BACKGROUND PAPER

Prepared for the 2015 Global Assessment Report on Disaster Risk Reduction

Effects of Drought and Land Degradation on Vegetation Losses: in Africa, Arab Region, Drought and Conflict in Syria, Drylands in South America and Forests of Amazon and Congo Rivers Basins.

Wadid Erian

Senior Advisor
Climate Change Adaptation and Disaster Risk Reduction
The League of Arab States - LAS
UNDP Regional Arab Climate Resilience Initiative (ACRI)

Bassem Katlan
Naji Assad
Sanaa Fouad Ibrahim
The Arab Centre for the Studies of Arid Zones and Dry Lands ACSAD

2014

Chapter1. Background Drought and Land Degradation Impacts on Crop Losses

1.1. Introduction

As indicated by IPCC (2012), drought will increase in many regions causing serious threat for large number of countries worldwide that already are suffering from fragility ecosystems, and facing severe risks of depletion of soil, vegetation, and water resources on daily basis.

The strong seasonal and inter-annual variability of vegetation in most drylands areas (semi-arid and arid regions) is a subject of particular interest due to the ecological and economic impacts.

The Severe sensitivity of vegetation to climate forcing may result in rapid land use changes and severe vulnerability to land degradation, as result of human action. When drought conditions end, recovery of vegetation may follow but such recovery process may last for longer periods of time. This is coupled with a population increase within this regions rushing at scary rates further increase stresses on natural resources. Land degradation constitutes one of the major problems facing a healthy environment and sustainable management of natural resources.

In Africa and in Arab region, Land degradation is considered extremely serious problem, as most countries are suffering from desertification in various types and degrees. It can be noted that many areas were exposed throughout history to the overuse of the natural resources which led to their deterioration and the acceleration of desertification problems in these roots of land degradation lie in increasing population, introduction of new and inappropriate technology in the affected regions, and in general, bad strategies of land management, and the breakdown between indigenous nomadic peoples and their traditional market and livelihood systems.

Associated with these changes are growing of livestock numbers, intensive cultivation and excessive irrigation, deforestation, overgrazing; trees and shrubs are removed to produce fuel wood, or agricultural land; the land becomes increasingly impacted by wind and water erosion.

The land cover may become more barren or diverse, and nutrient-rich species are replaced by vegetation of poorer quality. The carrying capacity of the land is reduced, people who do not have land tenure security and/or water rights have little or no incentive to invest in sustainable land management. Instead, they tend to focus on meeting their short-term economic needs, to the detriment of the environment. (Nicholson et al 1998 and Abou Kheir and Erian 2009).

The negative impacts of land degradation are both ecological and socio-economic. Land degradation undermines the structure and functions of ecological systems that are critical for the survival of human beings. This impact has already put at risk the livelihoods and economic wellbeing, and the nutritional status of more than 1 billion people in developing countries (World Bank, 1998).

In fact the trigger for the surge of interest in desertification was the drought that ravaged the Sahel in the early 1970s. Reportedly, a million people starved, 40% to 50% of the population of domestic stock perished, and millions of people took refuge in camps and urban areas and became dependent on external food aid (Graetz 1991). In this regard, lands that are prone to degradation processes should be identified in advance to avoid possible damages.

As drought becomes and important phenomena since the 70's of the last century, arose the idea that regions that were undergoing a process of desertification, may have exacerbated or even caused the drought risk or at least enhanced its impact, (Nicholson et al 1998). In fact the complexity of desertification and its relationship to rainfall variability and drought is underscored by the extensive field work and analysis, Akhtar-Schuster (1995), Graetz (1991), and others.

In this study, areas in Africa, and Arab region that are subject to different Severe levels of both land degradation (LD) and agricultural drought hazard (ADH) will be characterized as well as their impacts to land cover. And finally crop losses will be estimated with more economi3 of the impacts of combined Drought and Land Degradation.

As Drought has its consequences on environment, natural resources and socio-economi3, a special case study, "Syria" will deal with drought consequences and show how it could accelerate conflicts.

1.2 Methodology

1.2.1. Developing Agriculture Drought Hazard Map

On this study Agriculture Drought Hazard analysis is depend on satellite images (MODIS (250m*250m), and the following steps were for calculating ADH:

Step 1: Computing Vegetation Healthy Index

MODIS – NDVI and MODIS – LST, images were down loaded from NASA site, https://wist.echo.nasa.gov/wist-bin/api

Several drought indicators have been used, after, Kogen (1995)[1], Thenkabail et al (2004) and European Commission (2006), for calculating the following monthly indices for all agriculture season's months during the years from 2000 till 2011:

a. The Normalized Difference Vegetation Index

   NDVI were also used for identifying the main agriculture seasons in the region and for calculating VCI. Numbers of months with value for NDVI were calculated.

b. vegetation Condition Index

   A GIS model was created for studying VCI, the model main steps includes:

- Preparation of monthly mosaic
- Preparation for monthly minimum and maximum NDVI stocks.
- The NDVI Stack layer were prepared for each month covering the period from 2000– 2011
- Storing results in memory
- Calculating monthly Vegetation Condition Index using the following equation Monthly VCI = (NDVI – NDVI min)/(NDVI max- NDVI min)*100,
- The VCI values were classified to the following classes:

Class Description	%
Extremely Severe Drought	Less than 10
Severe Drought	10 – 20
Moderate Drought	20 – 30
Slight Drought	30 – 40
No Drought	More than 40

- Finally, a VCI classified map for each month has been produced.

[1] Kogen, E.N. 1995. Application of vegetation index and brightness temperature for drought detecting. Advances in Space Research 15:91-100.

c. Temperature Condition Index
A GIS model were created for studying TCI, its main steps includes:

- Preparation of monthly mosaic
- Preparation for monthly minimum and monthly maximum brightness temperature BT (MODIS LST) stocks. The NDVI Stack layer were prepared for each month covering the period from 2000 – 2011.
- Storing results in memory
- Calculating monthly Temperature Condition Index using the following equation Monthly TCI= (BT max – BT)/(BT max- BT min)*100
- The TCI values were classified to the following classes:

Class Description	%
Extremely Sever Drought	Less than 10
Severe Drought	10 – 20
Moderate Drought	20 – 30
Slight Drought	30 – 40
No Drought	More than 40

- Finally, a TCI classified map for each month has been produced.

d. Vegetation Healthy Index
A GIS model were created for studying VHI its main steps includes:

- Calculating monthly Vegetation Healthy Index using the following equation Monthly VHI= (TCI *0.5)+(VCI*0.5)
- The VHI values were classified to the following classes:

Class Description	%
Extremely Sever Drought	Less than 10
Severe Drought	10 – 20
Moderate Drought	20 – 30
Slight Drought	30 – 40
No Drought	More than 40

- Finally, a VCI classified map for each month has been produced.

<u>Step 2: Developing Agriculture Drought Hazard Map</u>

a. The monthly obtained VHI were classified to 2 classes, the first class correspond to areas with no drought (class 1 was given a value 1) and the second class correspond to areas with any level of drought (class 2 was given value 0).
b. Classification for each winter's months for the years from 2000 till 2010, took place 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, and 5 to 6 months during summer season in monsoon areas.
   - Group (2), slight impacts of drought, where the VHI is more than 40% through 5 months including October and November in the beginning of the season and March and April months during the winter season in Northern Africa, April and May in the beginning of

season and October and November months during the summer season in Southern Africa, the VHI must not be less than 40% for one month during summer season in monsoon areas north of equator , and VHI is more than 40% through 3 from July to September , and must not must not be less than 40% for one month during winter season in monsoon areas south of equator , and VHI is more than 40% through 3 from January to March

- Group (3), Moderate impacts of drought, where the VHI is more than 40% through 5 months including October and November in the beginning of the season and March and April months during the Winter season, , April and May in the beginning of season and October and November months during the summer season in Southern Africa,. The VHI must not be less than 40% for another one or two months during the winter season in North Africa and in south Africa, and where the VHI is less than 40% through most months during summer season in monsoon areas including August or September North of equator and including February and March south of equator.
- Group (4), Sever impacts of drought, didn't fulfill any of the above mentioned conditions and the VHI is less than 40% for most of the months.

The Seasonally VHI maps for the studied seasons were classified to 2 classes, the first class correspond to areas with no drought (the first class was given a value 1) and the second class correspond to areas with any level of drought (the second class was given value 0).

c. Agriculture drought frequency could be obtained from the vertical calculation from (0,1) classified VHI maps for the different agriculture seasons. The total studied seasons were 10 seasons
d. Agriculture drought consecutive could be obtained from the horizontal calculation from (0,1) classified VHI maps for the different agriculture seasons. The total studied seasons were 10 seasons
e. Agriculture drought intensity could be calculated for each pixel as an average of all studied monthly VHI for all seasons, 88 maps that represents (11 seasons*8 months in each season), The obtained results were then classified into 4 classes as follows:

Severe Drought	less than 15
Moderate Drought	15– 30
Slight Drought	30 – 45
No Drought	More than 45

f. For calculating Agriculture drought variability classes, the first step is subtract the annual NDVI from the maximum average NDVI of all studied years. The obtaining significant variability classes only the shift of 5 to 6 months from average could be considered, as crop calendar for vegetation and natural vegetation in rangelands showing that in many years the crop cycle is not completed and NDVI reached its maximum in January instead of the normal months in April, May and sometimes early June.

   The deviation from average were calculated for all years and grouped to 4 classes as follows:

   No variability : If the positive and negative values were calculated from (0 – 1 month).

   Low variability : If the positive and negative values of (2 month).

Moderate variability: if the positive and negative values of (3 – 4 months).
Severe variability : If positive and negative values of (5 -6).

g. Finally, the Agriculture drought Hazard ADH map for the studied area was created by crossing between the agriculture drought "Intensity", "Variability", "frequency" and "Consecutive" maps in order.

1.2.2. Developing Vegetation degradation Map

Vegetation degradation classes were studied using images for long time (MODIS 1km) for time-series analysis. The time series calculations were carried out using the TimeStats software package. which was specifically developed for analyzing long-term hyper-temporal satellite data archives (Udelhoven, 2006).

1.2.3. Exposing Land Use Map to ADH and LD Map.

Both vegetation degradation time series trend analysis map and ADH map were crossed and the result were re-crossed with land cover/land use map, after Arino et al (2008), that allow a better understanding for the type (s) of land use that are more vulnerable to LD and ADH .

1.2.4. Measuring Vulnerability

Based on parameter to identify national capacity for coping with drought hazard, for studding the impact of ADH on socio-economy the FAOSTAT/ country profile data were used, the main indicators used to compare the changes during the last decade and the changes during the last five years were:

i. Economic Indicator Coded As Ec
ii. Population Coded As Po
iii. Land Use Coded As Lu
iv. Water Availability Coded As Wa

i.	Economic Indicator (Ec)
EcA	: GDP in Million US$.
EcB	: GDP Growth rate NGI US$.
EcC	: Agriculture Share In GDP %.
EcD	: Labor Force% in Agriculture
EcE	: Unemployment Rate:%.
EcF.	: Below Poverty Line %
EcG	: Agriculture, value added per agricultural worker (USD) 2009-1999
EcH.	: Evaluation of the Value of Total Agriculture Production and Food Production
EcI	: Value (millions of 2004-2006 in ($).
EcJ	: Change in crop production value per ha %
ii.	Population (Po)
PoA	: Mean Population Density person/Km2
PoB	: People in working age (15-64) years %
PoC.	: Population growth rate
PoD.	: Net migration rate: for each 1000 person
PoE.	: Females % of Labour force in Agriculture- 2011.
PoF.	: Average Agriculture population Change 2011 - 2001%

iii. Land Use (Lu)

LuA. : Arable Area % from Total
LuB : Change in Arable Areas 1999 - 2009
LuC : Permanent Crops Area % from Total
LuD : Change in Permanent Crops Areas 1999 - 2009
LuE : Forest Area % from Total
LuF. : Change in Forest Areas 1999 - 2009

iv. Water Availability

WaA Total Renewable Water Resources cu km
WaB Fresh water Withdrawal Total Cu km/y
WaC Fresh water Withdrawal agricultural %
WaD Fresh water Withdrawal per Capita Cu km/y

Major National Capacity Indicators description is shown in (Table.1.1).

1.2.5. Estimating Crop Losses

For estimating crop losses it is important to understand the relation between land production and the moisture limits like wilting point, available moisture and field capacity, as those moisture levels are reflecting the plant ability for absorbing soil moisture and provide plants with its water requirements. Plant production in water-limited environments is very often affected by constitutive plant traits that allow maintenance of a high plant water status (dehydration avoidance), high yield potential (YP) might not be compatible with drought resistance (DR). However, under most dryland situations where crops depend on unpredictable seasonal rainfall, the maximization of soil moisture use is a crucial component of drought resistance (avoidance), which is generally expressed in lower water-use efficiency (WUE), (Blum 2005)[2].

Hillel (1971)[3], indicated that in order to obtain the highest possible yields of many agricultural crops, soil moisture content must provide an amount sufficient to prevent water from becoming a limiting factor. Knowledge of the potential evapotranspiration can therefore serve as a basis for planning the irrigation regime. Kramer (1969)[4], added that the plants growing in soils that have low storage capacity will exhaust the readily available water and suffer from drought much sooner than plants growing in soils with high storage capacity.

Relative evapotranspiration began to decrease when two-thirds of available soil water had been used. The length of drought periods is defined from that time until irrigation was resumed. Drought sensitivity per stress day (F/SD) was decreased from 0.14 during jointing to 0.08 during booting. For drought after heading F/SD was 0.038 corresponding to a 3.8% grain yield reduction per stress day. This means that one stress day corresponds to one day without grain growth, (Mogensen 1980)[5].

