières années ont permis d'élaborer un cadre juridique et des mécanismes de gestion de ces évènements qui méritent d'être renforcés et améliorés.

De même le premier rapport national sur la mise en œuvre du Cadre d'action de Hyōgo qui doit être soumis à la fin de l'année 2013 devra fournir un diagnostic de l'état actuel et le niveau de progrès atteint ainsi que des contraintes liées à la gestion des catastrophes regroupés selon cinq priorités définis par la cadre de Hyogo comme suit :

- Veiller à ce que la réduction des risques de catastrophe soit une priorité nationale et locale et à ce qu'il existe un cadre institutionnel solide pour mener à bien les activités correspondantes ;
- Mettre en évidence, évaluer et surveiller les risques de catastrophe et renforcer les systèmes d'alerte précoce ;
- Utiliser les connaissances, les innovations et l'éducation pour instaurer une culture de la sécurité et de la résilience à tous les niveaux ;
- Réduire les facteurs de risque sous-jacent ;
- Renforcer la préparation des populations aux catastrophes afin de pouvoir intervenir plus efficacement à tous les niveaux lorsqu'elles se produisent.

Une accélération de la fréquence et/ou l'intensité des événements climatiques extrêmes est constatée du fait des changements climatiques. De ce fait, les sociétés humaines sont aujourd'hui plus exposées aux risques qu'elles ont cru dominer. Ceci implique que la gestion de ces phénomènes doit être abordée dans le cadre d'une stratégie d'adaptation de ces extrêmes au changement climatique en tenant compte de la vulnérabilité et de l'impact des phénomènes extrêmes sur les écosystèmes et les services qu'ils rendent à la société. Cette stratégie doit se fonder sur la vision de développement national et régional en tenant compte non pas des risques de la sècheresse mais de la vulnérabilité structurelle à la sècheresse des différents secteurs et sous-secteurs à ces évènements extrêmes. La gestion des risques et des incertitudes sur les risques est fondamentale et conduit à orienter la recherche des solutions d'atténuation du type non structurelles (la connaissance, l'information, la prise de conscience du risque et l'éducation au risque des populations et en particulier des groupes les plus vulnérables, l'évolution du comportement). Les mesures conjoncturelles restent nécessaires mais non suffisantes.

Une gestion durable des sècheresses et des inondations nécessite des mesures qui dépassent les frontières nationales. Des collaborations régionales et avec les pays voisins partageant certaines ressources en eau sont fondamentales. Aussi, la mise en place d'un système d'alerte précoce à la sècheresse (SAPS) opérationnel comme outil d'aide à la décision et au développement durable est nécessaire. Le travail initié par l'Observatoire du Sahara et du Sahel (OSS) dans le cadre du projet Système maghrébin d'alerte précoce à la sécheresse (SMAS) peut servir de base pour l'élaboration d'un SAP national ou régional. Le SAP pour être efficacement opérationnel doit bénéficier d'une approbation et d'une adoption à très haut niveau par les pays concernés.

REFERENCES BIBLIOGRAPHIQUES

1. Banque centrale de Tunisie. Rapport annuel 2007, 2008, 2009 et 2010.
2. CNEA et Ministère de l'agriculture, 1996. Etude de la gestion des périodes de sècheresse. Analyse des périodes de sècheresse de 1988-1989 et 1994-1995 et les grandes lignes d'une stratégie d'allègement des effets de la sècheresse.
3. Bonvallot J. 1986. Tabias et jessour du Sud tunisien. Agriculture dans les zones marginales et parade à l'érosion. Cah. ORSTOM, Ser. Pedol., vol. XXII, no 2, 19846 : 163-I 71.
4. Daoud a. et Dahechs., 2012. résilience de l'agglomération de Sfax (Tunisie méridionale) face au changement climatique: essai d'évaluation. Climatologie, numéro spécial 'Climats et changement climatique dans les villes' (2012)
5. DGRE, 2003. Crue et inondations dans le bassin versant de la moyenne Medjerda. Janvier-Février 2003.
6. DGRE, 2003. Crues et inondations dans la basse vallée de la Medjerda. Janvier-Février 2003 tronçon barrage Laroussia-la mer.
7. DGRE, 2005. Etude des crues de la Medjerda de décembre 2003 et de janvier 2004.
8. DGRE, 2006. Crue du 21 janvier 2006 dans le bassin de la Medjerda. Actualisation de la courbe de tarage de la station de Jedeida au pont route n°7.
9. DGRE, 2009. Crue avril 2009 dans la haute vallée de la Medjerda.
10. DGRE, 2012. Crue et inondations de la Medjerda. Rapport de synthèse.
11. Verner, Dorte. 2013. Tunisia in a Changing Climate: Assessment and Actions for Increased Resilience and Development. Washington, DC: World Bank. doi:10.1596/978-0-8213-9857-9 License: Creative Commons Attribution CC BY 3.0
12. FAO, 2013. Tunisie- financement du secteur agricole.
13. Frigui H. L.i, 2010. Sècheresses en Tunisie indicateurs et gestion, Ministère de l'Agriculture, Tunisie. (www.emwis.org/topics/...madrid/...Tunise.../20100217-Tunise_LF.pdf.
14. JICA, 2009. Etude sur la gestion intégrée du bassin axée sur la régulation des inondations dans le bassin de la Mejerda en République Tunisienne
13. Louati M. et al., 2005.Tunisia. Options Méditerranéennes, Series B, No. 51

