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Drought vulnerability in the Arab region:

Special case study: Syria

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Drought in Syria

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Droughts have been a part of our environment since the beginning of recorded history, and humanity's survival may be testimony only to its capacity to endure this climatic phenomenon. Drought is considered by many to be the most complex but least understood of all natural hazards, affecting more people than any other hazard (Hagman 1984).

A. Drought: Definitions and Types

Drought is the consequence of a natural reduction in the amount of precipitation over extended period of time, usually a season or more in length, often associated with other climatic factors (such as high temperatures, high winds and low relative humidity) that can aggravate the severity of the event, (Sivakumar, 2005). It is a normal event that takes place in almost every climate on Earth, even the rainy ones. Drought manifestation varies from region to region and therefore a global definition is a difficult task e.g. Drought is a recurring extreme climate event over land characterized by below-normal precipitation over a period of months to years. Drought is a temporary dry period, in contrast to the permanent aridity in arid areas. Drought occurs over most parts of the world, even in wet and humid regions. This is because drought is defined as a dry spell relative to its *local normal condition. On the* other hand, arid areas are prone to drought because their rainfall amount critically depends on a few rainfall events, (Sun et al 2006). One might define drought in Libya as occurring when annual rainfall is less than 180 mm, if less than 2.5 mm of rainfall in 48 hours in USA, about 15 consecutive days with daily precipitation totals of less than 25 mm in GB, actual seasonal rainfall deficient by more than twice the mean deviation in India, but in Indonesia, Bali drought might be considered to occur after a period of only 6 days without rain, (Ragab, 2005).

Generally there are three types of conditions that are referred to as drought, Meteorological drought is brought about when there is a prolonged period with below average precipitation; Agricultural drought is brought about when there is insufficient moisture for average crop or range production, this condition can arise, even in times of average precipitation, due to soil conditions or agricultural techniques; and Hydrologic drought is brought about when the water reserves available in sources such as aquifers, lakes and reservoirs falls below the statistical average, this condition can arise even in times of average (or above average) precipitation, when increased usage of water diminishes the reserves, American Meteorological Society (AMS 1997). (Wilhite, 2000 and Sivakumar, 2005). A lack of precipitation often triggers agricultural and hydrological droughts, but other factors, including more intense but less frequent precipitation, poor water management, and erosion, can also cause or enhance these droughts. For example, overgrazing led to elevated erosion and dust storms that amplified the Dust Bowl drought of the 1930s over the Great Plains in North America, (Cook et al 2009**).**

B. Drought: Negative Affects

Drought is the most complex of all natural hazards as it affects more people than any other hazard, According to EM/DAT data quoted in the World Disaster Report (2007), about 2.63 million people were affected by Hydro-metrological disasters globally during the period (1997-2006), about 41.82% are affected by drought, 38.87% of them were affected during the year 2002 During 1997/2006, hydro-metrological disasters caused an estimated damage of US$ 66.8 billion per year on average out of this 4.62% caused by drought. Average number of people reported killed by drought in million per year are, Asia (81.11), Africa (26.69), Americas (2.57), Europe (0.14). The effects of droughts are seriously worsened by human factors such as population growth that forces people into drier and drier regions and inappropriate cropping and herding practices. The impacts of drought are likely to become ever more severe as a result of development processes and population increases (Squires 2001).Droughts often stimulate sequences of actions and reactions leading to long-term land degradation, figure (1), after (Erian 2010) .

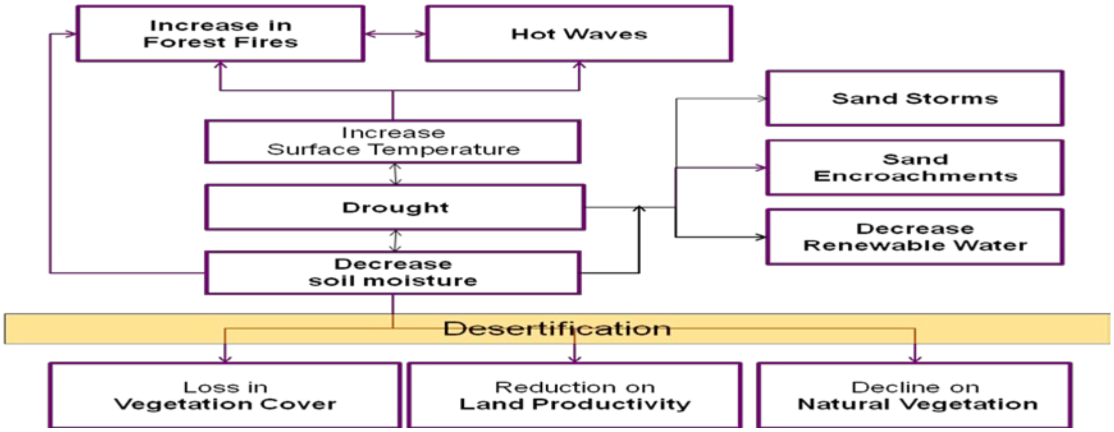


Figure 1. Drought Impacts on increasing Extreme Events and Desertification, after Erian 2010

The most prolonged and widespread droughts occurred in 1973 and 1984, when almost all the African countries were affected, and in 1992 all southern African countries experienced extreme food shortages. Rainfall has declined by up to 30% in the last 40 years and the Sahara is currently advancing at over a mile per year. The potential for conflict over disappearing pasture and evaporating water holes is huge. The southern Nuba tribe have warned they could restart the half-century war between North and South Sudan because Arab nomads (pushed into their territory by drought) are cutting down trees to feed their camels. Agricultural economist *Marshall Burke* of the University of California, Berkeley and his colleagues have analyzed the history of conflict in sub-Saharan Africa between 1980 and 2002 in a new paper in *Proceedings of the National Academy of Sciences*. *"We find that civil wars were much more likely to happen in warmer-than-average years, with one degree Celsius warmer temperatures in a given year associated with a 50 percent higher likelihood of conflict in that year,"* Burke says. The implication: because average temperatures may warm by at least one degree C by 2030, *"climate change could increase the incidences of African civil war by 55 percent by 2030, and this could result in about 390,000 additional battle deaths if future wars are as deadly as recent wars*."

C. Drought in West Asia/North Africa (WANA) region

The West Asia/North Africa (WANA) region is highly vulnerable to natural disasters, and is increasingly bearing greater social and economic losses due to natural disaster events. Over the last decades, the region is facing increasing number of disaster events and exponentially growing economic loss resulting from these disasters. Over the last twenty-five years the region faced 276 disaster events, killing 100,000, affecting 10 million and rendering nearly 1.5 million people homeless. More than 40% of these natural disasters occurred in the last five years, Increasing frequency and intensity of natural disasters pose serious challenge to the sustainability of development investments and the stability of economic growth in the region.