[2] A. Blum (2005) "Drought resistance, water-use efficiency, and yield potential—are they compatible, dissonant, or mutually exclusive?" Australian Journal of Agricultural Research 56(11) 1159–1168
[3] Hillel, D. (1971). "Soil And Water, Physical Principles And Process". Academicpress. New York
[4] Kramer, P. J. (1969). "Plant And Soil Water Relationships". A Modern synthesis Mc grans - Hill Book co., New York.
[5] Mogensen V. O. (1980). "Drought Sensitivity at Various Growth Stages of Barley in Relation to Relative Evapotranspiration and Water Stress", Agronomy Journal, Volume 72 Issue 6

Table.1.1. **Major National Capacity Indicator**

i. Economic Indicator

Classes	EcA.	EcB. .	EcC.	EcD.	EcE.	EcF.	EcG	EcH	EcI	EcJ
1	more than 1000000 Million US$	>6	>40000	<5 %	>5 %	<5 %	>5 %	>5000	>100%	>50%
2	250000 - 1000000	5 - 6	25000 – 40000	5 – 10%	5 – 10%	5 – 10%	5 – 10%	3000 5000	50 – 100%	25 – 50%
3	100 000– 250 000 Million US$	4 - 5	10000 – 25000	10 – 20%	10 – 15%	10 – 15%	10 – 15%	1500 – 3000	25 – 50 %	0 – 25 %
4	50000 - 100000 Million US$	3 - 4	5000 – 10000	20 – 30%	15 – 25%	15 – 20%	15 – 25%	750 – 1500	0 – 25%	No change
5	25000 - 50000 Million US$	2 - 4	2500 - 5000	30– 40 %	25– 35 %	20– 25 %	25– 35 %	500 - 750	No change	(1) - (25%)
6	10000 – 25000 Million US$	1 - 2	1000 –2 500	40 – 50	35 – 50	25 – 30	35 – 50	200 - 500	0 - (25%)	(25) - (50)
7	less than 10000	< 1	< 1000	➢ 50	➢ 50	➢ 30	➢ 50	< 200	< (25)	< (50)

ii. Population

Classes	PoA	PoB	PoC	PoD	PoE	PoF
1	>50	>60	< 0.5	0	Less than 10	More than 10
2	50 - 100	60 - 50	0.5 - 1	0 – (2)	10- 20	5 - 10
3	100 -500	50 - 40	1 – 1.5	(2) – (4)	20 - 30	0 - 5
4	250 - 500	30 - 40	1.5 - 2	(4) – (6)	30 - 40	No change
5	500 - 750	20 - 30	2 – 2.5	(6) – (8)	40 – 50	(0) – (5)
6	750 – 1000	10 -20	2.5 - 3	(8) – (10)	50 -60 %	(5) – (10)
7	less than 1000	less than 10	➢ 3	➢ (10)	More than 60	Less than 10

iii. Land Use (Lu)

Classes	LuA.	LuB.	LuC	LuD.	LuE	LuF
1	>25%	More than 50	>25%	More than 50	>25%	More than 50
2	20 – 25%	25 – 50	20 – 25%	25 – 50	20 – 25%	25 – 50
3	15 – 20 %	0 - 25	15 – 20 %	0 - 25	15 – 20 %	0 - 25
4	10 - 15	No change	10 - 15	No change	10 - 15	No change
5	5 - 10	0 - (25)	5 - 10	0 - (25)	5 - 10	0 - (25)
6	2 - 5	(25) – (50)	2 - 5	(25) – (50)	2 - 5	(25) – (50)
7	Less than 2	Less than (50)	Less than 2	Less than (50)	➢ Less than 2	Less than (50)

iV. Water Availability

Classes	WaA	WaB	WaC	WaD
1	More than 500	More than 60	Less than 50	More than 1200
2	200- 500	45 - 60	50 - 65	800 - 1200
3	100 - 200	35 - 45	65 - 70	600 - 800
4	75 - 100	25 - 35	70 - 75	500 - 600
5	50 - 75	10 - 25	75 - 80	400 - 500
6	25 - 50	5 - 10	80 - 85	200 - 400
7	Less than 25	Less than 5	More than 85	Less than 200

Zaghloul et al (1997)[6], also indicated that, as soil moisture content is less than 50 - 65% from the available water the yield is severely affected and reduced to 30 – 60% from the normal yield and if less than 50% the yield is extremely affected and might end like less than 30% from the normal yield, depend on crop requirements. durum wheat and triticale under different moisture levels, in a typical Mediterranean climate. Yield of wheat showed significant reductions (by 25, 54 and 87%) under drought stress, (Giunta et al 1993)[7] .
Changes in biomass production of a barley crop in response to droughts of various timing and duration, decreased growth rates were caused primarily by reductions in radiation-use efficiency when drought was imposed from emergence, and that radiation-use efficiency was depressed even after drought was relieved, Jamieson et al (1995)[8]. Moisture stress in all growth stages reduced the grain yield significantly, (Singha et al 1991)[9]. Hlavinkaa et al (2009)[10], found that severe droughts are linked with significant reduction in yields of the main cereals and majority of other crops through the most drought prone regions, and that a statistically significant correlation ($p \leq 0.05$) between the sum of Palmer's Z-index for the main growing period of each crop and the yield departures of spring barley within 81% (winter wheat in 57%, maize in 48%, potato in 89%, oats in 79%, winter rye in 52%, rape in 39%, hay in 79%) of the analyzed districts.
Rozelle et al (2008)[11], stressed on environmental degradation impacts as a major effect on grain production in many of China's agricultural areas that caused at the national level, the average rate of production fell to 1.8 percent per year from 1985 to 1990, after an average growth rate of 4.7 percent per year from 1978 to 1984. He added that supplies and application rates of critical farm inputs during 1985 to 1990 reached record levels, but had a disappointing effect on both yields and gross production, from his analysis he suggests that environmental degradation may have cost China as much as 5.7 million metric tons of grain per year in the late 1980s. Results also indicate that the projected losses due to environmental stress are not evenly distributed throughout China, but that regions which brought considerable amounts of marginal land into cultivation during the earliest years of the reform period now face the greatest problems. The accumulation of environmental pressures, including erosion, salinization, soil exhaustion, and degradation of the local environment, may be partially responsible for the recent slowdown of grain yields in China. Using provincial production data from 1975 to 1990, the analysis shows that environmental factors, especially the breakdown of the environment, did contribute to the decline in the rate of increase of yields in China during the late 1980s. Erosion and salinization had a small, negative effect on yields, (Huang and Rozelle 1995)[12].
At the meantime, Although the prices of agricultural commodities started to rise from as early as 2001, the sharpest increase occurred in the years 2006-08,(ICRISAT 2008[13]), (Figure 1.1).

---

[6] Zaghloul, K. F., W. Erian, and F. A. Gomaa,. (1997) "The Use of Geographic Information System (GIS) To Combine Soil Map With The Suggested Irrigation Scheduling In The Sugar Beet Zone, Nubariya - Egypt". The First International conference on "Earth Observation And Environment Information" 13-16 October, organized by Arab Academy for Science and Technology and Maritime Transport, Alexandria - Egypt.

[7] Giunta F,. R. Motzo, M. Deidda (1993). "Effect of drought on yield and yield components of durum wheat and triticale in a Mediterranean environment", Volume 33, Issue 4, , Pages 399–409

[8] Jamieson P.D., R.J. Martin, G.S. Francis, D.R. Wilson (1995), "Drought effects on biomass production and radiation-use efficiency in barley", Volume 43, Issues 2–3, Pages 77–86

[9] Singha P.K, A.K Mishrab, Mohd Imtiyazc (1991). "Moisture stress and the water use efficiency of mustard", Agricultural Water Management, Volume 20, Issue 3, Pages 245–253

[10] Hlavinkaa P, M Trnkaa, , D Semerádováa, , M Dubrovskýa, b, , Z Žaluda, , M Možnýc, (2009) "Effect of drought on yield variability of key crops in Czech Republic", Volume 149, Issues 3–4, Pages 431–442

[11] Rozelle S, G Veeck and J Huang, (2008)."The Impact of Environmental Degradation on Grain Production in China, 1975–1990", Economic Geography, Volume 73, Issue 1, pages 44–66

[12] Huang J and Scott Rozelle (1995) "Environmental Stress and Grain Yields in China", American J. of Agricultural Economics Volume 77, Issue 4Pp. 853-864.

[13] ICRISAT 2008. Strategic Assessments and Development Pathways for Agriculture in the Semi-Arid Tropics Policy Brief No. 13

The rise in prices can be attributed to a multitude of factors both on the demand and supply side. Fuelled by technological change, the real prices of agricultural commodities witnessed a secular decline until 2000, at an annual rate of about 2% a year between 1970 and 2005, with some minor intermittent ups and downs, both absolutely and relative to the manufactured products (FAO 2004[14]).

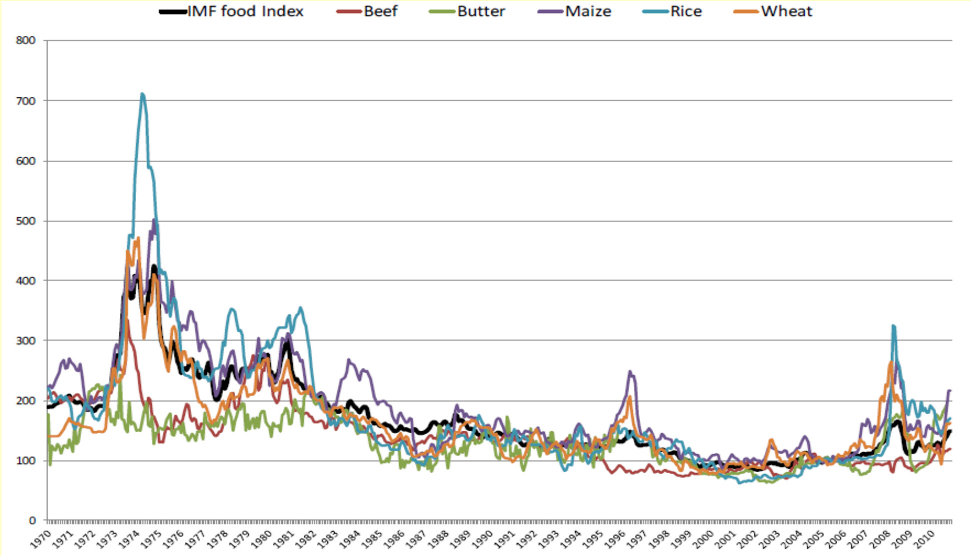


Figure.1.1 Agricultural commodity prices in real terms (2005=100)

While much has been written about the price trends of fine cereals and commercial crops, very little is known about the trends in crops like sorghum and millet that are both staples and an important source of income for the small-scale farmers in the semi-arid tropics, as in sub-Saharan Africa,(ICRISAT 2008), Trend in real export prices of sorghum, millets and maize 1970-2008, is shown in (figure 1.2).

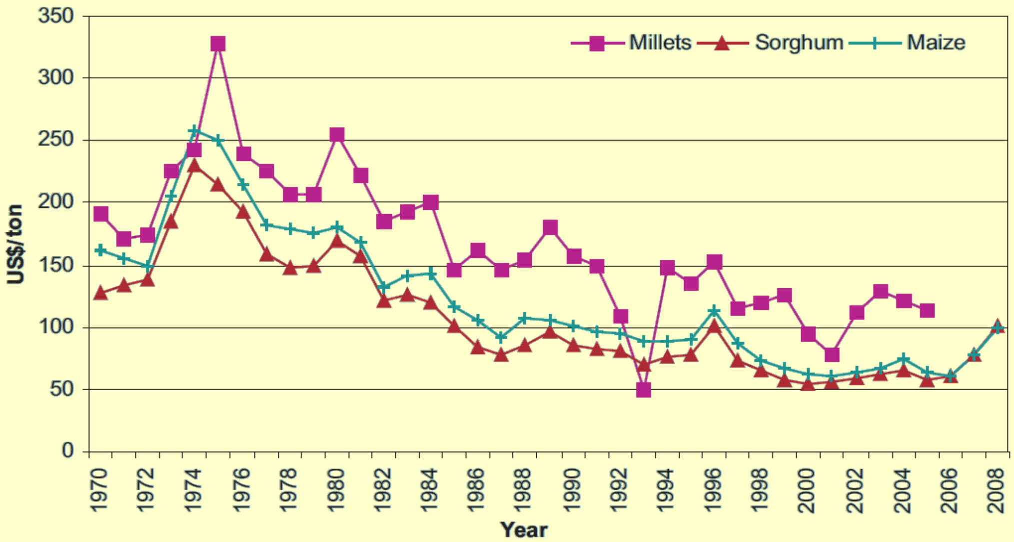


Figure 1.2 Trend in real export prices of sorghum, millets and maize 1970-2008, Source : World Bank 2008.

[14] FAO. 2004. The state of agricultural commodity market. Rome, Italy: FAO.

According to Erian et al (2012)[15], The estimated economical crop losses of the major crops grown in the studied area such as Wheat, sorghum, Millet, Maize, Cassava, Potatoes, Sweet Potatoes, and green Maize using the available data from 1999 – 2011 in FAO STAT , show the following Crop Losses classes: Class 1: Loss in US$ of more than 7 billion US$ in 12 years, as in Nigeria; Class 2: Loss in US$ range between 5- 7 billion US$ in 12 years, as in France, Iran and Angola; Class 3: Loss in US$ range between 2.5- 5 billion US$ in 12 years, as in Malawi, Morocco and Turkey; Class 4: Loss in US$ range between 1- 2,5 billion US$ in 12 years, as in Egypt, Ghana, Algeria, Syrian Arab Republic, South Africa, Ethiopia, Rwanda, Mozambique, Iraq and Italy; Class 5: Loss in US$ range between 0.75- 1.0 billion US$ in 12 years, Benin, Saudi Arabia and Cameroon; Class 5: Loss in US$ range between 0. 5- 0.75 billion US$ in 12 years, Madagascar, Tunisia, Congo Democratic Republic, Uganda, Kenya and Spain; Class 6: Loss in US$ range between 0.25- 0.5 billion US$ in 12 years, Senegal, Greece, Zambia, Mali, Niger and Cote d'lvoire; Class 7: Loss in US$ range between 0.1- 0.25 billion US$ in 12 years, Burundi, Burkina Faso, Portugal, Guinea, Zimbabwe, Congo, Lebanon, Togo, Chad and Yemen; Class 8: Loss in US$ range between 0.05 - 0.1 billion US$ in 12 years, Libya, Comoros, Sierra Leone, Central African Republic and Liberia and Class 9: Loss in US$ less than 0.05 billion US$ in 12 years, Jordon, Somalia, Lesotho, Gabon, Guinea-Bissau, Gambia, Mauritania, Eritrea, Equatorial Guinea, Oman, Swaziland, Namibia, Kuwait, Botswana, and Sao Tome and Principles

The real crop losses figures related to the severity of drought hazard are wider than obtained from the studied crops and could be improved in more detailed studies for each country using similar technique like the one used in this study. But from figures (1 and 2) and above mentioned relationship between soil moisture drought and yield and foe estimating the crop losses and cost for creating alternative job opportunity for affected worker by both Agriculture Drought Hazard and Land Degradation, the lead author suggested the following relations for the general estimation as presented in (table 2).

Table 1.2. Estimated Crop losses and Cost for Creating Alternative Job Opportunity for Affected Workers

Total Affected Land Use Type	Level of Severity								
Rangelands	Sevier	Moderate	Slight	Sevier	Moderate	Slight	Sevier	Moderate	Slight
	Production losses in %			Lost land value US$			Number of workers lost Job		
	60	35	15	160	90	30	0.25	0.1	0.07
Rainfed	Sevier	Moderate	Slight	Sevier	Moderate	Slight	Sevier	Moderate	Slight
	Production losses in %			Lost land value US$			Number of workers lost Job		
	45	25	10	400	200	90	1	0.5	0.1
Forest	Sevier	Moderate	Slight	Sevier	Moderate	Slight	Sevier	Moderate	Slight
	Production losses in %			Lost land value US$			Number of workers lost Job		
	40	20	7.5	1000	500	200	0.7	0.3	0.1

[15] Erian W., B Katlan, B. Oul.dbedy, H. Awad, E. Zaghtity and S Ibrahim, (2012). "Agriculture Drought in Africa Mediterranean and Middle East, Background paper prepared for the 2013 Global Assessment Report on Disaster Risk Reduction. Geneva, Switzerland: UNISDR.