14. MA et GIZ, 2006. Changements climatiques : effets sur l'économie tunisienne et stratégie d'adaptation pour le secteur agricole et les ressources naturelles

15. MA et Nippon Koei, 2009. Etude sur la gestion intégrée du bassin axée sur la régulation des inondations dans le bassin de la Mejerda en République tunisienne.

16. MA, 1999. Guide pratique de gestion de la sècheresse en Tunisie. Approche méthodologique.

17. OTEDD et GTZ, 2008. Gestion durable des ressources en eau

18. OSS, 2006. Evaluation des systèmes existants d'alerte précoce à la sècheresse en Tunisie. Projet Life 05TCY /TN :00150.

19. OSS, 2009. Vers un système d'alerte précoce à la sècheresse au Maghreb.

20. Sherif Arif et Fadi Doumani. 2012. Tunisie, Coût de la Dégradation des Ressources en Eau du Bassin de la Medjerda. Programme de Gestion Intégrée Durable de l'Eau (SWIM-SM) financé par la Commission européenne et mis en œuvre par le consortium comprenant : LDK Consultants Ingénieurs & Programmateurs S.A. (Chef de file) ; l'Association des Services d'Eau des Pays Arabes (ACWUA) ; le Réseau Arabe pour l'Environnement et le Développement (RAED) ; le Bureau de Conseils DHV B.V., le Global Water Partnership - Mediterranean (GWP-Med) ; le Ministère Grec de l'Environnement, de l'Energie et du Changement Climatique/Département des Relations Internationales et des Affaires de l'Union européenne ; le Ministère Libanais de l'Energie et de l'Eau/Direction Générale des Ressources Hydrauliques et Electriques ; le Ministère Tunisien de l'Agriculture, des Ressources Hydrauliques et de la Pêche/Direction Générale des Ressources en Eau ; ainsi que l'Agence Autrichienne pour l'Environnement (UmweltbundesamtGmbH). Bruxelles.

ANNEXE 1: IMPACTS DES PERIODES SECHES ET DES INONDATIONS SUR LES PRINCIPALES COMPOSANTES DES ECOSYSTEMES EN TNUISIE

Evènement	Sur la végétation	Sur la faune	Sur l'homme
Inondation	-Amélioration de la régénération naturelle -Amélioration de la production des parcours -Asphyxie sur sols engorgés d'eau -Défrichement de la steppe pour la céréaliculture	-mortalité des animaux causée par les crues d'oueds. -Destruction des habitats -Afflux de l'avifaune aux zones humides	Destruction des habitations et mortalité par suite des crues d'oueds. -Perturbation de la circulation routière. -Pertes financières suite aux dégâts des cultures et aux pertes de cheptel
Sècheresse	Accroissement du taux de mortalité des espèces. -Disparition d'espèces. -Manque de régénération naturelles. -Diminution ou annulation des rendements des cultures. -Diminution ou perte de la productivité des parcours. -Diminution ou perte de la couverture végétale -Accentuation des incendies. -Accentuation des attaques parasitaires -Augmentation de la pression sur la forêt due à l'ouverture des parcours forestiers	-Mortalité des animaux due à la soif. -Migration de la faune vers des zones plus clémentes. -Destruction de la microfaune et de la microflore du sol	Augmentation des dépenses pour l'alimentation des troupeaux -Pertes financières dues aux pertes des cultures et du cheptel.

Source: MA et GIZ, 2006