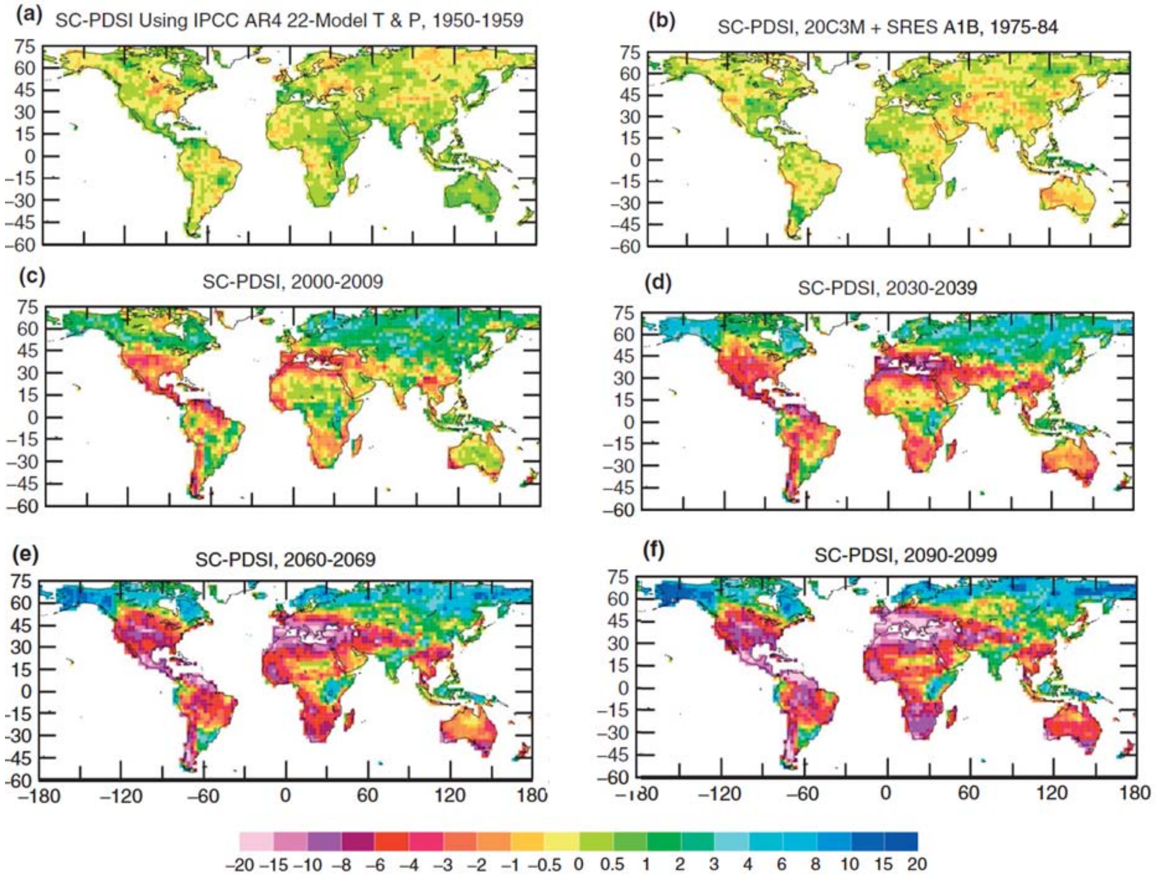
Drought is considered the major disaster occurring in the Arab region, where, the total people affected between the years 1970-2009, by drought is of about 38.09 million, (Abu Swaireh, 2009). The Global Assessment Report included Mauritania, Sudan and Comoros Islands as countries exposed to drought hazard. Some countries of the region are also economically vulnerable to natural hazards, (GAR, 2009), Syria could be considered one of the most economically affected countries by drought.

Drought cause agriculture uncertainty in many parts of Sudan

Most of the Arab counties in both West Asia and North Africa (WANA Region) falls within the Hyper arid, arid and semi arid zones receiving average rainfall of up to 400mm with a winter growing season of 60-120 days; the dry lands support the livelihoods of 60% of the total population living in WANA region, the region is subject to frequent droughts agriculture is a major and sensitive sector of the economy, consumes most of the water resources, rainfed crops strongly affected by precipitation fluctuations; rainfed areas that receive an annual amount of rainfall range between 120/150 – 400 mm are considered vulnerable areas to drought, (Erian et al, 2006). In Sudan, areas were crops depend on monsoon season for replenish their water requirements, the rainfed agriculture uncertainty increased within the annual amount range of rainfall that vary between 200 - 550 mm, (ACSAD, 2008).

The patterns shown in figure (2) are consistent with published regional analyses of projected aridity changes in the 21st century, often by a smaller number of models than used here. These include decreases in precipitation-minus-evaporation over southwestern North America, Seager (2007) and Mexico, Seager (2009), stream flow decreases over most of (except northern) Europe, Feyen and Dankers, (2008), increases in drought frequencies over most of Australia, Mpelasoka et al (2008), It is also broadly consistent with the trends in model-simulated soil moisture, Wang et al (2005) and Sheffield et al (2008), and the PDSI pm trends of Burke et al.(2006) and (Burke and Brown.2008). The quantitative interpretation of the PDSI values requires caution because many of the PDSI values, which are calibrated to the 1950–1979 model climate, are well out of the range for the current climate, based on which the PDSI was designed. Nevertheless, figure

(2), together with all the other studies cited above, suggests that drought may become so widespread and so severe in the coming decades that current drought indices may no longer work properly in quantifying future drought (Dai 2010).



The mean annual self-calibrating Palmer Drought Severity Index Penman–Monteith method (sc-PDSI pm), Wells et al. (2004), for years (a) 1950–1959, (b) 1975–1984, (c) 2000–2009, (d) 2030–2039, (e) 2060–2069, and (f) 2090–2099 calculated using the 22-model ensemble-mean surface air temperature, precipitation, humidity, net radiation, and wind speed used in the IPCC AR4 from the 20th century and SRES A1B 21st century simulations.128 Red to pink areas are extremely dry (severe drought) conditions while blue colors indicate wet areas relative to the 1950–1979 mean.

D: Drought in Syria (2000 – 2010)

Droughts are recurring climatic events, which often hit Syria, bringing significant water shortages, economic losses and adverse social consequences. In the last 10 years, increasing population has added to the growing demand for water and other natural resources in Syria. The latest drought in South Asia (2007–2009) affected more than 1 million people, with severe impacts felt in Al-Hasakah, Ar-Raqqah, Aleppo or Halab, and Dier ez-Zor Governerates, socioeconomic instability, Health problems, food insecurity and migration have further exacerbated the effects of drought.

The magnitude of the annual vegetation cycle in Syria as shown in figure (2,a and b), where the yellow color represent the agriculture areas, these areas represent 22.34 % of the total Syria Lands According to Nashawatii, (2010) and according to ESA (2009) regional land cover map that has been calculated for the years 2004 – 2006 , the rainfed agriculture areas represent 71% of the total agriculture lands in Syria.

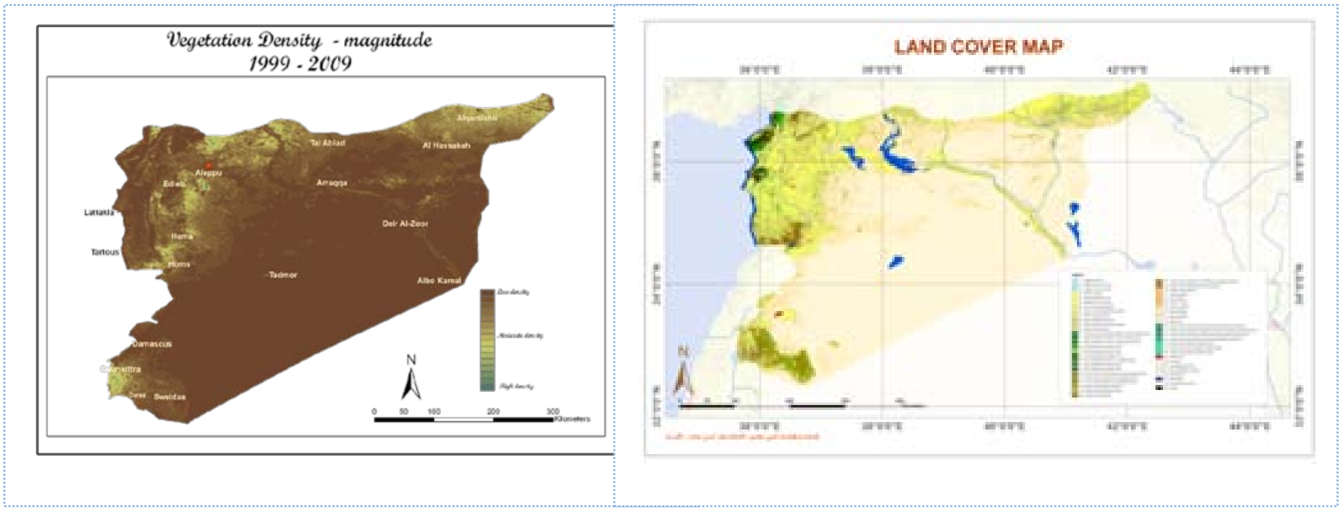


Figure 2. a) Left Magnitude map, b) Land Cover Map

The rainfall represents 68.5% of the available water sources in Syria, due to drought the deficit in available water has been estimated of about 651 million M^3 during the years 1995-2005, and still increasing, that has its impact on the rainfed agriculture areas The vegetation cover in most of those areas suffered from drought, rainfall variability within the agriculture season and total amount, (Nashawatii, 2010) . During the 2009/10 growing season, rainfall conditions have been extremely mixed with the most favorable accumulations occurring in western and northwestern regions. Southern, southeastern and northeastern regions all suffered continuing drought conditions and well-below normal rainfall. The provinces primarily affected by poor rainfall included the top four wheat producers which account for 75 percent of total wheat production in Syria (Al-Hasakah, Ar-Raqqah, Aleppo or Halab, and Dier ez-Zor). Rainfed wheat area in these provinces normally amounts to more than 800,000 hectares, and is extremely reliant on timely rainfall during the growing season. Favorable rainfall in April and May are typically critical to successful growing seasons, and this year non-irrigated crops were already failing in late March. April rainfall was extremely low throughout northern and northeastern wheat regions this year, causing even greater moisture stress and decimating crop yield potential, (USDA, 2010).