Chapter2: Estimating Crop Losses in Africa

2.1. Agriculture Drought Hazard in Africa

The total studied area covers 50 countries and represents approximately 2.95 billion hectares of land. The total rainfed areas are covering 2.16 billion hectares (represent 57.48% of the total studied area). These rainfed areas could be sub-divided into 3 main land use types, the rainfed croplands area, the Rangelands area and the Forests that represent 20.32%. 39.23% and 40.64% of the total studied area respectively

The Agriculture Drought Hazard map was produced, as shown in figure (2.1) and table (2.1) and classified into 4 major groups. The main Classes are:

- Class 1:No Drought hazard covers 213.88 million Km^2 of the study area and represents 72.52%
- Class 2 Slight Drought Hazard covers 3.66 million Km^2 of the study area and represents 12.4%
- Class 3 Moderate Drought Hazard covers 3.75 million Km^2 of the study area and represents 12.72% ; and
- Class 4 Severe Drought Hazard covers 0.7 million Km^2 of the study area and represents 2.36%

Total effected areas by Agriculture Drought Hazards are ≈ 810.47million hectares represents 27.48% of the total Africa area, but the severely affected (moderate and Severe) areas are ≈ 444. 76 million hectares represents 15.08% of the total Africa area.

Countries were ranked to seven groups according to the total present of the ADH severity during the last decade (2000 – 2011), the range for each group was as follows:

<u>Group 1:</u> including countries with extremely Severe extend of ADH, and were ADH, affected more than 85 % of the total country area, but none of the African countries are in this group;
<u>Group 2,</u> including countries with very Severe extend of ADH affected areas of more than 75% of the total country area, this group includes countries like, Morocco, Eritrea and Equatorial Guinea with a ADH percentage coverage of 84.22, 79.42 and 77.17 respectively;
<u>Group 3,</u> including countries with Severe extend of ADH affected areas of about 60 - 75% of the total country area; this group includes the following countries: Gabon, Tunisia, Djibouti, and Namibia, Israel with a ADH percentage coverage of 70.53, 69.8, 68.33, and 61.41 respectively;
<u>Group 4,</u> including countries with moderate extend of ADH effected 45 - 60% of the total country area, this group includes the following countries: Somalia, Ivory Coast, Nigeria, Senegal, Liberia, Kenya' Sierra Leanne and, Ghana with a ADH percentage coverage of 56.53, 55.78, 53.83, 52.62, 51.05, 49.26, 48.31 and 45.03, respectively;
<u>Group 5,</u> including countries with low to moderate extend of ADH effected areas of about 30 - 45% of the total country area, this group includes the following countries: Western Sahara, Ethiopia, Benin, Mali, South Africa, Burkina Faso, Togo, Botswana, Sudan and South Sudan, Cameroon. and Chad with a ADH percentage coverage of 43.68, 41.68, 40.48, 39.84, 38.45, 38.26, 37.97, 36.5, 33.3, 32.02, 30.87 respectively;

Group 6, including countries with low extend of ADH effected areas of about 15 - 30% of the total country area, this group includes the following countries: Niger, Congo, Algeria, Mauritania, , Libya and Egypt with a ADH percentage coverage of 29.11, 25.56, 25.52, 24.77, 16.8, and 15.9 respectively;

Finally, the rest of Africa Countries are in Group 7 with very low extend of ADH effected areas of less than15 of the total country area,

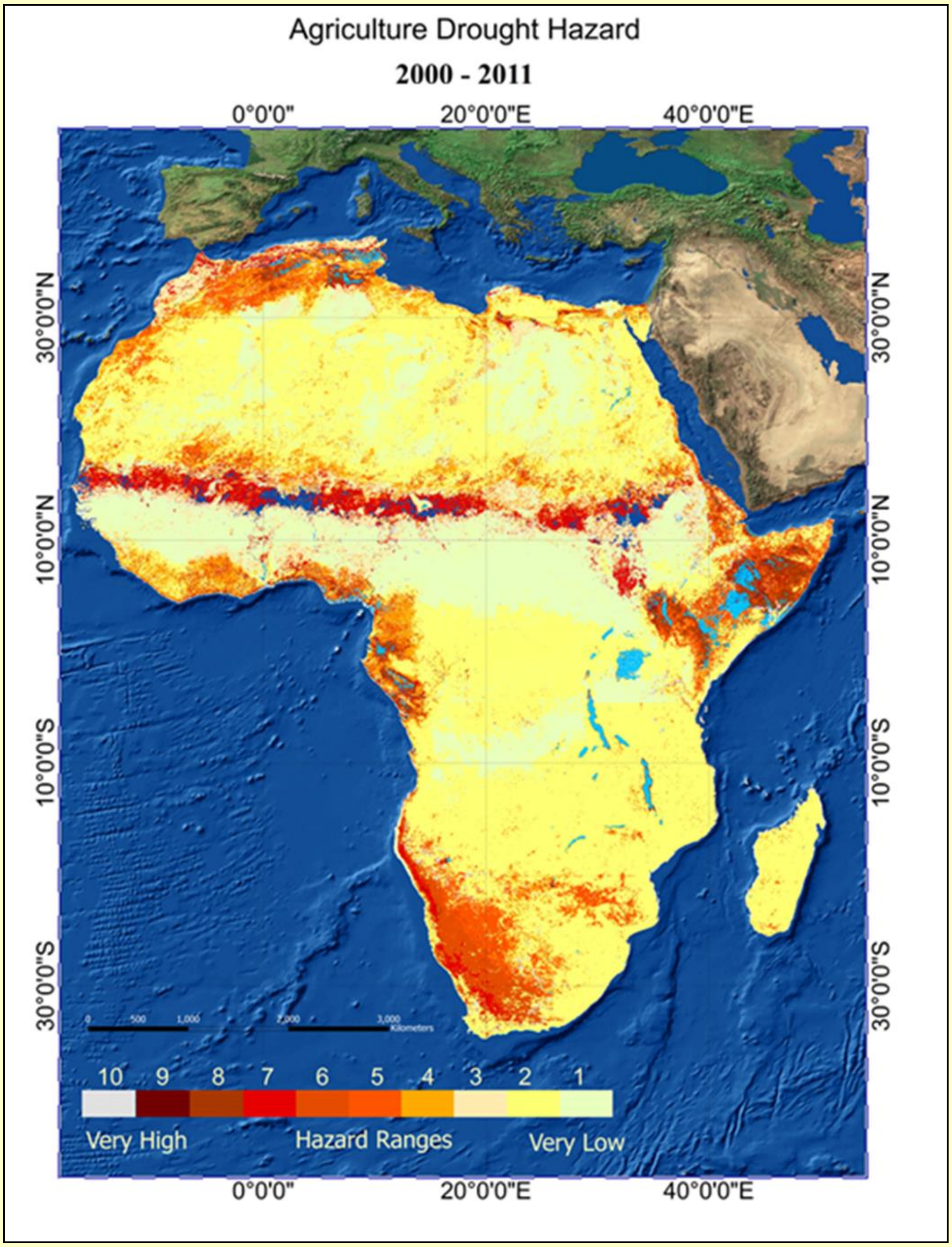


Figure 2.1. Areas Affected by Agriculture Drought Hazard

Table 2.1. Agriculture drought hazard in the African countries

Country	High	Moderate	Slight	No Change	All Hazard	Sever ADH High/Moderate
	3	2	1	0	(1+2+3)	(2+3)
	Class 6, High coverage of ADH 75 – 85%					
Morocco	2.9	31.14	50.18	15.77	84.22	34.04
Eritrea	6.43	32.01	40.98	20.58	79.42	38.44
Equatorial Guinea	4.96	30.86	41.35	22.83	77.17	35.82
	Class 5, high to Moderate Coverage of ADH 60-75 %					
Gabon	15.5	24.55	30.48	29.48	70.53	40.05
Tunisia	10.6	20.17	39.03	30.2	69.8	30.77
Djibouti	9.08	38.74	20.51	31.67	68.33	47.82
Macedonia	25.18	36.62	4.92	33.28	66.72	61.8
Namibia	0.45	58.54	2.42	38.59	61.41	58.99
	Class 4, Moderate Coverage of ADH 45-60 %					
Somalia	18.56	34.01	3.96	43.46	56.53	52.57
Ivory Coast	0.95	21.62	33.21	44.23	55.78	22.57
Nigeria	4.01	19.56	30.26	46.17	53.83	23.57
Senegal	4.26	26.59	21.77	47.38	52.62	30.85
Liberia	0.43	12.09	38.53	48.95	51.05	12.52
Kenya	13.62	27.54	8.1	50.74	49.26	41.16
Sierra Leone	0.12	13.35	34.84	51.69	48.31	13.47
Ghana	1.96	15.8	27.27	54.96	45.03	17.76
	Class 3, moderate to low Coverage ADH 30-45 %					
Western Sahara	0.17	12.43	31.08	56.32	43.68	12.6
Ethiopia	9.88	19.88	11.92	58.32	41.68	29.76
Benin	2.57	6.44	31.47	59.52	40.48	9.01
Mali	1.18	16.1	22.56	60.16	39.84	17.28
South Africa	0.03	33.52	4.9	61.55	38.45	33.55
Burkina Faso	1.85	20	16.41	6174	38.26	21.85
Togo	1.34	6.54	30.09	62.04	37.97	7.88
Botswana	0.08	24.06	12.36	63.5	36.5	24.14
Sudan	1.74	13.21	18.35	66.7	33.3	14.95
Cameroon	1.72	10.36	19.94	67.99	32.02	12.08
Chad	1.25	11.68	17.94	69.14	30.87	12.93
	Class 2, low Coverage of ADH 15-30 %					
Niger	1.28	10.96	16.87	70.89	29.11	12.24
Congo	7.12	9.08	9.36	74.44	25.56	16.2
Algeria	3.34	9.41	12.77	74.49	25.52	12.75
Mauritania	1.03	9.61	14.13	75.23	24.77	10.64
Libya	0.6	2.86	13.34	83.2	16.8	3.46
Egypt	0.89	3.09	11.92	84.09	15.9	3.98
	Class 1, very low Coverage of ADH <15 %					
Zimbabwe	0.03	10.13	3.57	86.27	13.73	10.16
Guinea	0.03	1.59	11.96	86.42	13.58	1.62
Malawi	3.36	5.38	3.22	88.04	11.96	8.74
Gambia	0.69	0.96	9.33	89.01	10.98	1.65
Lesotho	0	3.11	4	92.89	7.11	3.11
Mozambique	0.21	4.8	1.85	93.14	6.86	5.01
Angola	0.2	3.5	2.07	94.14	5.77	3.7
Tanzania	0.66	1.66	1.46	96.22	3.78	2.32
Uganda	1.39	1.2	1.18	96.23	3.77	2.59
Burundi	1.44	1.16	0.84	96.55	3.44	2.6

2.2. Vegetation DEGRADATION IN AFRICA

Total effected areas by land degradation are ≈ 1.54 billion hectares represents 52% of the total Africa area, as shown in figure (2.2) and (table 2.2).
Countries effected areas by land degradation could be grouped as follows:

Group 1: including countries with extremely Severe extend of LD in more than 75% of their areas: in Lesotho, Kuwait, Djibouti, Sierra Leanne, Zambia, and D R Congo.

Group 2: including countries with Severely extend of LD in 50- 75% of their areas: in Swaziland, R Congo, Zimbabwe, Guinea, Liberia, Ethiopia, Botswana, Comoros, Eritrea, South Africa, Angola, Madagascar, Uganda, CAR, Nigeria, Cameroon, Rwanda, Equatorial Guinea, Mozambique, Tanzania, Guinea-Bissau, Burundi, Somalia, and Benin

Group 3: including countries with moderately extend of LD in 25- 50% of their areas: in Kenya, Niger, Gabon, Sudan & S. Sud, Egypt, Mali, Libya, Chad, Togo, Cote d'Ivoire, Algeria, Ghana, Gambia, Malawi, S. T. & Principe, Burkina Faso, Mauritania and Tunisia.

Group 4: including countries with low extend of LD in 10- 25% of their areas: in Senegal, Namibia and Morocco.

The effects of land degradation are often irreversible, and land rehabilitation frequently requires inputs which are costly, labor-demanding or both.

Although plant nutrients and soil organic matter may be replaced, degraded pastures can be recovered under improved range management, salinized soils can be restored to productive use. However, to replace the actual loss of soil material requires thousands of years. In addition, the cost of reclamation or restoration to productive use of degraded soils is invariably Severer than the cost of preventing degradation before it occurs