D.1. Drought Monitoring in Syria:

Two important trends in drought management could be considered: (1) improved drought monitoring tools and early warning systems EWSs and (2) an increased emphasis on drought preparedness and mitigation. Effective drought EWSs are an integral part of efforts worldwide to improve drought preparedness, activities of regional centers, (Wilhite 2005).

The need for proper quantification of drought impacts and monitoring and reporting of drought development is of critical importance**.** The ability of many countries to deal with droughts is constrained by the absence of reliable data, weak information networks as well as the lack of technical and institutional capacities. Country like Syria is just beginning to establish relevant drought monitoring and management procedures and institutions. But existing drought monitoring and declaration procedures lag behind the development of drought events.

Traditional methods of drought assessment and monitoring rely on rainfall data, which are limited, often inaccurate and, most importantly, difficult to obtain in near-real time. In contrast, the satellite-sensor data are consistently available and can be used to detect the onset of drought, its duration and magnitude (Thiruvengadachari and Gopalkrishna 1993). Even crop yields can be predicted 5 to 13 weeks prior to harvests using remote-sensing techniques (Ungani and Kogan 1998). Vegetative conditions over the world are reported occasionally by NOAA National Environmental Satellite Data and Information System (NESDIS) using the Advanced Very High Resolution Radiometer (AVHRR) data (Kogan 2000).

Drought indicators can be derived for any world region using these data, but the characteristic spatial resolution of 1km (at which well-calibrated long-term historical data are freely available), is likely to be moderate for effective drought monitoring at small scales (a district or a village). A successor to AVHRR is the Moderate-Resolution Imaging Spectrometer (MODIS), an advanced narrowband-width sensor, from which composited reflectance data are made available at no cost every 8 days by NASA and USGS, through the Earth Resources Observation Systems (EROS) data center (Justice and Townshend 2002). Raw images are available on a daily basis, but their use involves considerable extra processing. Time series of MODIS imagery provide nearreal-time, continuous and relatively high-resolution data, on which the assessment of drought development and severity in a country or a region with scarce and inaccurate on-the-ground meteorological observations (like Syria and most Arab countries) could be based.

Several drought indicators have been used, after, Thenkabail et al (2004) and European Commission (2006), such as:
The Normalized Difference Vegetation Index NDVI = (λNIR – λred) / (λNIR + λred)

- The Normalized Difference Water Index NDWI = (ρ NIR — ρ SWIR)/(ρ NIR + ρ SWIR)
- Standardize Precipitation Index SPI
- Vegetation Condition Index VCI = (NDVI – NDVI min)/(NDVI max- NDVI min)*100
- Temperature Condition Index TCI= (BT max – BT min)/(BT max- BT min)*100
  Where, BT is the brightness temperature (MODIS LST)
- Vegetation Healthy Index VHI= VCI * 0.5 + TCI * 0.5
- Soil Moisture SM

The Standardized Precipitation Index (SPI) can be determined relatively easily as it is based on precipitation totals alone but this is also its main weakness; the index does not take into account differences in evaporative demand or soil moisture storage (McKee, et al 1993 and Edwards et al 1997). The SPI for the middle east has been studied by Göbel and De Pauw (2010), "the results as shown in figures (3 and 4) illustrate that the following:

- Over the last century the SPI has dropped by around 0.5 to 1 points.

- With the exception of a part of Iraq, the entire region has negative trends of annual SPI and annual precipitation. This can be seen from the coefficients of correlation between time and SPI or between time and precipitation.
- In all but the most humid areas along the coast of the Mediterranean Sea, this negative trend is highly significant as shown by the probability levels of the t-tests.
- The low values of the coefficients of determination are due to the high inter-annual variability of precipitation overlying the small, but – due to the long observation period – significant trends.
- the relative changes of precipitation, might be misled to assume that Egypt were the country most affected by the negative trend of precipitation, but the absolute decrease there has been very small due to the very low levels of precipitation in the desert areas.
- The countries most affected by the decrease have been Jordan, Syria, and, to a lesser degree, Lebanon and Palestine. This negative trend of precipitation during the past century is of a similar magnitude as that predicted by most of the Global Circulation Models for the Mediterranean Region in the coming decades.
- This suggests that forces of climate change have been active in the region since at least a century and that human activity is only exacerbating an already existing trend.

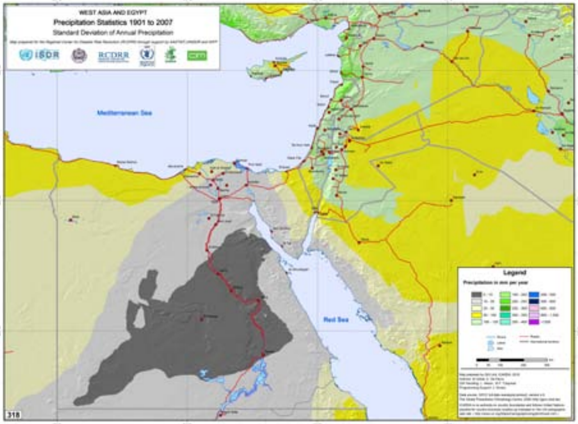


Figure.3 Standard Deviation of Annual Precipitation

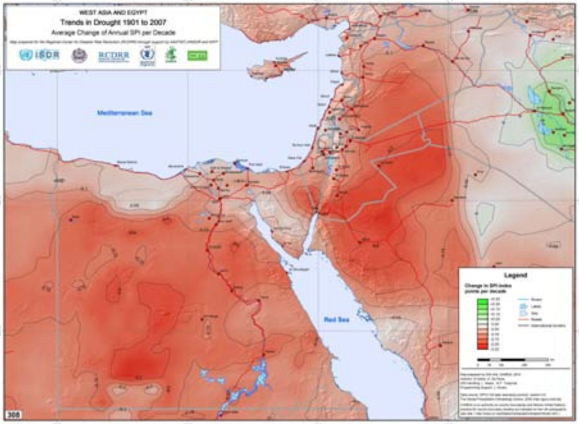


Figure. 4 Change of Annual SPI per Decade

For better understanding the drought within the Arab region, its severity, distribution and impacts, the Arab Center for the Studies of Arid Zones and Dry Lands (ACSAD) took the initiatives in cooperation with GTZ and the National Center of Remote Sensing in Lebanon (NCRS) for establishing their Regional/National drought monitoring system based on the most recent applications of remote sensing. The images source from MODIS NDVI 1 km , 250m; MODIS LST (8 days) and SPOT vegetation 1 km. The major outcomes of ACSAD drought analyses in Syria could be presented as follows:

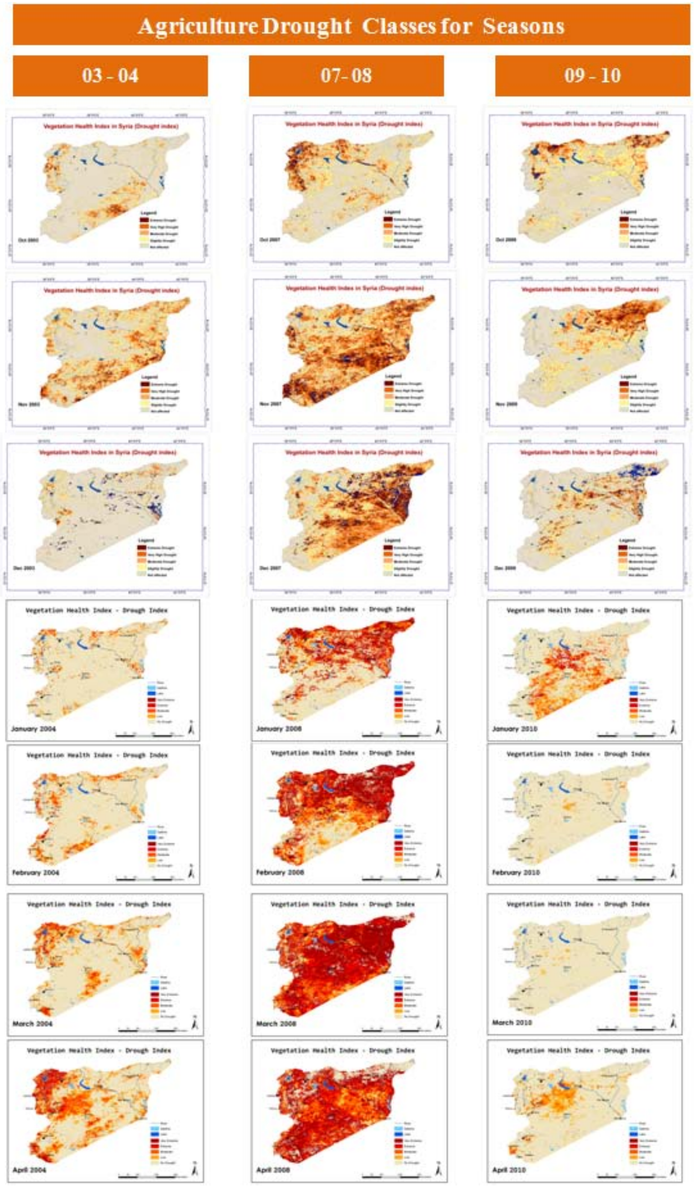
1. The Vegetation Healthy Index (VHI) as drought index has been calculated for all the winter season's months for the years from 2000 till 2010. The analysis illustrated the drought variability spatial distribution in time and space. The main drought classes are as follows: Extremely drought (< 10%), V. High Drought (10-20 %), Moderately Drought (20-30%),

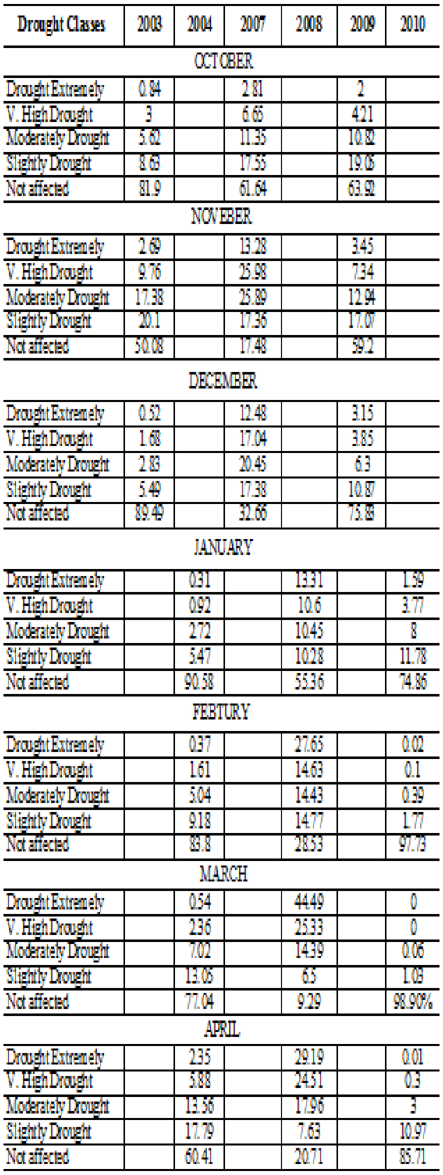
Slightly Drought (30-40%), and Not affected (> 40%). The distribution for three different seasons 03/04, 07/08 and 09/10 have been shown in figure (5) for illustration. The agriculture season 03/04 was better than season 09/10 and season 07/08 was the worst among all studied seasons. The season 07/08 is considered to be one of the worst droughts in devastated crops in Syria, The drought frequency increased during the last 10 years, and the rainfall as total and variability have shown negative impact on yield for most of the years. The rainfall was not enough to satisfy the water requirements of the cereal crops, beside half of the animal population in the steppe areas has been died or get read of due to the continues drought cycles. As a consequence of the agriculture drought the population immigration increased from the northwestern part of Syria and from Syrian steppe to Urban causing high pressure on the services and stability of those communities, (Erian, 2010 and Nashawatii, 2010).

The Vegetation Healthy Index (VHI)VHI has been classified for each season to illustrate the seasonal drought spatial variability to four classes. The drought grouping classification system is as follow:

- Group (1), very slight impacts of drought, where the VHI is more than 40% through 6 to 7 months during the winter season,
- Group (2), slight impacts of drought, where the VHI is more than 40% through 5 including October and November in the beginning of the season and March and April months during the winter season. The VHI must not be less than 40% for one month during the season,
- Group (3), Moderate impacts of drought, where the VHI is more than 40% through 5 including October and November in the beginning of the season and March and April months during the winter season. The VHI must not be less than 40% for one or two months during the season, and
- Group (4), Sever impacts of drought, didn’t fulfill any of the above mentioned conditions and the VHI is less than 40% for more than 4 months including October and November in the beginning of the season and March and April months during the winter season.

The drought maps that resulted from the grouping classification system are shown in figure (6) and (table 1). The drought areas distribution as percentage are shown in (figure 7). These maps illustrate that during 7 to 8 seasons, drought had a negative impact on the crop lands and the Syrian steppe. The significant improvement in crop vegetation in Northwestern provinces during the seasons 03/04 and 09/10 following unusually as previously beneficial winter and spring rainfall. At this time last season (09/10) severe drought gripped the vast majority of Syria’s grain producing provinces, causing an estimated 48 percent decline in national wheat production. crop vegetative development in the drought areas is well-below normal, (USDA, 2010). Though the declines in vegetative vigor are not as severe as last year, they indicate that only a modest recovery in wheat production is to be expected. Harvest activities normally begin in June, with crops reaching their maximum biomass in late April. This year, however, the majority of rainfed wheat crops began to wither in late March, some 7-8 weeks early. This is indicative of severe drought stress, resulting in substantial crop yield losses if not total crop failure. Given the mixed crop conditions across Syria. Accordingly, USDA (2010) estimates 2009/10 wheat production at 3.0 million tons, up 0.9 million or 44 percent from last year but down approximately 30 percent from the 5-year average.





Drought Classes	2003	2004	2007	2008	2009	2010
OCTOBER						
Drought Extremely	0.84		2.81		2	
V. High Drought	3		6.65		4.21	
Moderately Drought	5.62		11.35		10.82	
Slightly Drought	8.63		17.55		19.06	
Not affected	81.9		61.64		63.92	
NOVEBER						
Drought Extremely	2.69		13.28		3.45	
V. High Drought	9.76		25.98		7.34	
Moderately Drought	17.38		25.89		12.94	
Slightly Drought	20.1		17.36		17.07	
Not affected	50.08		17.48		59.2	
DECEMBER						
Drought Extremely	0.52		12.48		3.15	
V. High Drought	1.68		17.04		3.85	
Moderately Drought	2.83		20.45		6.3	
Slightly Drought	5.49		17.38		10.87	
Not affected	89.49		32.66		75.83	
JANUARY						
Drought Extremely		0.31		13.31		1.59
V. High Drought		0.92		10.6		3.77
Moderately Drought		2.72		10.45		8
Slightly Drought		5.47		10.28		11.78
Not affected		90.58		55.36		74.86
FEBTURY						
Drought Extremely		0.37		27.65		0.02
V. High Drought		1.61		14.63		0.1
Moderately Drought		5.04		14.43		0.39
Slightly Drought		9.18		14.77		1.77
Not affected		83.8		28.53		97.73
MARCH						
Drought Extremely		0.54		44.49		0
V. High Drought		2.36		25.33		0
Moderately Drought		7.02		14.39		0.06
Slightly Drought		13.06		6.5		1.03
Not affected		77.04		9.29		98.90%
APRIL						
Drought Extremely		2.35		29.19		0.01
V. High Drought		5.88		24.51		0.3
Moderately Drought		13.56		17.96		3
Slightly Drought		17.79		7.63		10.97
Not affected		60.41		20.71		85.71