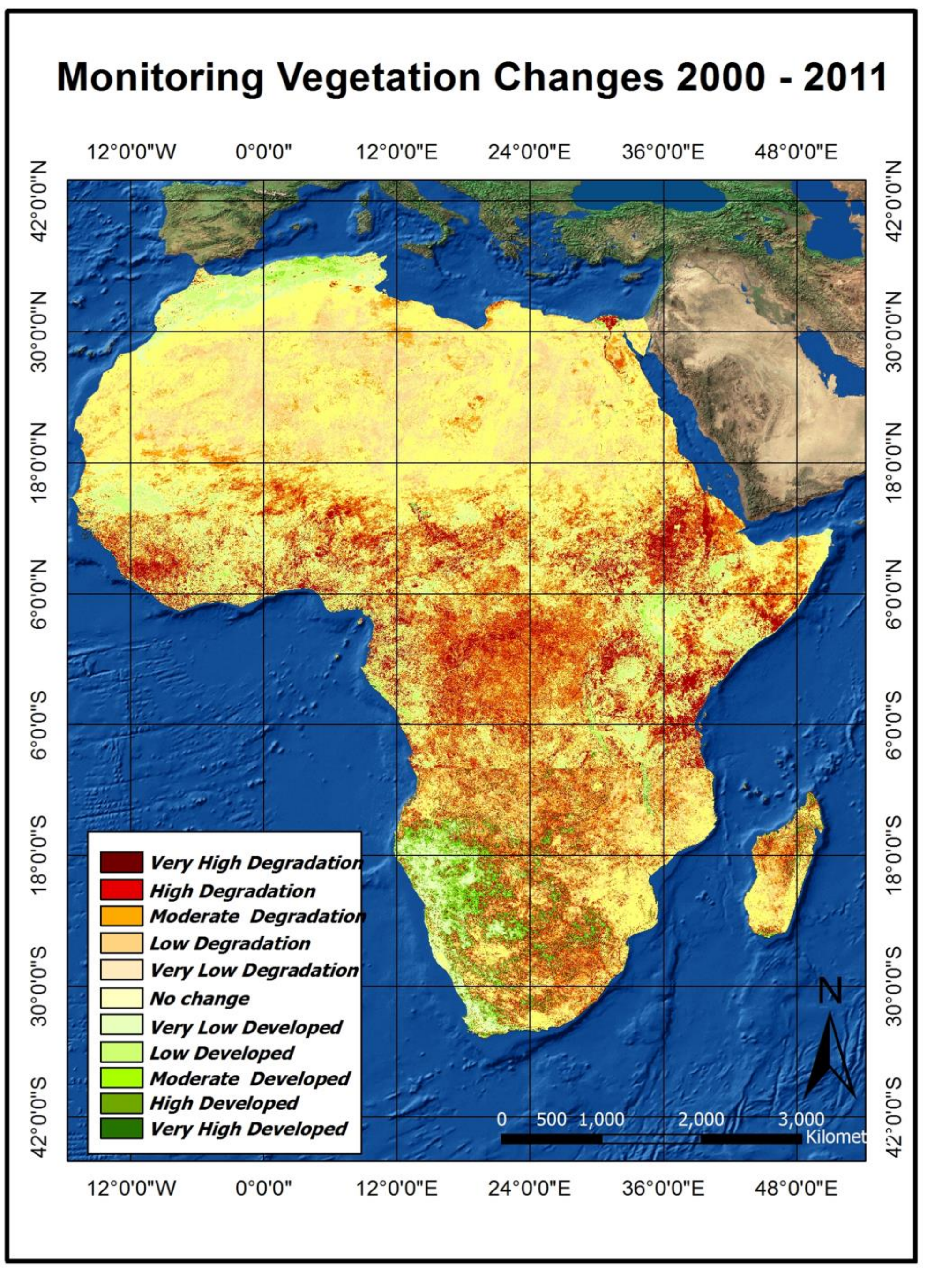


Figure 2.2. Land Degradation Map of Africa

Table 2.2. Land Degradation in Africa

Country	vh_deg (1)	h_deg (2)	m_deg (3)	hot spots (1-3)	l_deg (4)	vl_deg (5)	Deg Total	No LD	vh_de v	h_dev	m_dev	l_de v	vl_dev	Dev Total
	%	%	%	%	%	%	%	%	%	%	%	%	%	%
Algeria	0.1	0.2	2.6	2.9	22.1	15.5	40.5	48.8	0	0.2	0.7	6.4	3.5	10.8
Angola	12.5	16.6	16.7	45.8	11.7	4.6	62.1	16.5	4.2	4.2	3.3	3.1	6.6	21.4
Benin	14.5	17.2	11.7	43.4	5	1.7	50.1	25.8	0	0	0	9.8	14.3	24.1
Botswana	19.1	16.2	15.2	50.5	10.8	4	65.3	6.5	9.1	8.3	4.8	1.7	4.2	28.1
Burkina Faso	5.1	11.4	11.9	28.4	6.2	2.3	36.9	39	0	0	0	7.5	16.6	24.1
Burundi	15.1	17.7	11.9	44.7	4.8	1.6	51.1	23.5	0.3	0.3	0.6	10.9	13.2	25.3
C A Republic	6.6	23.3	18.1	48	7.6	2.5	58.1	29.4	0	0	0	3.5	8.9	12.4
Cameroon	15	20.9	13.8	49.7	5.5	1.8	57	23.2	0	0.1	0.3	9.3	10	19.7
Chad	6.2	9.3	11.5	27	10.9	7.7	45.6	49	0.1	0	0.1	1.6	3.7	5.5
Comoros	20	14.9	15.3	50.2	9	5	64.2	9.2	9.1	8.9	5.5	1.3	1.8	26.6
Cote d'Ivoire	13.1	13.3	9	35.4	4	1.4	40.8	21.2	0	0.1	0.6	22.5	14.9	38.1
D R Congo	14.7	35.8	19.1	69.6	6.5	2	78.1	15.9	0.3	0.2	0.1	1.8	3.6	6
Djibouti	2.9	30.6	35.8	69.3	10.4	2.5	82.2	16.1	0	0	0.1	0.6	1.1	1.8
Egypt	1.4	2.3	7	10.7	19.6	17	47.3	50.7	0.1	0.1	0.2	1	0.7	2.1
Eq. Guinea	26.3	14.5	8.4	49.2	3.3	1	53.5	17	0	0.1	1	17.6	10.6	29.3
Eritrea	7.3	18.5	23.3	49.1	11.5	3.6	64.2	31.1	0	0	0	1	3.6	4.6
Ethiopia	21.8	23.2	14.4	59.4	5.2	1.7	66.3	18.7	0.1	0.1	0.3	7.9	6.8	15.2
Gabon	18.6	14.4	9.3	42.3	3.8	1.3	47.4	19	0.1	0.4	1.5	19.9	11.8	33.7
Gambia	8.6	12.7	10.9	32.2	4.8	1.8	38.8	33.3	0	0	0.1	11.3	16.5	27.9
Georgia	1.5	14.3	10.3	26.1	4.3	1.5	31.9	27.9	5.2	0.1	0.4	20.9	15.2	41.8
Ghana	10.9	12.3	10.1	33.3	4.9	1.7	39.9	28.2	0	0.1	0.3	15	16.4	31.8
Guinea	21.7	23.1	14.3	59.1	5.7	1.9	66.7	22.1	0	0	0	3.7	7.5	11.2
Guinea-Bissau	10.6	18	13.9	42.5	8.5	2	53	29.7	0	0	0.2	8.5	11	19.7
Kenya	17.1	15.2	10.5	42.8	4.5	1.6	48.9	23.7	0.1	0.2	0.8	13.9	12.3	27.3
Kuwait	1.9	13.2	29.6	44.7	31.8	6.5	83	15.8	0	0	0	0.7	0.6	1.3
Lebanon	1.6	2.8	2.7	7.1	1.6	0.8	9.5	30.5	0	0	0.3	29.1	30.5	59.9
Lesotho	11	17.6	32.4	61	26.7	5	92.7	2.2	3	1.6	0.4	0.1	0.1	5.2
Liberia	32.5	19.5	9.7	61.7	3.7	1.2	66.6	17	0	0.1	0.3	8.5	7.5	16.4

Libya	0.1	0.7	5.4	6.2	21.9	17.7	45.8	53.7	0	0	0	0.1	0.4	0.5
Macedonia	1.9	1.9	1.9	5.7	1.2	0.6	7.5	12.7	0.5	0.4	2.1	58.3	18.6	79.9
Madagascar	9.3	11.7	16.2	37.2	16.5	8	61.7	29.4	3.3	2.6	16.2	0.5	1.1	23.7
Malawi	5.6	8.1	14.5	28.2	2.8	7.4	38.4	21	2.6	3.1	3.5	2.8	7.4	19.4
Mali	1.3	6.5	13.9	21.7	16.1	8.5	46.3	39.6	0	0	0	5.3	8.7	14
Mauritania	0	0.8	8.1	8.9	17.2	10.8	36.9	57.4	0	0	0	1.2	4.4	5.6
Mauritius	17.7	13.2	14.9	45.8	9.4	4.8	60	8.4	8.9	8.3	6.2	2.7	5.6	31.7
Morocco	0.5	0.6	2.5	3.6	6.8	4.1	14.5	53.2	0	0	0.2	14.8	17.2	32.2
Mozambique	3	6.1	12.9	22	19.4	12	53.4	44.2	0.7	0.5	0.4	0.2	0.6	2.4
Namibia	9.9	5.5	4.1	19.5	2.8	1.2	23.5	5.5	8	12.3	13.3	7.5	30	71.1
Niger	1.5	6.4	10	17.9	16.8	14	48.7	49.3	0	0	0	0.4	1.6	2
Nigeria	15.7	19.1	14.4	49.2	6.2	2	57.4	25.5	0	0	0.2	7.6	9.3	17.1
R Congo	19.4	28.4	14.2	62	5.1	1.5	68.6	16.4	0	0.1	0.3	7.6	7	15
Rwanda	23.7	16.4	9.4	49.5	4	1.4	54.9	18.7	0.1	0.2	0.8	14.3	10.9	26.3
Senegal	2.1	7.1	8.7	17.9	4.7	1.7	24.3	32.9	0	0	0.2	23	19.6	42.8
Sierra Leone	38.5	24.1	11.9	74.5	4.3	1.3	80.1	15.6	0	0	0	1	3.2	4.2
Somalia	9	14.1	16	39.1	8.1	3	50.2	35.3	0	0.1	0.2	6.3	7.9	14.5
South Africa	15.7	15.4	15.3	46.4	11.1	4.6	62.1	13.4	6.7	5.7	3.6	1.7	6.8	24.5
Sudan & S. Sud	5.2	9.8	11.7	26.7	12.6	8.1	47.4	42.3	0	0	0.2	4.4	5.7	10.3
Swaziland	14.3	17.8	19.3	51.4	15.7	6.6	73.7	16.9	4.2	2.5	1	0.4	1.3	9.4
Tanzania	18	14.6	11.4	44	6.7	2.6	53.3	23.2	0.3	0.2	0.3	11	11.7	23.5
Togo	8.7	13.6	11.3	33.6	5.7	2	41.3	32.5	16.7	0	0.1	9.4	16.7	42.9
Tunisia	0.7	2	10.3	13	9.2	5.1	27.3	41.3	0	0.1	0.2	12.6	18.5	31.4
Uganda	24.4	18.9	10.5	53.8	4.1	1.3	59.2	17.1	9.2	0.2	0.7	13.5	9.2	32.8
Zambia	14.5	19.5	22.6	56.6	16.5	5.9	79	11.8	4.1	2.3	0.9	0.7	1.4	9.4
Zimbabwe	7.2	11.3	18.2	36.7	20.5	10.3	67.5	28.5	0.3	1.1	0.5	0.1	0.3	2.3

2, 3. Combined Effect of Agriculture Drought Hazard and Land Degradation.

2.3.1. Combining LD and ADH Effects.

The overall study area that is subject to different Severe levels of both land degradation (LD) and agricultural drought hazard (ADH) was calculated as in table (2.3) and (Figure 2.3). The results reflected that different Severe levels of both land degradation (LD) and agricultural drought hazard (ADH) are covering approximately 0.335 billion hectares represent 11.3% of Africa total area. With regard to this percentage, severe levels of both LD and ADH effects 0.9%, severe LD and moderate ADH effects 3.8%, moderate LD and Severe ADH effects 0.2%, and 1.2% is affected by moderate levels of both LD and ADH. The most effected countries are: Djibouti, Somalia, Eritrea, Equatorial Guinea, South Africa, Gabon, Ethiopia and Kenya.

Table 2.3. Ranking Studied Countries based on (%) Affected Areas by Both LD and ADH.

Country	Slight HAZ_ Mod. DEG	Slight HAZ_ Severe DEG	Normal	Mod HAZ_ Mod DEG	Mod HAZ_ Severe DEG	Severe HAZ_ Mod DEG	Severe HAZ_ Sevier DEG	Total Affected Vegetation Cover
Djibouti	3.20	13.40	44.40	4.60	26.50	1.30	6.50	38.90
Somalia	0.40	1.00	68.70	4.20	12.60	2.00	11.10	29.90
Eritrea	5.40	19.60	50.50	4.70	15.60	1.20	3.20	24.70
Equatorial Guinea	2.00	19.70	59.00	1.10	15.70	0.30	2.10	19.20
South Africa	0.90	2.60	77.90	5.40	13.10	-	-	18.50
Gabon	1.50	12.70	67.40	1.10	9.90	0.60	6.80	18.40
Ethiopia	0.70	7.30	73.70	1.50	10.40	1.00	5.40	18.30
Kenya	0.50	4.00	77.80	1.70	10.30	1.00	4.80	17.80
Namibia	0.10	0.60	85.60	2.90	10.80	-	-	13.70
Botswana	2.30	6.10	78.50	3.10	9.80	-	-	12.90
Nigeria	2.40	14.50	70.90	1.60	8.50	0.30	1.80	12.20
Sierra Leanne	2.00	27.90	58.80	0.50	10.70		0.10	11.30
Burkina Faso	1.30	3.20	86.00	1.90	7.00	0.20	0.40	9.50
Niger	3.40	5.30	83.50	1.60	5.30	0.20	0.70	7.80
Ivory Coast	1.60	10.40	80.30	1.00	6.40	-	0.30	7.70
Liberia	1.70	24.80	66.00	0.50	6.70	-	0.20	7.40
Comoros	-	-	92.60	-	7.40	-	-	7.40
Sudan	2.90	6.00	83.90	1.70	4.80	0.20	0.60	7.30
Mali	4.60	6.40	82.00	2.00	4.50	0.20	0.40	7.10
Ghana	1.80	9.50	81.50	0.90	5.10	-	1.10	7.10
Cameroon	1.10	10.90	81.60	0.50	5.10	0.10	0.70	6.40
Congo	0.60	3.70	89.50	0.50	3.30	0.30	2.10	6.20
Tunisia	5.90	5.90	82.70	1.90	1.80	1.00	0.80	5.50
Senegal	1.00	2.20	91.80	1.40	2.90	0.30	0.60	5.20
Chad	2.70	5.50	86.80	1.70	2.80	0.20	0.40	5.10
Benin	1.80	15.00	78.50	0.40	3.10	0.10	1.10	4.70
Zimbabwe	1.10	0.90	93.70	-	2.80	1.50	-	4.30
Malawi	1.20	1.00	93.50	1.70	1.50	0.30	0.70	4.20
Togo	2.00	11.00	83.60	0.50	2.60	0.10	0.30	3.50
Lesotho	1.00	2.20	93.70	1.30	1.80	-	-	3.10
Mauritania	2.30	1.30	93.80	1.20	1.20	0.10	0.20	2.70
Western Sahara	5.20	1.00	92.10	1.50	0.30	-	-	1.80
UA Emirates	7.70	1.90	88.60	1.20	0.60	-	-	1.80
Madagascar	0.30	0.60	97.60	0.50	0.90	-	-	1.40
Morocco	0.70	1.50	96.40	0.30	0.90	-	0.10	1.30
Angola	0.30	0.70	97.70	0.30	0.90	0.00	0.10	1.30
Guinea	0.80	7.30	90.70	0.10	1.10	-	-	1.20
Egypt	3.40	0.90	94.40	0.80	0.20	0.20	-	1.20

Tanzania	0.10	0.70	98.10	0.10	0.80	-	0.20	1.10
Burundi	0.00	0.40	98.40	0.00	0.60	0.10	0.40	1.10
Libya	3.30	0.90	94.90	0.50	0.30	0.10	0.10	1.00
Mozambique	0.40	0.30	98.20	0.70	0.30	-	-	1.00
Uganda	-	0.40	98.80	-	0.30	-	0.40	0.70
Rwanda	-	0.30	99.10	-	0.40	0.10	0.20	0.70
Gambia	0.50	3.40	95.60	-	0.20		0.30	0.50
Algeria	1.60	0.10	97.80	0.20	0.10	0.10	0.10	0.50
Swaziland	0.10	-	99.30	0.10	0.30	-	0.10	0.50
Congo DR	0.10	0.50	99.00	-	0.20	-	0.10	0.30
Zambia	0.30	0.40	99.00	0.10	0.20	-	-	0.30
Guinea-Bissau	0.10	1.10	98.50	-	0.10	-	0.10	0.20
C A R	0.10	0.40	99.50	-	-	-	-	0.00