Figure 5 . Monthly Vegetation Healthy Index (VHI), for the Winter Seasons 03/04, 07/08 and 09/10

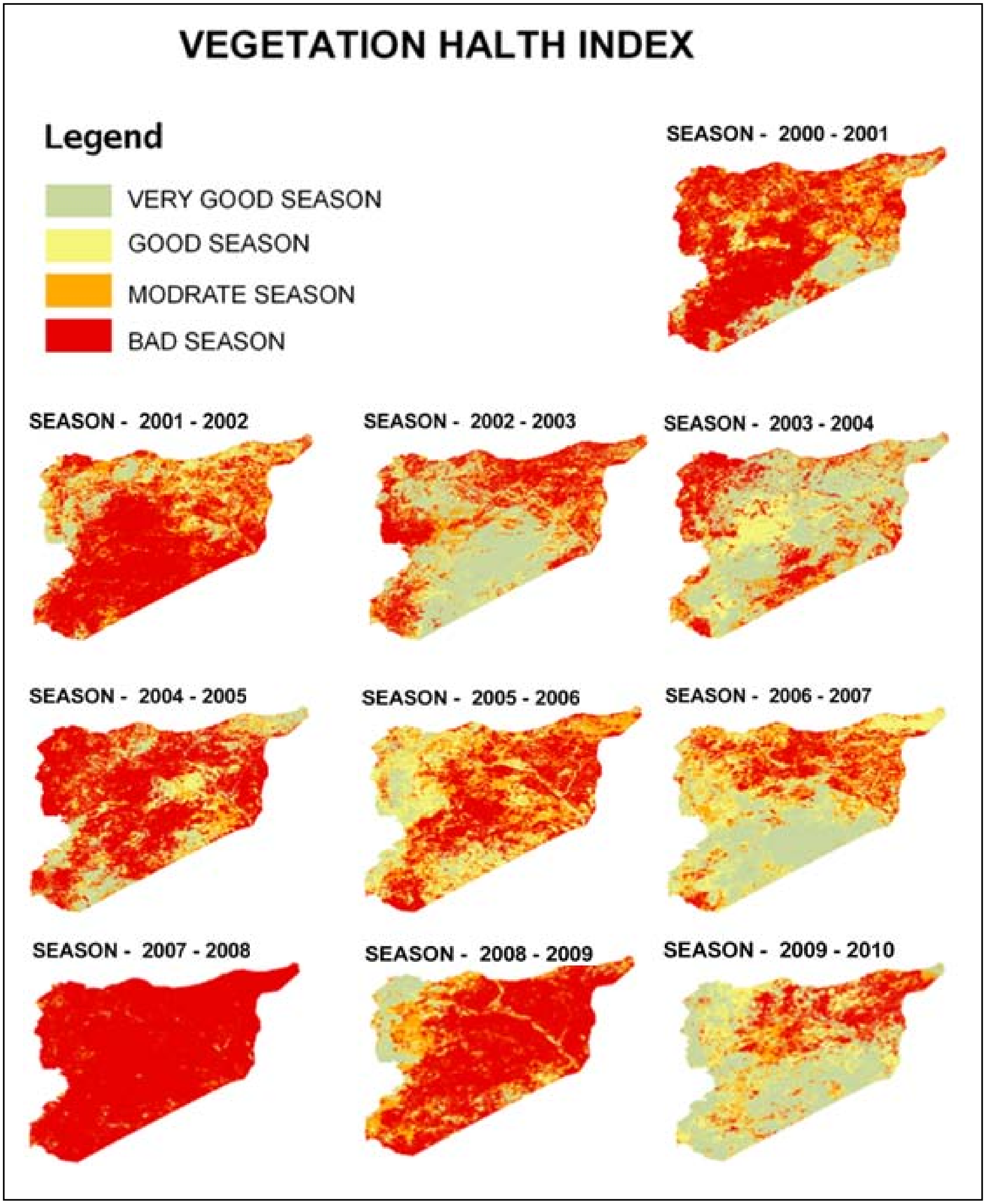


Figure 6. Annual Vegetation Healthy Index (VHI), for the Winter Seasons 00/01 - 09/10

Table 1. Annual Vegetation Healthy Index (VHI), for the Winter Seasons 00/01 - 09/10

YEARS	2000/2001		2001/2002		2002/2003		2003/2004		2004/2005		2005/2006		2006/2007		2007/2008		2008/2009		2009/2010	
Drought Effect	Area		Area		Area		Area		Area		Area		Area		Area		Area		Area	
	Million Ha	%	Million Ha	%	Million Ha	%	Million Ha	%	Million Ha	%	Million Ha	%	Million Ha	%	Million Ha	%	Million Ha	%	Million Ha	%
V. slight	2	10.9	1.4	7.3	6.2	33.7	7.3	39.3	2	10.7	1.3	7.1	5.7	30.7	0.1	0.3	1.5	7.9	7	37.7
Slight	1.9	10.4	2.4	13.1	3.2	17.2	4.8	25.9	2.5	13.5	5.2	28.3	5.2	28	0.1	0.8	1.5	8.3	5.5	29.6
Moderate	3.7	20	3.4	18.5	3.1	16.5	2.2	12.1	3	16.4	4.8	25.7	3.9	21	0.3	1.8	3.4	18.2	2.3	12.6
Severe	10.9	58.7	11.3	61	6	32.6	4.2	22.8	11	59.4	7.2	39	3.7	20.2	18	97.1	12.1	65.6	3.7	20.1

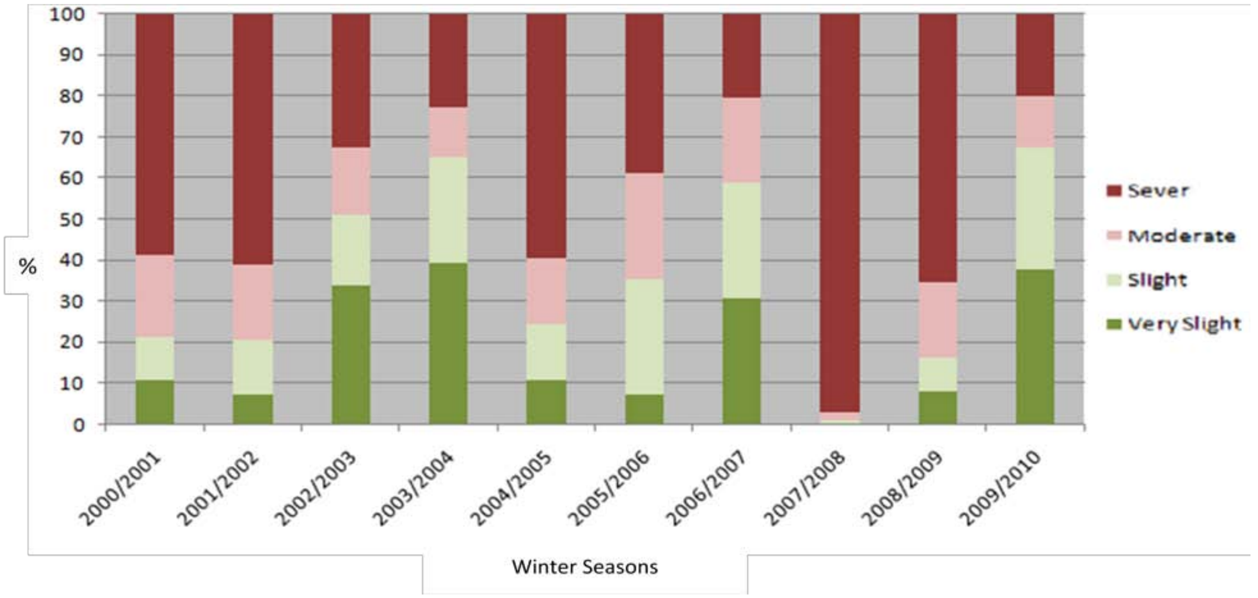


Figure 7. Annual Vegetation Healthy Index (VHI) Percentages, for the Winter Seasons 00 /01 - 09/10

2. The identification of the most vulnerable areas for drought in Syria three main steps were followed, a) studying drought frequency for each pixel, b) Consecutive Drought Period in ten Years, and c) crossing the drought frequency map with the drought length map and produce vulnerability map.

2.1.Studying Drought Frequency.

The study of the drought frequency in Syria as shown in figure (8), illustrate the following results:

- An area of about 1.54 million ha (that represent 8.33% of the total area of Syria) was a subject to drought for less than 2 years out of 10 years ,
- An area of about 6.67 million ha (that represent 36.05% of the total area of Syria) was a subject to drought for 2 - 4 years out of 10 years ,
- An area of about 7.56 million ha (that represent 40.88% of the total area of Syria) was a subject to drought for 4 - 6 years out of 10 years
- An area of about 2.5 million ha (that represent 13.49% of the total area of Syria) was a subject to drought for 6 - 8 years out of 10 years, and
- An area of about 0.23 million ha (that represent 1.25% of the total area of Syria) was a subject to drought for more than8 years out of 10 years

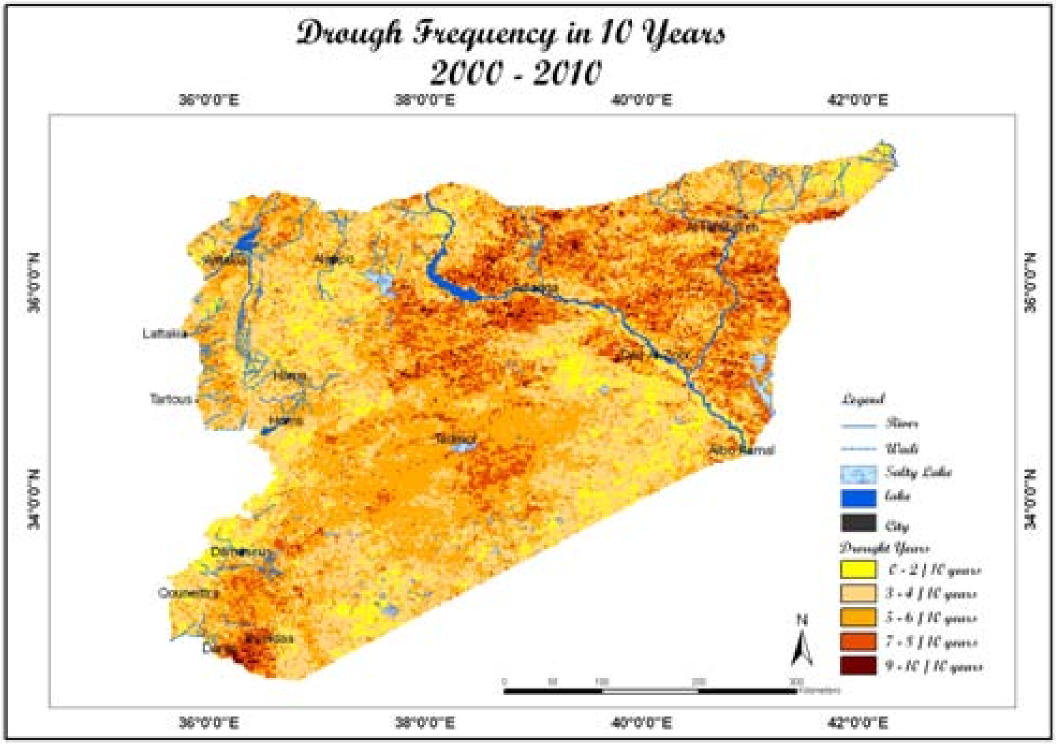


Figure 8. Drought Frequency in Ten Years

2.2.Studying Consecutive Drought Period in ten Years.

The study of the consecutive drought period in ten years is shown in figure (9), the results illustrate the following:

- An area of about 11.29 million ha (that represent 61.03 % of the total area of Syria) is a subject to consecutive drought for less than 3 years out of 10 years ,
- An area of about 4.03 million ha (that represent 21.8 % of the total area of Syria) was a subject to drought for 3 years out of 10 years ,
- An area of about 0.98 million ha (that represent 5.3 % of the total area of Syria) was a subject to drought for 4 years out of 10 years
- An area of about 1.35 million ha (that represent 7.32 % of the total area of Syria) was a subject to drought for 5 years out of 10 years
- An area of about 0.64 million ha (that represent 3.49 % of the total area of Syria) was a subject to drought for 6 years out of 10 years
- An area of about 0.04 million ha (that represent 1.35 % of the total area of Syria) was a subject to drought for 7 years out of 10 years, and
- An area of about 0.15 million ha (that represent 0.83 % of the total area of Syria) was a subject to drought for more than8 years out of 10 years

The spatial distribution of the drought frequency shown that the most affected farming regions are southwestern and northeastern of the country, especially the northeastern governorate of Hassakeh.

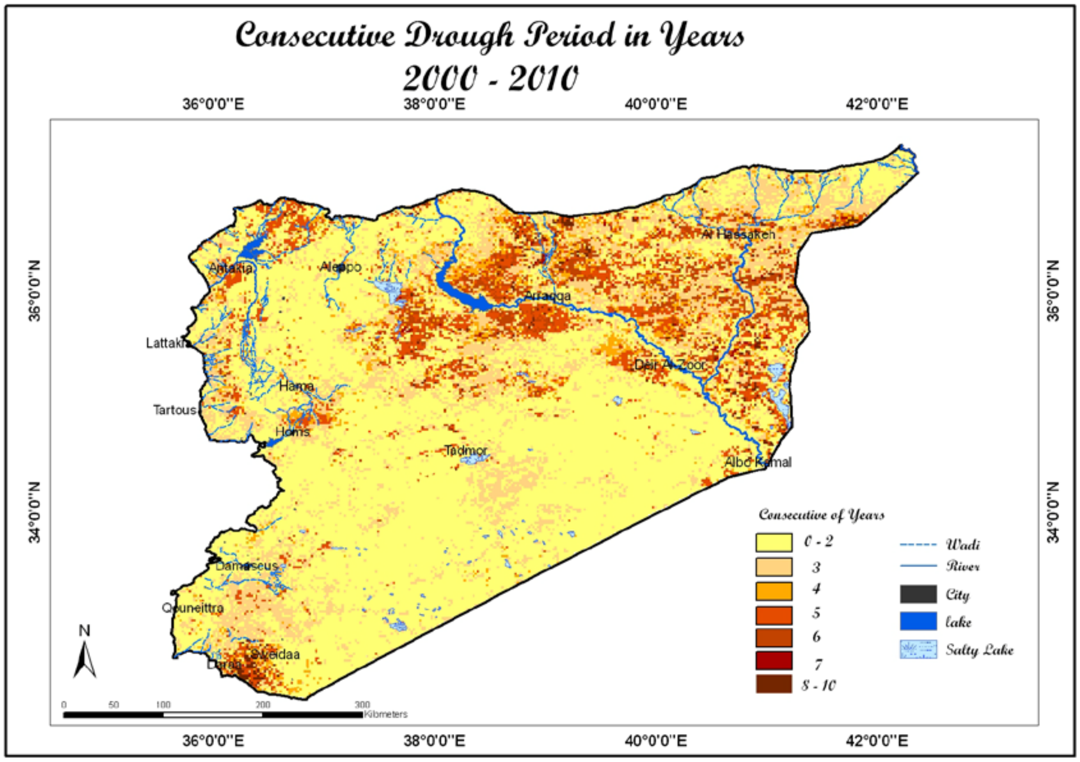


Figure 9. Consecutive Drought Period in Ten Years

2.3. Vulnerable for Drought

Areas that are vulnerable for drought could be obtained as a result of the crossing between the drought frequency map with the consecutive drought period in ten Years.

The vulnerability to drought in Syria as shown in figure (10), illustrate the following results:

- An area of about 12.20 million ha (that represent 65.92% of the total area of Syria) is not vulnerable to drought ,
- An area of about 3.6 million ha (that represent 19.4% of the total area of Syria) is low vulnerable to drought ,
- An area of about 1.92 million ha (that represent 10.4 % of the total area of Syria) is moderately vulnerable to drought, and
- An area of about 0.8 million ha (that represent 4.25 % of the total area of Syria) is highly vulnerable to drought.