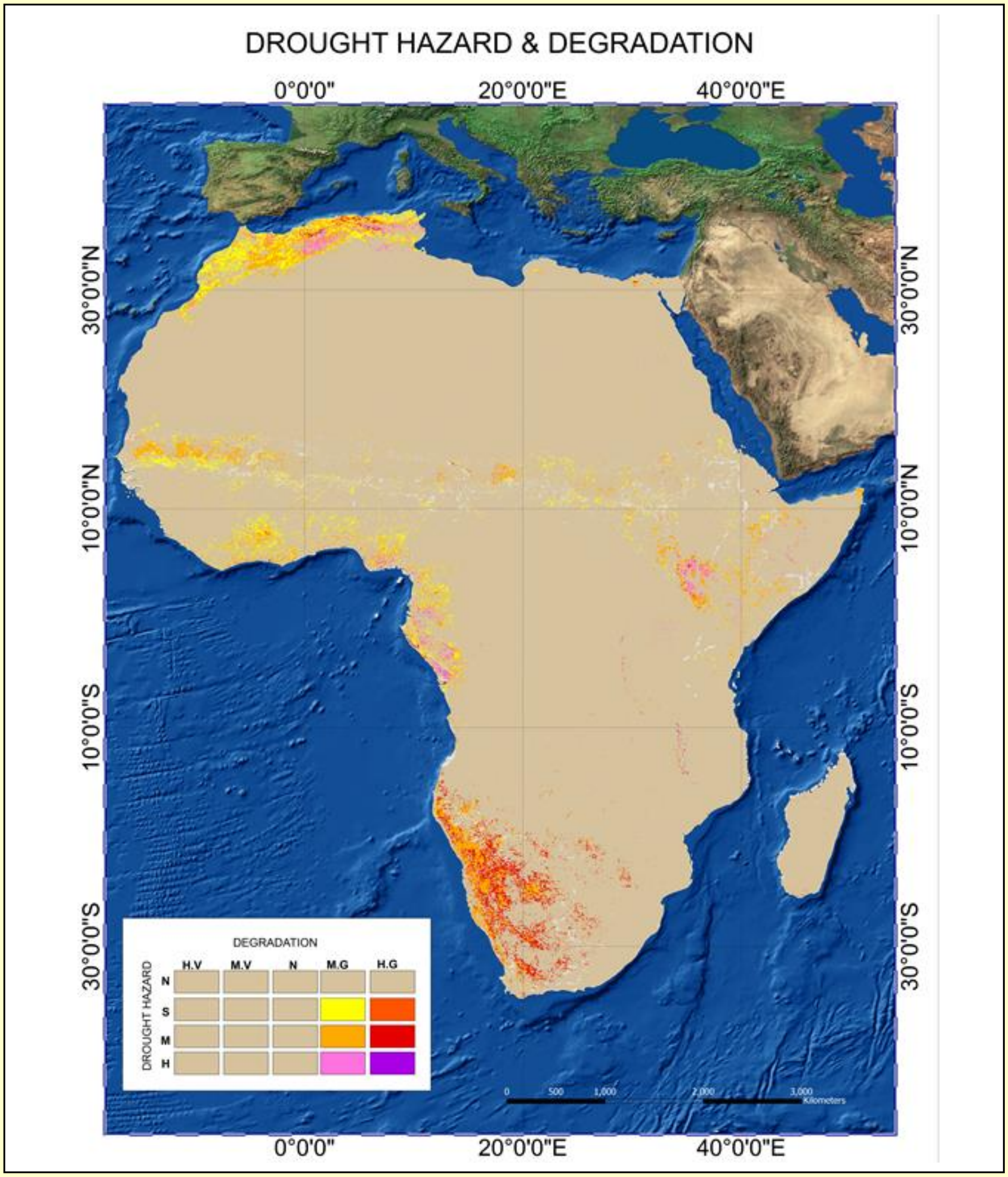


Figure 2.3. Effected areas by Combining LD and ADH

2.3.2. Exposed Agriculture Land Use Areas to Hazards

The total affected land used areas (Rangelands, Rainfed croplands and Forests) by combined ADH and LD are covering approximately 0.414 billion hectares that represent 13.9 % of Africa total area Countries and its local communities that depend on such areas for earning their leaving could be considered under a real threat. Africa area could be sub-divided into two major classes:

Class 1: Areas exposed to Severe threat of both sever ADH and sever LD, they cover 329 million hectares represents 11.5% of the total Africa area, (within this percent, severe levels of both LD and ADH effects 5.93%, severe LD and moderate ADH effects 2.43%, moderate LD and Severe ADH effects 1.96%, and 1.18% is effected by moderate levels of both LD and ADH).

Class 2: Areas exposed to slight to moderate threat of both slight ADH and sever LD, they cover 85.3 million hectares represents 2.86% of the total Africa area, (where, slight ADH_ moderate LD represents 20.8 million hectares represents 0.7 % of the Africa area and slight ADH_ Severe LD represents 64.4 million hectares represents 2.16% of the total Africa area).

The detailed impacts of combined ADH and LD on Rangelands, Rainfed croplands and Forests in each studied country are shown in Table (2.4), and could be summarized as follows:

- Impacts on Rangelands

The total affected areas by combined ADH and LD is covering 215 million hectares represents 6.36 % of the total studied area, almost 49% of the total rangelands in Africa (Figure 2.4, a). Countries affected over 25% could be ranked as follows: The Gambia, Burkina Faso, Egypt, Uganda, Zimbabwe, Lesotho, Morocco, Ethiopia, Rwanda, Somalia, Sierra Leanne, Nigeria, Senegal, Kenya, Chad, Malawi, Mali, Botswana, Tunisia, Benin and South Africa

- Impacts on Rainfed Croplands:

The total affected area by combined ADH and LD is covering 164 million hectares represents 5.51 % of Africa area almost 19.4 % from total Rainfed croplands area in Africa, (Figure 2.4,b). Countries affected over 25% could be ranked as follows: Djibouti, Niger, Namibia, Mauritania, Eritrea, Libya, Botswana, Mali, Somalia, Sudan, Ethiopia, Kenya, Morocco, South Africa, Chad, Tunisia and Egypt..

- Impacts on Forests:

The total affected Forests area by combined ADH and LD is covering 34.8 million hectares represents 1.17 % of the total studied area, Almost 3.96% of the total forests in Africa, (Figure 2.4, c). Countries affected over 25% could be ranked as follows: Comoros, Sao Tome & Principe, Equatorial Guinea, Angola, Central African Republic, Gabon, Madagascar, Cameroon, Mozambique, Congo, Congo DR, Liberia, Zambia, Swaziland, Cote d'Ivory, Burundi, Guinea-Bissau, Tanzania, Ghana, Guinea, Algeria, Togo, Malawi, Sierra Leanne, Rwanda, Benin, Senegal, Nigeria, Tunisia, Sudan, South Africa, Lesotho, Chad, Uganda, Zimbabwe and Kenya.

Table.2.4. Impacts of combined ADH and LD on Rangelands, Rainfed croplands and Forests

CONTRY	Rangelands			Rainfed Croplands			Forests		
	slight ADH and Severe LD	sever ADH and Severe LD	Total Affected Rangelands	slight ADH and Severe LD	sever ADH and Severe LD	Total Affected Rainfed coplands	slight ADH and Severe LD	sever ADH and Severe LD	Total Affected Forests
Algeria	6.38	8.51	14.89	6.38	10.64	17.02	0.00	68.09	68.09
Angola	0.09	0.10	0.19	0.70	1.24	1.94	0.10	97.78	97.88
Benin	3.00	24.24	27.24	12.76	2.23	14.99	0.53	57.25	57.77
Botswana	3.97	24.67	28.64	29.18	39.78	68.96	0.00	2.40	2.40
Burkina Faso	16.89	56.27	73.16	3.75	15.00	18.75	0.00	8.09	8.09
Burundi	0.01	19.55	19.56	0.02	0.00	0.02	0.05	80.37	80.41
Cameroon	1.24	4.47	5.71	0.82	0.36	1.18	0.77	92.34	93.11
C A R	0.01	3.05	3.06	0.30	0.02	0.32	0.00	96.62	96.62
Chad	7.59	26.21	33.80	20.03	14.38	34.41	0.47	31.32	31.79
Comoros	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00	100.00
Congo	0.47	4.15	4.62	1.62	2.29	3.90	2.32	89.16	91.47
Congo, DRC	0.06	10.85	10.92	0.11	0.09	0.20	0.07	88.81	88.88
Cote d'Ivory	5.94	7.32	13.27	2.94	0.78	3.72	0.10	82.91	83.02
Djibouti	0.13	0.06	0.19	28.37	71.37	99.74	0.00	0.06	0.06
Egypt	21.43	50.00	71.43	21.43	7.14	28.57	0.00	0.00	0.00
Equatorial Guinea	1.35	0.30	1.65	0.01	0.07	0.08	2.55	95.72	98.27
Eritrea	4.44	5.05	9.49	47.40	40.86	88.25	0.00	2.26	2.26
Ethiopia	2.26	44.11	46.37	9.89	30.53	40.41	0.00	13.22	13.22
Gabon	0.75	1.54	2.29	0.51	1.03	1.54	7.65	88.52	96.17
Ghana	5.63	8.15	13.78	5.78	2.68	8.46	0.24	77.52	77.76
Guinea	1.46	21.51	22.97	4.44	0.27	4.71	0.00	72.32	72.32
Guinea-Bissau	0.08	19.37	19.45	0.18	0.02	0.19	0.00	80.36	80.36
Kenya	4.14	30.54	34.68	7.25	32.72	39.98	0.00	25.34	25.34
Lesotho	0.74	51.42	52.17	8.43	5.69	14.12	0.00	33.71	33.71
Liberia	3.85	9.78	13.63	0.01	0.05	0.06	0.11	86.20	86.31
Libya	11.76	8.82	20.59	52.94	26.47	79.41	0.00	0.00	0.00
Madagascar	0.03	4.59	4.62	0.63	1.08	1.71	0.02	93.65	93.67
Malawi	1.12	28.01	29.13	2.80	2.61	5.42	0.09	65.36	65.45
Mali	8.07	20.60	28.67	29.40	32.51	61.90	0.00	9.42	9.42
Mauritania	6.47	3.48	9.95	33.33	55.72	89.05	0.00	1.00	1.00
Morocco	36.72	12.99	49.72	24.29	13.56	37.85	0.00	12.43	12.43
Mozambique	0.26	7.33	7.59	0.31	0.51	0.83	0.01	91.57	91.58
Namibia	0.29	8.51	8.80	4.04	85.58	89.62	0.00	1.59	1.59
Niger	3.95	6.03	9.98	37.76	52.26	90.02	0.00	0.00	0.00
Nigeria	8.96	28.62	37.58	8.49	7.05	15.54	1.68	45.20	46.88
Rwanda	0.01	40.13	40.15	0.07	0.01	0.08	0.00	59.77	59.77
Sao Tome & Principe	0.00	0.62	0.62	-	-	0.00	0.00	99.38	99.38
Senegal	13.01	24.35	37.36	1.89	3.65	5.54	0.00	57.09	57.09
Sierra Leanne	9.46	28.24	37.70	1.33	0.73	2.06	0.12	60.12	60.24
Somalia	8.84	29.52	38.36	2.26	54.32	56.58	0.00	5.06	5.06
South Africa	2.08	23.28	25.37	5.09	30.23	35.32	0.00	39.31	39.31
Sudan	8.32	10.29	18.61	22.43	19.51	41.94	0.11	39.34	39.45
Swaziland	0.04	13.98	14.02	0.07	0.20	0.27	0.12	85.59	85.71
Tanzania	0.37	19.28	19.65	0.69	0.52	1.22	0.03	79.10	79.13
The Gambia	0.74	90.07	90.81	0.53	0.40	0.94	0.00	8.26	8.26
Togo	2.50	12.65	15.15	15.27	4.01	19.27	0.06	65.52	65.58
Tunisia	14.10	13.66	27.75	21.15	10.13	31.28	0.00	40.97	40.97
Uganda	0.06	68.15	68.21	0.16	0.12	0.29	0.00	31.51	31.51
Zambia	0.08	12.93	13.00	0.50	0.21	0.71	0.00	86.29	86.29
Zimbabwe	4.01	58.17	62.17	2.77	7.21	9.98	0.00	27.85	27.85