Most of the vulnerable areas are considered important areas for crop production in Syria. The spatial distribution of the vulnerability to drought shown that farming regions at south-western and north-eastern parts of the country are mostly affected, especially in Hassakeh governorate.

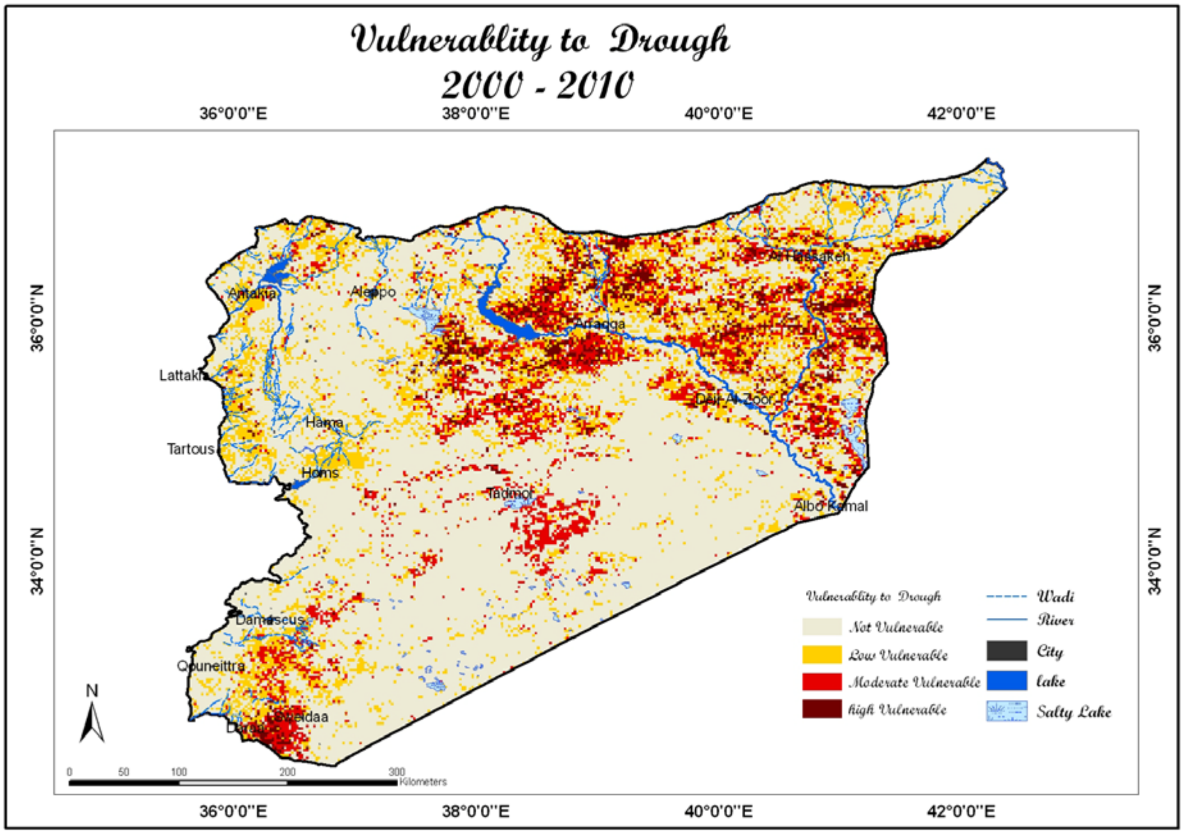


Figure 10. Vulnerable for Drought

D.2 Drought hits Syria badly

Rainfall in eastern Syria fell to 30 percent of the annual average in 2008 -- the worst drought for 40 years -- and al-Khabour, a main tributary of the River Euphrates, dried up. With Syria's population expected to triple by 2025, the severity of the drought presents yet another challenge for sustainable development and vulnerabilities in Syria. Drought hits Syria badly and the direct and indirect impacts could be illustrated as follows:

– Drought Challenges facing food security and agriculture

The country's agriculture sector, which until recently employed 40 percent of Syria's workforce and accounted for 25 percent of gross domestic product, has been hit badly, but farmers themselves are worst affected Poor and erratic rainfall since October 2007 has caused the worst drought to strike Syria in four decades. Approximately one million people are severely affected and food insecure, particularly in rainfed areas of the northeast – home to Syria's most vulnerable, agriculture-dependant families.

Since the 2007/2008 agriculture season, nearly 75 percent of these households suffered total crop failure. Depleted vegetation in pastures and the exhaustion of feed reserves have forced many herders to sell their livestock at between 60 and 70 percent below cost. Syria's drought break point was the season 07/08 which extended for two more seasons, affecting farming regions in the Middle north, Southwestern and Northeastern of the country, especially the northeastern governorate of Hassakeh.

Wheat and barley yields have dropped by 47 and 67 percent, respectively, Wheat production in non-irrigated areas dropped by 82 percent as compared to the previous year, drastically reducing the ability of families to meet daily food requirements. The country's emergency wheat stocks have been exhausted. Lack of income, furthered by the necessity to sell off livelihood assets to afford basic needs, is increasing the risk of vulnerable households to fall into permanent destitution.

Syria's estimated livestock stands at 14-16 million. But it is only that low because many died during the drought. Prior to this the national herd stood at around 21 million.

Without assistance, families will continue to resort to harmful coping strategies, such as reducing their food intake, selling essential assets and migration. Inaction will further deteriorate the livelihoods and self-reliance of vulnerable households and prolong the need for costly relief, such as food aid. The World Food Programme (WFP) had begun distributing food rations to 190,000 people in the eastern provinces of Hasakah, Deir al-Zor and Raqqa, but another 110,000 people also required emergency food aid. In addition, the WFP will start distributing supplementary feeding rations to children under five, and to pregnant and nursing mothers in Al-Shadadi district of Al-Hasakeh, one of the worst-affected areas with the highest rate of migration and school closures.

– Drought driving farmers to the cities

The drought is causing a high drop-out rate, families left in the area who cannot afford, or do not want, to move are suffering. Some figures estimated the people lifted their villages to be more than one million people. Thousands of Syrian farming families have been forced to move to cities in search of alternative work after two years of drought and failed crops followed a number of unproductive years.

- **Drought increases Land susceptible to desertification**

According to ACSAD regional early warning for desertification 68 percent of Syria is susceptible to desertification, Syria's drought over the past three years and its increasing desertification is due to a combination of man-made and natural factors the sum of the climatic, biological and human factors which lead to the degradation of the physical, and endanger biodiversity and the survival of human communities. Flora and fauna species that lose their natural habitat can become extinct.

E. Drought Managements

The traditional approach to drought management has been reactive, relying largely on crisis management. This approach has been ineffective because response is untimely, poorly coordinated, and poorly targeted to drought stricken groups or areas, (Wilhite 2005).

He added that two important trends in drought management could be considered: (1) improved drought monitoring tools and early warning systems EWSs and (2) an increased emphasis on drought preparedness and mitigation.

Effective drought EWSs are an integral part of efforts worldwide to improve drought preparedness, activities of regional centers in eastern and southern Africa and efforts in WANA are increasing, but not enough. An Expert group meeting on EWSs sponsored by WMO and others, Wilhite et al, (2000) summarized the outcome the shortcoming on the following areas: lack of data networks on all major climate and water supply parameters; inadequate data sharing and high cost of data limits the application of data in drought preparedness, mitigation and response; EWSs products are not user friendly; inadequate indices for detecting the early onset and end of drought; no historical drought data base exists.

In 1992, Australia adapted a National Drought Policy that has three objectives. These objectives were: (1) to encourage primary products and other sections of rural Australia to adapt self-reliant approaches to managing for climatic variability; (2) to maintain and protect Australia's agricultural and environmental resource base during periods of extreme climate stress; and (3) to ensure early recovery of agricultural and rural industries, consistent with long-term sustainable goals, (O'Meagher et al 2000).