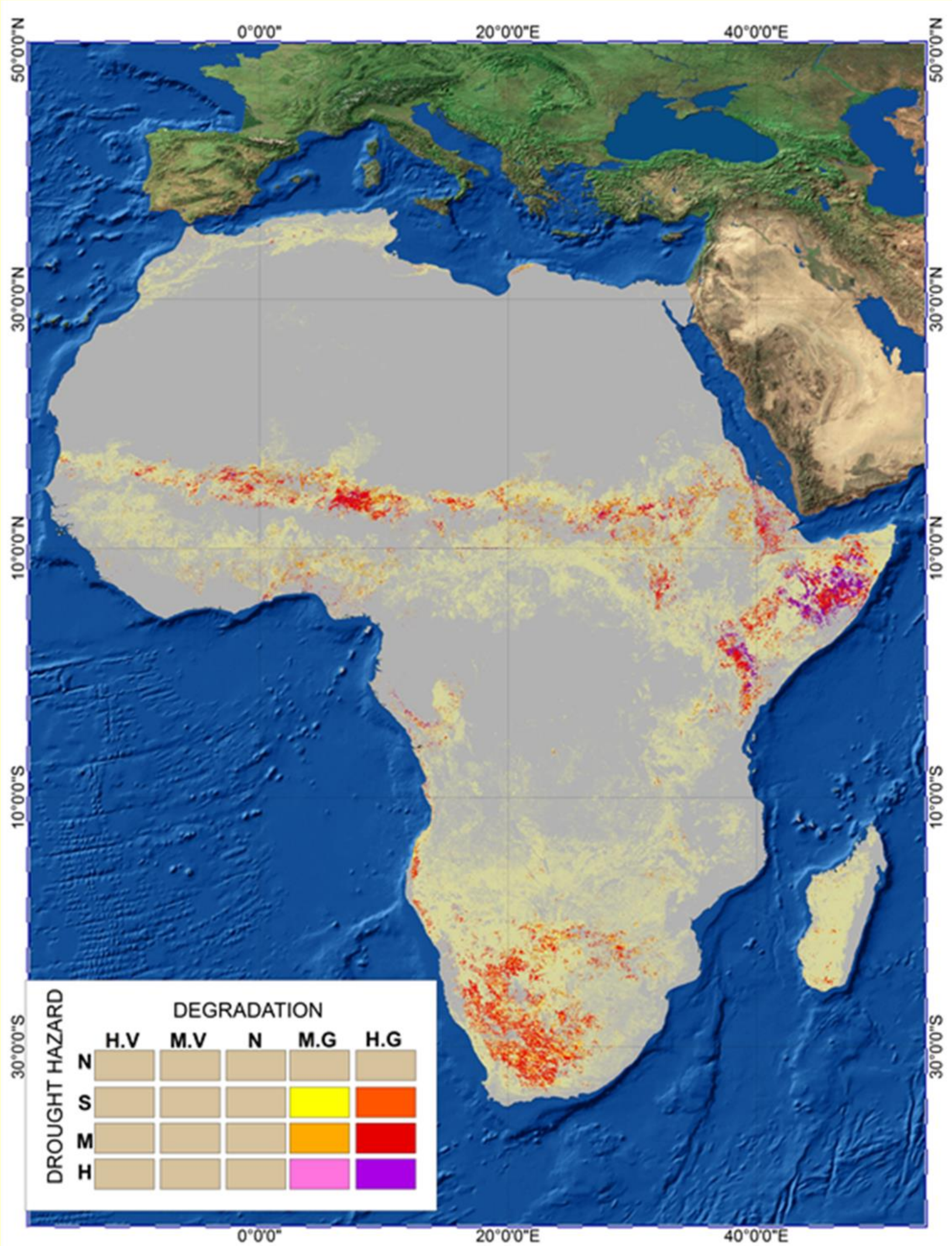


Figure 2.4a Impact of drought and Land Degradation on Rangelands Areas

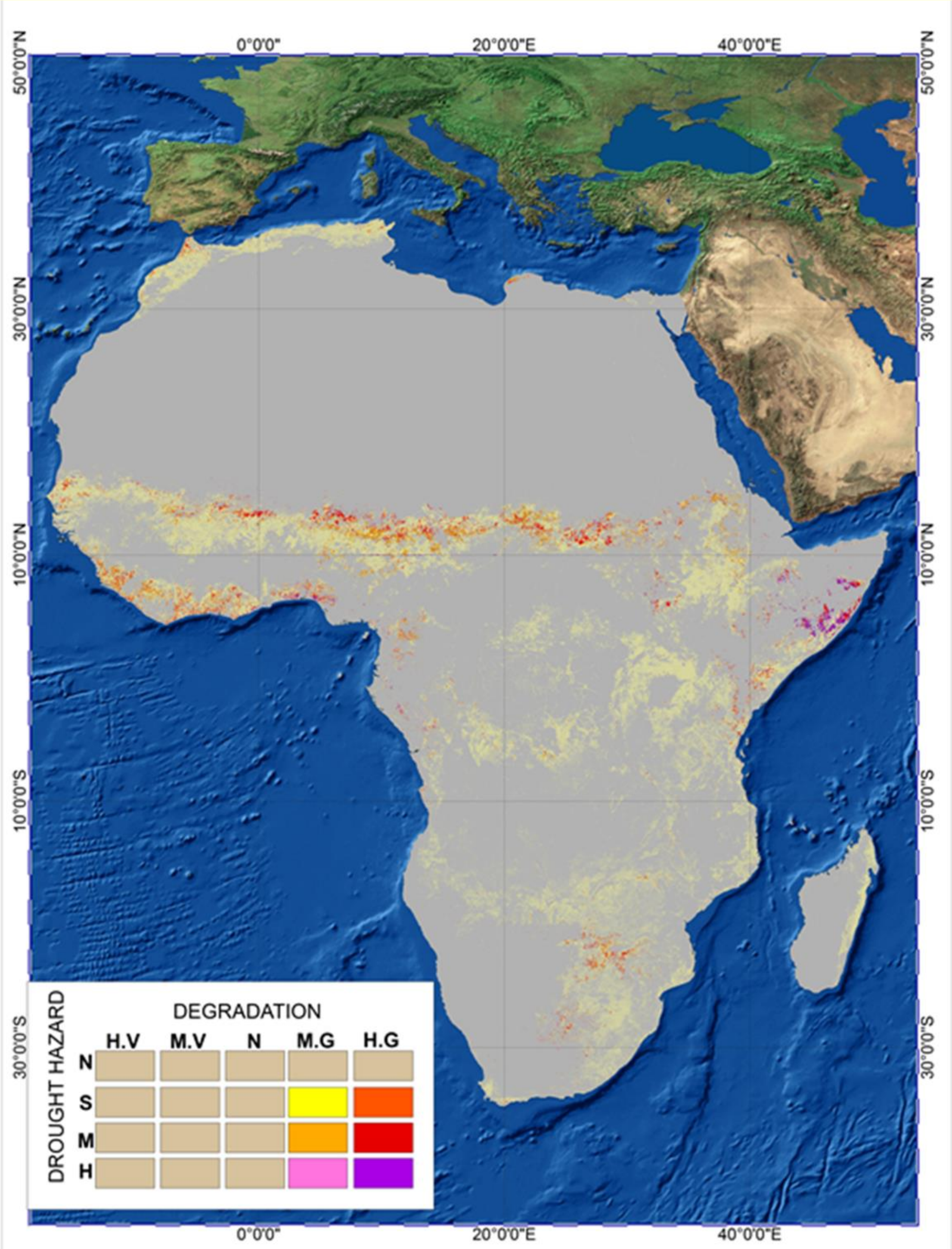


Figure 2.3b Impact of drought and Land Degradation on Rainfed Areas

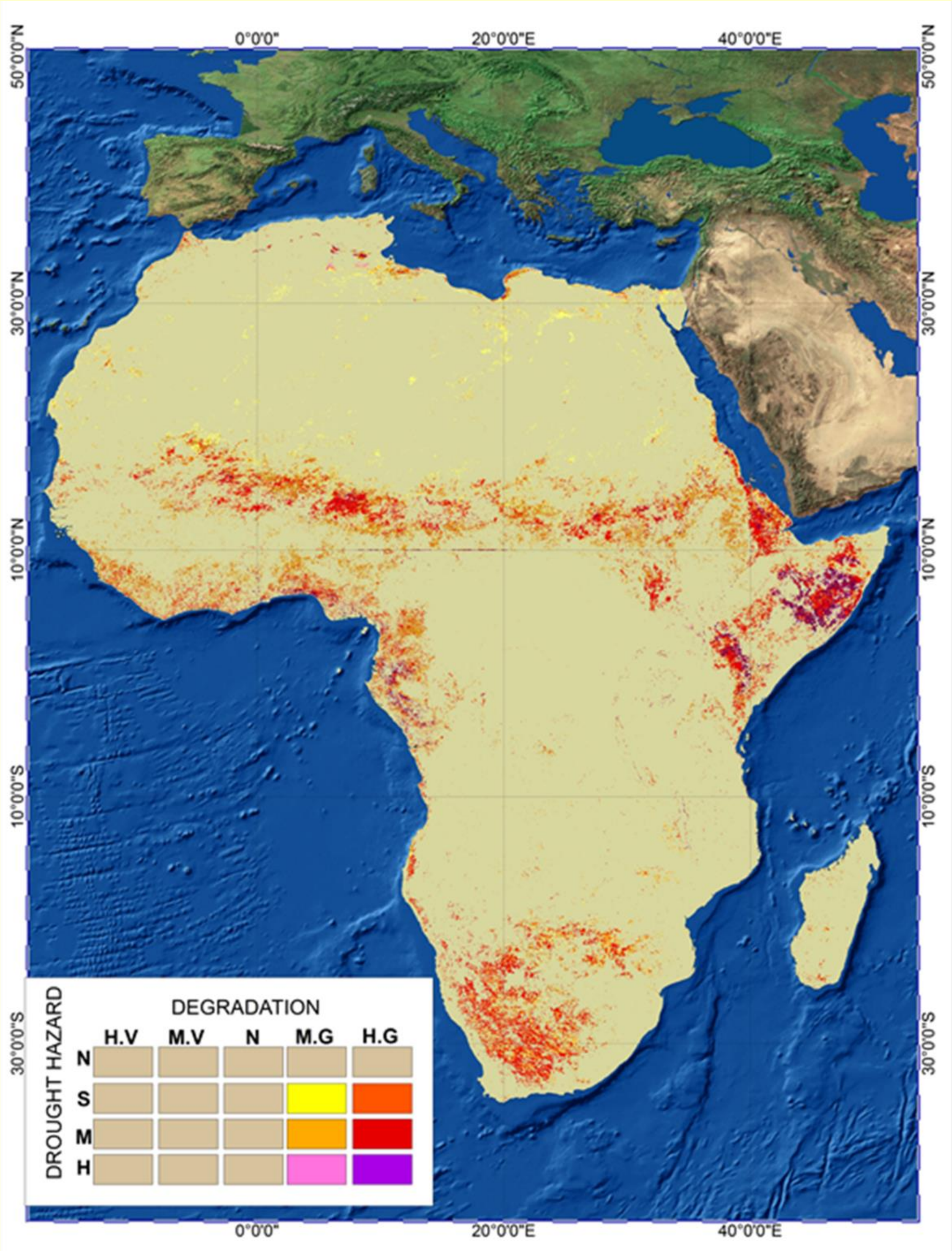


Figure 2.3c Impact of drought and Land Degradation on Forest Areas

2.3.3. Vulnerability to Agriculture Drought Hazard and Land Degradation.

Future vulnerability is embedded in the present conditions of the communities that may be exposed in the future (Patt et al., 2005 , 2009); that is, new hazards in areas not previously subject to them. Identifying vulnerability to ADH and LD will rely on the level of capacity within a country, As Africa countries are considered under developed countries for most of them and in transition in few of them, they could be seen as facing greater impacts and having the most vulnerable populations, greatest number, who are least able to easily adapt to changes (IPCC, 2001 ; McCarthy et al., 2001 ; Beg et al., 2002, Erian et al 2012).

Levels of vulnerability for Africa countries could be classified, after, Erian et al (2012) as follows:

- Countries with severe to Moderate Vulnerability: with moderate coverage of ADH and LD, with moderate severity and very Low to low capacity such as Somalia, Senegal and Kenya.
- Countries with Moderate Vulnerability: Severe coverage of ADH and LD , with moderate severity and moderate capacity such as Eritrea, Morocco, and Eq Guinea
- Countries with Moderate Vulnerability: Severe to moderate coverage of ADH and LD, with moderate severity and Severe to moderate capacity such as Tunisia, Djibouti, and Namibia. Countries with Moderate to Low Vulnerability: moderate coverage of ADH and LD , with low severity and very low to low capacity such as Cote D Lvoire, Sierra Leanne, Ghana, Liberia and Nigeria
- Countries with Moderate to Low Vulnerability: moderate to low coverage ADH and LD , with moderate to low severity and moderate to low capacity such as South Africa, Burkina Faso, Chad, Benin, Togo, Ethiopia, Botswana, Cameroon, Sudan and Mali.
- Countries with Low Vulnerability: low coverage of ADH and LD, with low severity and high to moderate capacity such as Niger, Mauritania, Algeria, Libya, Malawi, Burundi, Angola, Zimbabwe, Lesotho, Mozambique, Gambia, Tanzania, DR Congo, Zambia, Swaziland, Rwanda, Egypt, Congo, Guinea, Guinea-Bissau, Madagascar, Uganda, and Central Africa

2.4. Assessing ADH and LD vulnerability vs GDP and Agriculture Share in GDP.

Countries were classified according to its capacity vs hazard for identifying its level of vulnerability, (Erian et al 2012). They vary in their economic capacity and those with relatively low gross domestic product (GDP) and relatively high agriculture share on their GDP are with less resilience and more vulnerable, they require humanitarian food supplies and are more under instability and conflicts, displacement and migration could potentially increase.

Accordingly, countries that are more affected by ADH and LD could be re-ranked due to its potential instability and ranking is mainly based on two main criteria's:

1) Low GDP, and
2) Increased share of agriculture in GDP.

The result is shown in figure (2.4), and could be summarized as follows:

- Countries with high vulnerability to_ADH and LD are food in-secured with increased drought and land degradation: they include Somalia, Kenya, Senegal, Morocco, Eritrea, Equatorial Guinea, Tunisia, Namibia, Djibouti, Liberia, Sierra Leanne, Nigeria, Cote D Lvoire and Ghana.
- Countries with moderately vulnerability to ADH and LD are food in-secured with increased drought and land degradation: including Chad, Togo, Ethiopia, Mali, Benin, Burkina Faso, Sudan, Cameroon, South Africa and Botswana.
- Countries with Low vulnerability to ADH and LD are food in-secured with increased drought and land degradation: including Central Africa, Niger, DR of The Congo, Rwanda, Mozambique, Burundi, Malawi, Madagascar, Tanzania, Gambia, Uganda, Zambia, Zimbabwe, Mauritania, Egypt and Algeria.

2.5. Assessing Economic of Vegetation Losses in Africa.

The assessment of the economi3 vegetation losses is based on the combined impact of ADH and LD on Africa vegetation cover that includes Rangelands, Rainfed croplands, Forests and limited scattered irrigated areas.

The total estimated Losses on land and rural permanent and seasonal workers that lost their jobs on Africa are shown in figure (2.5) and table (2.5), they could be classified as follows:

- About 164.3 million hectares of Rangelands, that value 19.1 billion US$, that left 31.16 million workers Jobless, and countries of relatively larger losses could be ranked as follows: South Africa, Ethiopia, Somalia, Sudan, Botswana, Namibia, Niger, Kenya, Mali, Nigeria, Chad, Eritrea, Angola, Mauritania, Zimbabwe, Burkina Faso, Congo, Madagascar, Ghana, Tanzania, Mozambique, Congo DR, Benin, Cote d'Ivory, Gabon, Djibouti, Cameroon, Libya, Togo, Senegal, Malawi, Zambia, Algeria, Morocco, Guinea, Lesotho, Sierra Leone and Tunis.
- About 203.3 million hectares of Rainfed croplands, that value 73.4 billion US$, that left 180.3 million workers Jobless and countries of relatively larger losses could be ranked as follows: Congo DR, Ethiopia, Nigeria, South Africa, Tanzania, Zimbabwe, Sudan, Somalia, Uganda, Kenya, Botswana, Zambia, Chad, Mozambique, Burkina Faso, Mali, Cote d'Ivory, Madagascar, Guinea, Cameroon, Sierra Leone, Senegal, Ghana, Benin, Congo, Central African Republic, Malawi, Niger, Liberia, Namibia, Rwanda, Lesotho, Gabon, Burundi, Guinea-Bissau, Togo and Morocco
- About 48.43 million hectares of Forests, that value 44.9 billion US$, that left 31.2 million workers Jobless and countries of relatively larger losses could be ranked as follows: Gabon, Cameroon, Nigeria, Congo, Cote d'Ivory, Liberia, Congo DR, Ghana, Angola, Benin, Madagascar, Sudan $ South Sudan, Sierra Leone, Equatorial Guinea, Guinea, Algeria, South Africa, Mozambique, Tanzania, Zambia, Togo, Chad, Ethiopia, Kenya, Malawi and Zimbabwe.
- In total for all Africa countries about 416.06 million hectares of Forests, that value 137.4 billion US$, that left 242.7 million workers Jobless and countries of relatively larger losses could be ranked as follows: South Africa, Nigeria, Congo DR, Sudan, Ethiopia, Somalia, Tanzania, Niger, Zimbabwe, Gabon, Kenya, Uganda, Mauritania, Cameroon, Zambia, Botswana, Chad, Comoros, Mozambique, Cote d'Ivory, Burkina

Faso, Congo, Benin, Ghana, Mali, Madagascar, Guinea, Liberia, Angola, Sierra Leone, Malawi, Central African Republic, Senegal, Burundi and Namibia.

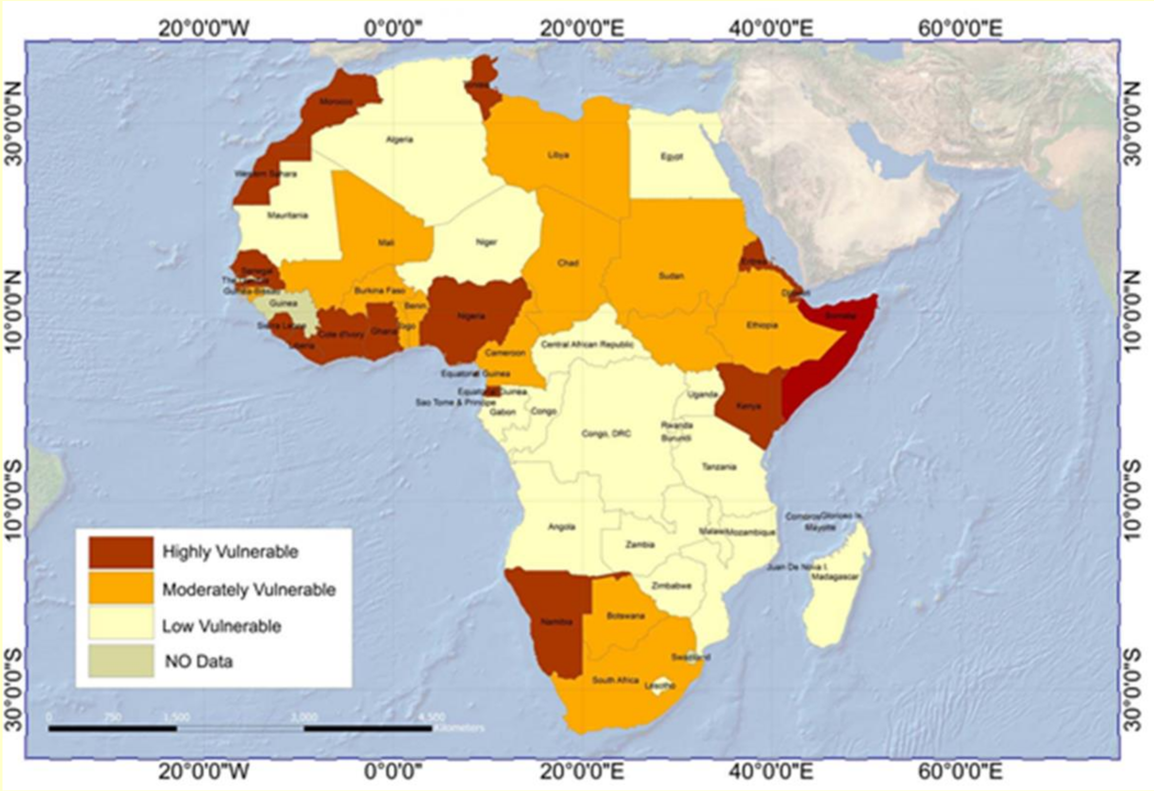


Figure 2.5. Countries Resilience classes to Agriculture Drought Hazard and Land Degradation

Table 2.5. Economic Vegetation Losses in Africa

country	Raingelands			Rainfed			Forests			Total Loss		
	1	2	3	1	2	3	1	2	3	1	2	3
Ethiopia	21878256	8418262599	20911366	19174720	2458	3948948	5611925	4479	3078726	46664901	8418269536	27939040
South Africa	16032279	6004534972	14846669	7819584	906	1477126	9957652	5803	3854354	33809515	6004541681	20178149
Congo DR	28055794	11172788001	27911998	533926	50	84043	2413521	501	255215	31003241	11172788552	28251257
Somalia	8236064	2683335114	6461930	22318580	3153	5001313	317666	66	33956	30872310	2683338333	11497200
Nigeria	17538679	5717725855	13771030	7249065	645	1098746	0	0	0	24787744	5717726499	14869776
Niger	1335075	372172530	865166	12106219	1277	2112534	4312830	1482	895712	17754124	372175288	3873412
Kenya	7823063	2839999346	6983375	9015468	1230	1959127				16838531	2840000575	8942502
Sierra Leone	2036320	655995855	1576065	12605125	1952	3061041	16674	4	2104	14658118	655997810	4639210
Tanzania	12089149	4762851536	11877771	3158	0	459	39	0	4	12092346	4762851536	11878233
Namibia	1009361	393169722	978660	10253836	1580	2479731	46	0	5	11263243	393171302	3458396
Mali	3446490	1076533093	2569533	7414864	728	1218765				10861355	1076533821	3788298
Uganda	8039382	3213507632	8032864	2857	0	278				8042239	3213507632	8033141
Zambia	6467461	2575984357	6435525	1454236	180	290676	88094	18	8809	8009791	2575984555	6735010
Cameroon	2343408	780189198	1887096	474	0	37	5116982	1270	696986	7460864	780190469	2584119
Botswana	7009434	2501728569	6132529	0	0	0	46838	9	4684	7056272	2501728578	6137213
Chad	6466895	2135893922	5157935	160082	6	13018	267372	122	78430	6894349	2135894050	5249382
Mozambique	5226078	2034930893	5064948	570398	63	103375	1631	0	163	5798107	2034930956	5168486
Burkina Faso	5082968	1669010440	4025681	1202	0	183	10313	2	1259	5094483	1669010443	4027123
Congo	1673171	615649142	1517502	1410963	150	247601	1696863	479	274358	4780997	615649770	2039461
Cote d'Ivory	2921363	762435131	1742334	819173	47	88152	684359	561	386180	4424894	762435738	2216666
Madagascar	2872513	1143787089	2857364	1059305	119	194399	117123	27	14543	4048940	1143787235	3066306
Benin	1748699	639673878	1575069	961485	47	93072	1219047	273	143434	3929231	639674198	1811575
Ghana	1750982	478593798	1107049	1074882	76	136323	725425	355	230059	3551288	478594229	1473431
Eritrea	276553	70335602	159595	2571094	232	394297	201508	42	21788	3049155	70335876	575680
Guinea	2386558	907663703	2250224	489435	18	39306	19564	4	1965	2895557	907663725	2291496
Gabon	575245	171596761	405403	387151	45	73841	1783878	382	197185	2746274	171597189	676428
Lesotho	618083	244454506	610016	167043	14	23819	1817647	370	186691	2602773	244454890	820526

Tunis	103880	25368377	56895	1374727	171	275759	1095823	733	494666	2574430	25369280	827320
Senegal	1751424	511314986	1201975	58636	9	14659	635308	527	363710	2445367	511315522	1580344
Swaziland	283465	113108745	282660	2042302	230	376333	10651	8	5322	2336418	113108983	664314
Mauritania	203294	40492057	84768	1831671	204	335024	97040	83	57495	2132004	40492344	477287
CA Republic	1601356	637451047	1592381	479767	33	59541	26525	5	2652	2107648	637451085	1654574
Malawi	1479609	574349198	1428819	274327	25	43098	51724	11	5288	1805661	574349234	1477205
Burundi	472546	188954976	472362	1300986	174	278436	8525	3	1546	1782056	188955153	752344
Liberia	1283347	400931129	957002	5130	1	1065				1288476	400931129	958067
Morocco	390333	65446875	127050	298522	23	39951	467506	102	53090	1156361	65447000	220092
The Gambia	306826	121968464	304614	544213	31	58529	264295	55	27745	1115334	121968550	390888
Algeria	149498	37752685	85492	187894	23	37016	722952	146	73610	1060344	37752854	196119
S T & Principe	601	240296	601	831650	59	105525	1255	1	427	833505	240356	106553
G-Bissau	434507	173269904	432960	4237	0	332	358015	150	94968	796758	173270055	528260
Rwanda	770111	307958386	769861	1618	0	175				771728	307958386	770036
Egypt	107980	34356316	82328	37234	3	5115	624223	173	98586	769437	34356492	186029
W Sahara	0	0	0	716193	63	106952	520	0	52	716713	63	107004
Libya	115226	25266517	54770	439206	32	56855	57457	45	30514	611889	25266594	142138
Togo	426700	148720462	362947	116058	8	14895	7456	2	813	550213	148720472	378655
Djibouti	764	178337	394	368858	45	73319				369622	178382	73713
E Guinea	40401	5851365	10471	1789	0	415	2146	0	215	44337	5851366	11101
Tunis	103880	25368377	56895	1374727	171	275759	1095823	733	494666	2574430	25369280	827320
Senegal	1751424	511314986	1201975	58636	9	14659	635308	527	363710	2445367	511315522	1580344
Swaziland	283465	113108745	282660	2042302	230	376333	10651	8	5322	2336418	113108983	664314
Mauritania	203294	40492057	84768	1831671	204	335024	97040	83	57495	2132004	40492344	477287
C A R	1601356	637451047	1592381	479767	33	59541	26525	5	2652	2107648	637451085	1654574
Malawi	1479609	574349198	1428819	274327	25	43098	51724	11	5288	1805661	574349234	1477205
TOTAL	**184861188**	**67455783361**	**16602305(**	**130539342**	**16111**	**26023203**	**40858416**	**18294**	**11677308**	**356258945**	**67455817766**	**203723561**

Losses in Million Hectares = 1 Losses in Million US$ = 2 in No. of Worker lost Job = 3

2.6. Conclusion

Studying drought, Land degradation and socio-economic nexus in Africa are important for understanding their impact on increased food aid and instability of Africa countries. Most Africa countries are increasingly suffering from drought and land degradation in various types and degrees as well as poverty, food insecurity, conflicts, and displacements.
The Study reflected the Following:

- Agriculture drought hazard in Africa, the total effected areas by Agriculture Drought Hazards are ≈ 810.47million hectares represents 27.48% of the total Africa area,
- Drought severely affected (moderate and high) areas are ≈ 444. 76 million hectares represents 15.08% of the total Africa area.
- Total effected areas by land degradation are ≈ 1.54 billion hectares represents 52% of the total Africa area. Most of it related to degradation in natural vegetation due to overgrazing, deforestation, water erosion, soil fertility deplane due to mono crop cultivation or lack of organic fertilization, salinity, sand movement, and urbanization over agriculture land.
- The effects of land degradation are often irreversible, and land rehabilitation frequently requires inputs which are costly, labor-demanding or both. Although plant nutrients and soil organic matter may be replaced, degraded pastures can be recovered under improved range management, salinized soils can be restored to productive use.
- However, to replace the actual loss of soil material requires thousands of years. In addition, the cost of reclamation or restoration to productive use of degraded soils is invariably higher than the cost of preventing degradation before it occurs.
- Different high levels of both land degradation (LD) and agricultural drought hazard (ADH) are covering approximately 0.335 billion hectares represent 11.3% of Africa total area and their combined effect is harmful to agriculture cover in Africa.
- The total affected area by combined ADH and LD is covering 164 million hectares represents 5.51 % of Africa area almost 19.4 % from total Rangeland area in Africa.
- Total affected areas by combined ADH and LD is covering 215 million hectares represents 6.36 % of the total studied area, almost 49% of the total rainfed croplands in Africa.
- The total affected Forests area by combined ADH and LD is covering 34.8 million hectares represents 1.17 % of the total studied area, Almost 3.96% of the total forests in Africa.
- Countries could have been re-ranked based on it's potential instability based on two main criteria's: 1) Low GDP, and 2) increased share of agriculture in GDP. The most vulnerable countries with high socio-economic instability were Somalia, Kenya, Senegal, Morocco, Eritrea, Equatorial Guinea, Tunisia, Namibia, Djibout, Liberia, Sierra Leane, Nigeria, Cote D Lvoire and Ghana.
- Countries of High to Moderate vulnerability are likely facing, Shortage food production, increased agriculture uncertainty and Suffering rural communities' instability, such instability could cause crises with the increase in agriculture drought hazard and/or Land degradation

They require building resilience in agriculture sector and variety their economic resources specially on their rural and fragile communities were displacement; migration to urban areas or other countries could increase internal or trans-boundary conflicts.

Chapter3: Social Vulnerability to Drought Risk in the Arab Region

3.1. Main Climatic and Natural Resource Challenges in Arab Region[16].

As climate change becomes globally agreed reality and extreme events are increasing on intensity, frequency and duration, stresses environmental factors are becoming important in fragile ecosystems and drylands with limited natural resources as in the Arab region. On the one hand, demographic growth and high per capita consumption are increasing the demand for environmental resources. On the other hand, environmental depletion and degradation are reducing both the quantity and the quality of renewable resources. In addition to this supply/demand-induced dynamic, the unequal distribution of environmental resources must be considered. These combined tends create an increasing probability of serious environmental scarcity in poor countries that fuel pre-existing grievances such as ethnic, religious or economic marginalization.

The populations in Arab countries are growing; in some places they are increasing at unprecedented rates. The total population of the Arab world is likely to hit 700 million people by 2050; this is roughly twice the size of today‗s population, This growth will increase the demand for scarce resources, including water and land, (World Bank, 2012). For thousands of years, people of the region have coped with the challenges of climate variability by adapting their survival strategies to changes in rainfall and temperature. But the message is clear: over the next century this variability will increase and the climate of Arab countries will experience unprecedented extremes. Higher rates of poverty and unemployment percentage and that will reduce the quality of life; socio-economic disturbance; increase food insecurity; with expectation of higher rates of conflicts and displacement that will cause high instability.

The Arab countries are rated among nations facing extreme and high water security risks as having least secure supplies of water, less than 500 cubic meters per person per year in some of the Arab countries and characterized by its aridity. Rainfall could be considered the critical climate variable as most of Arab region could be considered desert regions that receive annual rainfall totals of less than 200 millimeters, while, the central parts of the Sahara receive less than 50 millimeters, but the part located at Mediterranean zones receive above 500 millimeters of rainfall per year, whereas the annual rainfall in south Sudan and the Comoros is more than 1,000 millimeters, at the meantime the mean annual temperature is vary between 20°C and 25°C in the desert regions, up to 28°C on the Arabian Peninsula, between 15°C and 20°C in the Mediterranean and subtropical zones, (World Bank 2012). High evapo-transpiration rates greatly reduce the amount of water that turn into surface runoff or percolate through the soil to recharge aquifers. For example, it is estimated that in Jordan over 90 percent of the rain evaporates leaving a fraction to recharge aquifers and feed surface runoff (ESCWA 2005).

Information related to natural resources for Arab countries are shown in table (3.1), and in Figure (3.1)while information characterizing the socio-economic for the Arab countries are shown in (Table 3.2).

---

[16] Arab region covers 13.38 million Km^2 , and the Arab countries are “Algeria, Bahrain, Comoros, Djibouti, Egypt, Iraq, Jordan, Kuwait, Lebanon, Libya, Mauritania, Morocco and Western Sahara, Oman, Palestine, Qatar, Saudi Arabia, Somalia, Sudan, Syria, Tunisia, United Arab of Emirates UAE and Yemen”.

The majority of Arab countries are already experiencing water deficits in terms of internal and external renewable water resources. By midcentury all Arab countries will face serious water deficits as demand and supply continue to diverge. Total regional renewable water shortage will be about 200 cubic kilometers per year in 2040–2050 based on the average climate change projection, Uncertainty in the climate change projections was considered and the 10% and 90% range in water shortage is between 90 and 280 km^3 per year in the dry and wet scenarios considered in the World Bank study. The 2000-2009 supply-demand gap is filled by non-renewable water resources including fossil groundwater and desalination as well as through reuse. The demand is expected to rise by about 25 percent in 2020–2030 and up to 60 percent in 2040–2050 while renewable supply will drop by more than 10 percent over the same time period in the region This will result in an unmet demand for the entire Arab region, expressed as percentage of total demand, which will increase from 16 percent currently to 37 percent in 2020–2030 and 51 percent in 2040–2050, (World Bank 2011). The Arab region has the highest reliance on external water resources; more than 65% of the annually renewable resources originate outside the boundaries of the Arab, and many countries that are currently not facing any shortages will be confronted with huge deficits in the near and distant future, (World Bank 2012).

Climate stress combined with better social and infrastructural services in cities has already led to the rapid urbanization of many Arab countries. As a result, millions of people have left their rural homes to settle in urban centers, nd it is expected that by mid-centaury the total population in urban areas will reach 70% of the total population, (UNISDR 2013). All people of the region are vulnerable to the impacts of climate change and variability on water availability and food security. Conflicts and cities made worse by rapid growth partly driven by displacement and migration by rural and fragile communities poor.

Table 3.1. The Main Natural Resources Characteristic in Arab Countries.