In India, Syria, and in the Arab Center for The Studies of Arid Zones and Dry Lands ACSAD, major research efforts on improving the productivity of rainfed areas with focus on reducing the adverse effects of drought have been underway for at least 2-3 decades including improving and introducing appropriate crops, improved varieties and new varieties of cereal that are tolerant to drought and heat; improving conservation of soil and water increasing areas of conservation agriculture, improving water efficiency and improvement in terms of living conditions of the rural areas who suffer most due to scarcity and drought in particular. In the United States, there has been significant progress as well in addressing the impacts of drought through the development of preparedness plans, the basic goal of the drought plans created in most of the states should be to improve the effectiveness of preparedness and response efforts by enhancing monitoring and early warning, risk and impact assessment, and mitigation and response. Many plans are more pro-active, adapting a more risk management approach to drought management.

in arid, semi-arid and marginal areas with a probability of drought incidence It is recommended to re-planning their land use and developing methods of predicting many weeks/months in advance, the occurrence of rainfall deserves high priority. The agricultural planning and practices need to be worked out with consideration of overall water requirement within the individual agro-climatic zones. Crops that need shorter duration to mature and require less water need to be encouraged in the drought prone areas. Food reserves to meet the emergency of maximum up to two consecutive droughts must be planned.

F. REFERENCES

Abu Swaireh L., (2009). “Disaster Risk Reduction Global and Regional Context”, Regional Workshop on Climate Change and Disaster Risk Reduction in the Arab Region "Challenges and Future Actions", organized by ISDR, WB, GFDRR, LAS, AASTM, Cairo, Egypt, 21 - 23 November, 21-23Nuvember

ACSAD (2008). “Potential Land use Map of Sudan – Phase 1: Eastern part”. Published in the Arab Center for the Studies of Arid Zones and Dry Lands, Final Report (in Arabic)

American Meteorological Society (AMS) (1997). “Meteorological drought—policy statement.” Bull Amer Meteor Soc1997, 78:847–849.

Burke EJ, Brown SJ, Christidis N. (2006). “Modeling the recent evolution of global drought and projections for the twenty-first century with the Hadley centre climate model”. *J Hydrometeorol* 7:1113–1125.

Burke EJ, Brown SJ.(2008). “Evaluating uncertainties in the projection of future drought”. *J Hydrometeorol*, 9:292–299.

Cook BI, Miller RL, Seager R. Amplification of the North American (2009). ‘‘Dust Bowl’’ drought through human-induced land degradation. Proc Natl Acad Sci, 106:4997–5001.

Dai Aiguo 2010. “Drought under Global Warming “ . National Center for Atmospheric Research, Boulder, Colorado , USA , John Wiley & Sons, Ltd. DOI: 10.1002/wcc.81

Edwards, Daniel C., and Thomas B. McKee, (1997). “Characteristics of 20th century drought in the United States at multiple time scales”. Climo Report 97-2, Dept. of Atmos. Sci., CSU, Fort Collins, CO, May, 155 pp.

Erian, W.F., F.S. Fares, T. Udelhoven and B. Katlan, (2006). “Coupling Long-term NDVI for Monitoring Drought in Syrian Rangelands”, The Arab Journal for Arid Environments, volume (1), pp 77-87, Published by ACSAD.

Erian, W. F (2010). “Desertification and Drought in Arab Countries”. Expert Meeting of the ASPA Countries for developing scientific and technological cooperation on climate change, organized by LAS, ACSAD, MoE in Syria, Damascus, 4-6 May.

ESA (2009) “Regional Land Cover Map 2004 - 2006”. www.esa.int/due/ionia/globcover.

European Communities, (2006), “VGT4Africa user manual” First edition

GAR (2009). “Risk and Poverty in a Changing Climate” Global Assessment Report on Disaster Risk Reduction.

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

Justice, C.; Townshend, J. 2002. Special issue on the moderate resolution imaging spectro-radiometer (MODIS): A new generation of land surface monitoring. Remote Sensing of Environment 83: 1–2.

Kogan, F. N. 2000. Contribution of remote sensing to drought early warning. In Early warning systems for drought preparedness and drought management, ed. D.A. Wilhite and D.A. Wood. 75–87. Geneva: World Meteorological Organization.

Hagman G. (1984). Prevention better than cure: report on human and natural disasters in the Third World. Swedish Red Cross, Stockholm, Sweden.

McKee, Thomas B., Nolan J. Doesken, and J. Kleist, (1993). “The relationship of drought frequency and duration of time scales”. Eighth Conference on Applied Climatology, 17-22 January 1993, Anaheim, California.

Mpelasoka F, Hennessy K, Jones R, Bates B. (2008). Comparison of suitable drought indices for climate change impacts assessment over Australia towards resource management. *Int J Climatol* 28:1283–1292.

Nashawatii, H (2010). “Climate Change: impacts and adaptation in Syria”, in Arabic. Expert Meeting of the ASPA Countries for developing scientific and technological cooperation on climate change, organized by LAS, ACSAD, MoE in Syria, Damascus, 4-6 May.

O’Meagher B, Stafford Smith M, White DH (2000). “Approaches to integrate drought risk management. In Wilhite DA (ed) Drought: a global assessment, vol 3. Routledge Publishers, London, UK, pp 115-128.

Ragab R., (2005). “Water Management Strategies to Combat Drought in the Semi-Arid Regions”. Expert Meeting on Drought in the Arab Region, Organized by ACSAD, UNEP/ROWA and UNESCO, 28-30 March.

Seager R, Ting MF, Held I, Kushnir Y, Lu J, et al. (2007). “Model projections of an imminent transition to a more arid climate in southwestern North America”. *Science* , 316:1181–1184.

Seager R, Ting M, Davis M, Cane M, Naik N,Nakamura J, Li C, Cook ER, Stahle DW.(2009). “ Mexican drought: an observational modeling and tree ring study of variability and climate change. *Atmosfera*, 22:1–31.

Sheffield J, Wood EF. (2008). “Projected changes in drought occurrence under future global warming from multi-model, multi-scenario, IPCC AR4 simulations”. *Clim Dyn*, 31:79 –105.

Sivakumar, M.V.K.(2005). “Natural Disasters and Extreme Events in Agriculture, Chapter 1of the Book titled: Impacts of Natural Disasters in Agriculture, Rangeland and Forestry: an Overview”. Published by Springer Berlin Heidelberg New York.

Squires VR (2001) “Dust and Sandstorms: an early warning of impending disaster. In Yang Youlin, Squires V, Lu Qi (ed.) Global alarm: dust and sandstorms from the World’s Drylands, Asia RCU of the UNCCD, Bangkok.

Sun Y, Solomon S, Dai A, Portmann R. *2006. “* How often does it rain?”. *J Clim, 19:916–934.*

Thenkabail, P. S., Gamage, M. S. D. N. and Smakhtin, V. U.(2004). “The Use of Remote Sensing Data for Drought Assessment and Monitoring in Southwest Asia”, Research Report 85, International Water Management Institute IWMI.

Thiruvengadachari, S.; Gopalkrishna, H. R. 1993. An integrated PC environment for assessment of drought. International Journal of Remote Sensing 14:3201–3208.

Ungani, L.S.; Kogan, F. N. 1998. Drought monitoring and corn yield estimation in southern Africa from AVHRR data.*Remote Sensing of Environment* 63:219–232.

USDA (2010). “SYRIA: Wheat Production Outlook Improved in 2009/10”., USDA-FAS, Office of Global Analysis Report, usda.gov/wap/circular/2010/10-07/productionfull07-10

Wang GL. (2005). “Agricultural drought in a future climate: results from 15 global climate models participating in the IPCC 4th assessment”. *Clim Dyn* ,25:739–753.

Wells N, Goddard S and Hayes MJ (2004) A self-calibrating Palmer Drought Severity Index. *Journal of Climate* **17**, 2335-2351. Wilhite D.A.(2005). “The Role of Disaster Preparedness in National Planning with Specific Reference to Drought, Chapter 2 of the Book titled: Impacts of Natural Disasters in Agriculture, Rangeland and Forestry: an Overview”. Published by Springer Berlin Heidelberg New York.

Wilhite DA. (2000). Drought as a natural hazard: concepts and definitions. In: Wilhite DA, ed. Droughts: Global Assessment. London: Routledge; 3–18.

Willite DA, Silvakumar MVK and Woods DA (Eds.) (2000) Early Warning Systems for Drought Preparedness and Drought Management. Proceedings of an Export Group Meeting held in Lisbon, Portugal, 5-7 September 2000. Geneva, Switzerland: World Meteorological Organization.

World Disaster Report (2007).“International Federation of Red Cross and Red Crescent Societies, Geneva.