Country	Land area	Vegetation Cover	Rainfed Areas			Irrigated	Freshwater Withdrawal	
			Rangelands	Rainfed Croplands	Forests			
	(sq. km)	Hectare	Hectare	Hectare	Hectare	Hectare	cubic Km /year	per Capita
Algeria	2,381,740	41442276	20660325	17120925.3	1429044	569400	5.72	176
Bahrain	750	6900	Data missing	Data missing	175954	4000	0.36	540
Comoros	1,860	154938	Data missing	Data missing	5132450	100	0.01	17
Djibouti	23,180	1701412	1677929.3	3062.04	1009840	1000	0.02	44
Egypt	1,001,450	3705365	336662.8	376990.97	206140	3422000	68.3	999
Iraq	434,320	8729832	4241880.5	2254429.92	100145	3525000	66	2,911
Jordan	88,780	7881888.4	6373402	34329.56	825208	78900	0.94	163
Kuwait	17,818.00	151453	28398.896	12005.13	0	8600	0.91	390
Lebanon	10,230	688479	127479.79	420878.95	97658	104000	1.31	342
Libya	1,759,540	15483952	8907470.4	2710030.88	137082	470000	4.33	846
Mauritania	1,030,700	39681950	33619697	5507506.47	2460642	45000	1.35	437
Morocco	446,300	30035990	10305707	12383240.65	6954	1485000	12.61	385
Oman	309,500.00	2135550	1630461.4	332056.33	2976	58900	1.32	470
Palestine	6,000	-	-	-	54727630	0	-	-
Qatar	11,586.00	64881.6	15591.664	6769.37	0	12900	0.44	510
Saudi Arabia	2,149,690.00	173479983	69976538	17975820.82	6775240	1620000	23.67	876
Somalia	627,337.00	44039057.4	28521487	10520291.8	527968	200000	3.3	411
Sudan	1,861,484.00	107035330	55573964	16605886.27	0	1890000	27.59	687
Syria	183,630	13900791	4638727.3	4693440.54	317680	1341000	16.76	908
Tunisia	155,360	9787680	4133214.3	3808536.52	0	397000	2.85	294
UAE	83,600.00	568480	20247.372	17842.01	975	92000	3.99	1,557
Western Sahara	266,000.00	0	0	0	1074845	0	-	-
Yemen	527,968.00	23441779.2	14535037	3742794.81	5345.4	680100	3.57	172
TOTAL	13,378,823	524117967.6	265324219	98526838.34	75013776.4	16004900	245.35	673

Information is calculated by the Author from (Arino et al (2008) and The European Space Agency (2010) http://www.esa.int/images/globcover_poster 2010_H.jpg).

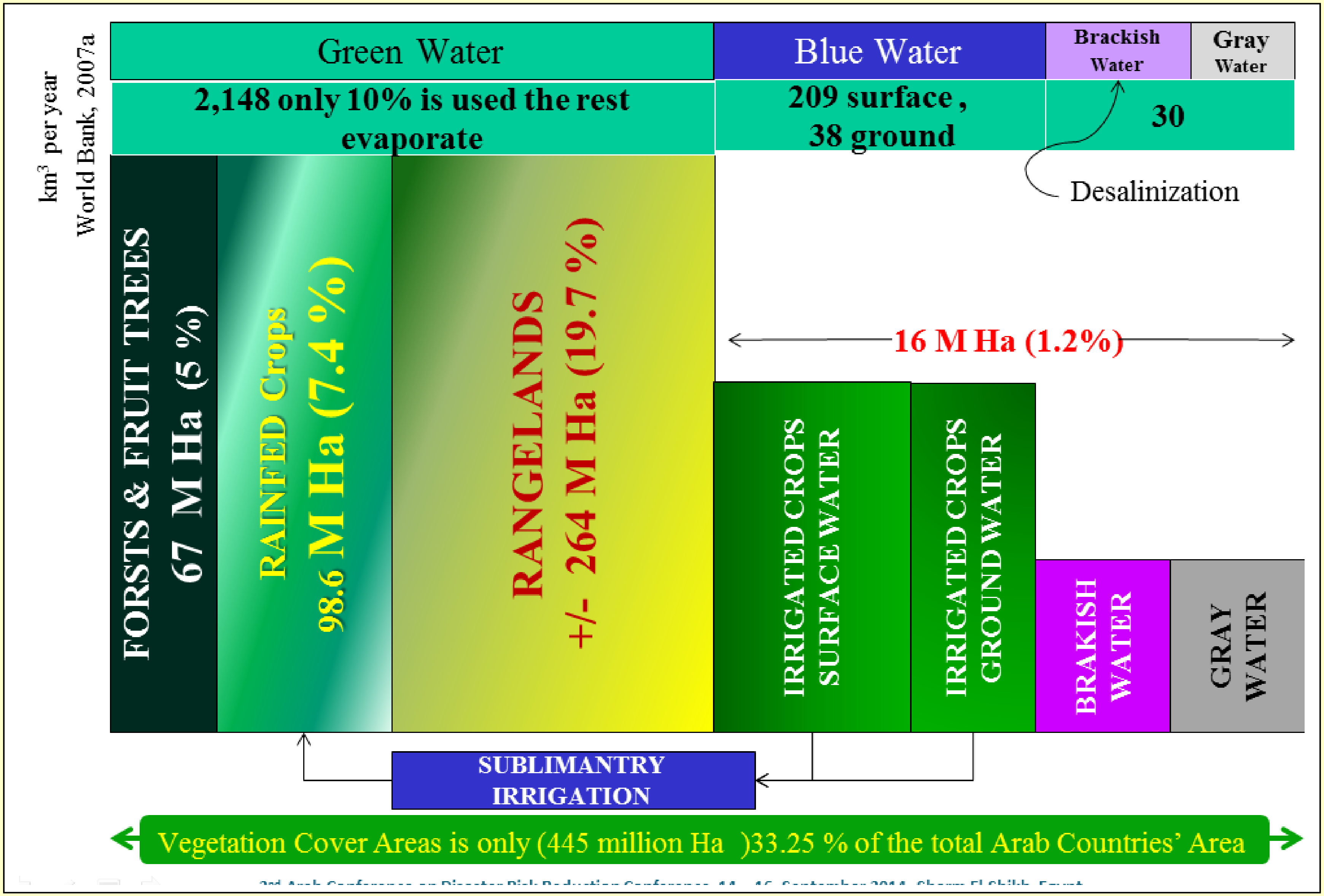


Figure 3.1. Water and Land uses in the Arab Region

Table 3.2. The Main Socio-Economic Characterization in Arab Countries.

Country	Population	Growth rates	Migration	GDP	per Capita	Agric Share in GDP	Unemployment rates	below Poverty line	Literacy
	person	%	person	million US$	US$	%	%	%	%
Algeria	38,814,000	1.88	-36097	284,700.00	7,475	12	10.3	23	72.6
Bahrain	1,314,100	2.49	17872	34,960.00	27,284	0.4	15	-	94.6
Comoros	766,900	1.87	-1979	911	1,211	45	20	60	75.5
Djibouti	810,200	2.23	4910	2,505.00	3,162	3	59	18.8	67.9
Egypt	86,895,000	1.84	-16510	551,400.00	6,465	14.5	13.4	22	73.9
Iraq	32,586,000	2.23	0	248,000.00	7,784	9.7	16	25	78.5
Jordan (*)	7,930,000	3.86	136555 (*)	40,020.00	6,174	4.5	14	14.2	95.9
Kuwait	2,743,000	1.7	-3045	165,800.00	61,514	0.3	3.4	-	93.9
Lebanon (*)	5,883,000	9.37	493113 (*)	64,310.00	15,565	4.6	-	28	89.6
Libya	6,244,000	3.08	99966	73,600	12,262	3.2	30	-	89.5
Mauritania	3,517,000	2.26	-2989	8,204.00	2,387	17.8	30	40	58.6
Morocco	32,987,000	1.02	-114135	180,000.00	5,513	16.6	9.5	15	67.1
Oman	3,220,000	2.06	-1449	94,860.00	30,075	1.5	15		86.9
Palastine	4,559,000	2.58	0	8,022.00	1,898	3.7	22.5	26.2	95.3
Qater	2,123,000	3.58	58064	198,700.00	97,285	0.1	0.3	-	96.3
saudi Arabia	27,346,000	1.49	-16134	927,800.00	34,440	2	10.5	-	87.2
Somalia	10,428,000	1.75	-99170	5,896.00	583	60.2	-	-	37
Sudan	35,482,000	1.78	-154702	89,970.00	2,582	25	20	46.5	71.9
Syria (*)	17,952,000	-9.73	-2037732 (*)	107,600.00	4,778	16.9	17.8	11.9	84.1
Tunisia	10,938,000	0.92	-19032	108,400.00	10,004	10.6	17.2	3.8	79.1
UAE	5,629,000	2.71	76442	269,800.00	49,288	0.8	2.4	19.5	90
Western Sahara	554,800	2.89	-1920	906.5	2,369	-	-	-	-
Yemen	26,053,000	2.72	67998	61,630.00	2,426	7.9	35	45.2	65.3
TOTAL	364,775,000	1.47	-1549973	3,527,994	9672	7	15.01	21.67	78.33

Information collected by the Authors from different resources including FAO Statisti3 "FAOSTAT" and http://world.bymap.org/ (2014).

(*). As a result of Syrian Conflict.

3.2. Agriculture Drought Hazard in Arab Region

The total studied area covers 22 countries and represents approximately 1.34 billion hectares of land. The total rainfed areas are covering 439 million hectares (represent 32.8% of the total studied area). These rainfed areas could be sub-divided into 3 main land use types, the rainfed croplands area, the Rangelands area and the Forests that represent 7.4%. 19.83% and 5.6% of the total studied area respectively.

The monthly VCI and TCI were calculated from the MODIES images and monthly VHI were then calculated from the monthly VCI and TCI. And from the VHI the monthly, Seasonally and decade ADI were calculated and presented as shown in (figure 2.2,a). ADF and ADC were also produced as shown in (figure 2.2b and 2.2c). ADV were also analyzed and calculated from the phases as shown in (figure 2.2d). The ADH map was then produced from the crossing of ADI, ADV, ADF and ADC as shown in table (3.3) and figure (3.3) and classified into 4 major groups

- C1. No DHA covers 885.74 million Km^2 of the study area and represents 66.21%
- C 2 Slight DHA covers 2.4 million Km^2 of the study area and represents 17.88%
- C 3. Moderate DHA covers 1.6 million Km^2 of the study area and represents 11.91%
- C 4. Severe DHA covers 0.53 million Km^2 of the study area and represents 4.01%

Total effected areas by ADH are ≈ 452 million hectares represents 33.76% of the total Arab Region area, but the severely affected (moderate and severe) areas are ≈ 213 million hectares represents 15.92% of the total Study area.

Countries could be sorted by ADH coverage % as follows: Lebanon, Qatar, Palestine, Morocco, Kuwait, Syria, Tunisia, Iraq, Djibouti, Somalia, Western Sahara, Saudi Arabia, U A E, Sudan, Yemen, Jordan, Algeria, Mauritania, Oman, Libya, and Egypt with the following coverage % 89.62, 86.37, 85.29, 84.22, 83.12, 79.79, 69.8, 68.87, 68.33, 56.53, 43.68, 39.71, 39.68, 33.3, 29.46, 28.73, 25.52, 24.77, 19.43, 16.8 and 15.9 Respectively.

Countries could be sorted by ADH Severity % as follows: Kuwait, Somalia, Qatar, Syria, Iraq, Djibouti, Lebanon, Palestine, Morocco, Tunisia, Saudi Arabia, Sudan, Yemen, Algeria, Western Sahara, Mauritania, Jordan, UAE, Egypt, Oman and Libya with the following severity % 73.83, 52.57, 51.49, 49.89, 49.26, 47.82, 39.83, 34.27, 34.04, 30.77, 15.59, 14.95, 13.67, 12.6, 10.64, 10.09, 6.83, 3.98, 3.58 and 3.46, respectively.

3.3. Affected Population by ADH.

The total affected population by ADH in Arab region is 194.3 million people that represent ≈54% of the total Arab region population, at least 100 million people are slightly affected, and 67 million people are moderately affected and 27 million people are severely affected. And countries are ranked according to the total affected population % as shown in (table 3.4).

3.4. Land Degradation in Arab Region

Total effected areas by LD are ≈ 600 million hectares represents 44.84% of the total Arab Region area, but the severely affected (moderate and severe) areas are ≈ 205 million hectares represents 15.35% of the total Study area. The LD map was then produced as shown in table (3.5) and figure (3.4). Countries could be sorted by LD coverage % as follows: Kuwait, Djibouti, Saudi Arabia, Comoros, Iraq, Syria, Somalia, Egypt, Yemen, Qatar, Libya, Bahrain, Algeria, Palestine, Oman, Mauritania, UAE, Sudan, Jordan, Tunisia, Morocco and Lebanon with the following coverage % 83, 82.2, 68.7, 64.2, 64.1, 63.1, 50.2, 47.3, 46.3, 45.9, 45.8, 41.1, 40.5, 39.4,38, 36.9, 35.3, 33.3, 29.1, 27.3, 14.5 and 9.5 Respectively. Countries could be sorted by LD Severity % as follows: Djibouti, Syria, Iraq, Comoros, Kuwait, Somalia, Saudi Arabia, Palestine, Bahrain, Yemen, Sudan, Qatar, Tunisia, Egypt, Oman, Jordan, Mauritania, Lebanon, Libya, UAE, Morocco and Algeria with the following severity % 69.3, 51.6, 51, 50.2, 44.7, 39.1, 28.9, 28.03, 24.2, 20.4, 14.95, 13.3, 13, 10.7, 9.5, 9.3, 8.9, 7.1, 6.2, 6, 3.6 and 2.9, respectively.

3.5. The Combined Effect of both ADH and LD on Land Use.

3.5.1. Combined ADH with LD.

The Combing of the ADH and LD maps in Arab Region as shown in figure (3.5, a, b, c, d), Table (3.5) could be classified in 6 classes as follows:

- Class 1: High severity ADH and High severity LD (H ADH_ H LD) that covers area of about 4.82 million hectares that represents 0.36% of the total Arab region area.
- Class 2: High severity ADH and Moderate severity LD (H ADH_ M LD) that covers area of about 18.73 million hectares that represents 1.41% of the total Arab region area.
- Class 3: Moderate severity ADH and High severity LD (M ADH_ H LD) that covers area of about 5.54 million hectares that represents 0.41% of the total Arab region area.
- Class 4: Moderate severity ADH and Moderate severity LD (M ADH_ M LD) that covers area of about 18.68million hectares that represents 1.41% of the total Arab region area.
- Class 5: Slight severity ADH and High severity LD (M ADH_ H LD) that covers area of about 3.31million hectares that represents 0.25% of the total Arab region area.
- Class 6: Slight severity ADH and Moderate severity LD (M ADH_ M LD) that covers area of about 15.32 million hectares that represents 1.15 % of the total Arab region area.

Countries could be ranked according to severity coverage as follows: Syria, Algeria, Sudan, Oman, Tunisia, Comoros, Jordan, Djibouti, Yemen, Somalia, Lebanon, Libya, Palestine, Mauritania, Egypt, Iraq, Kuwait, Morocco, Qatar, Saudi Arabia, UAE and Western Sahara

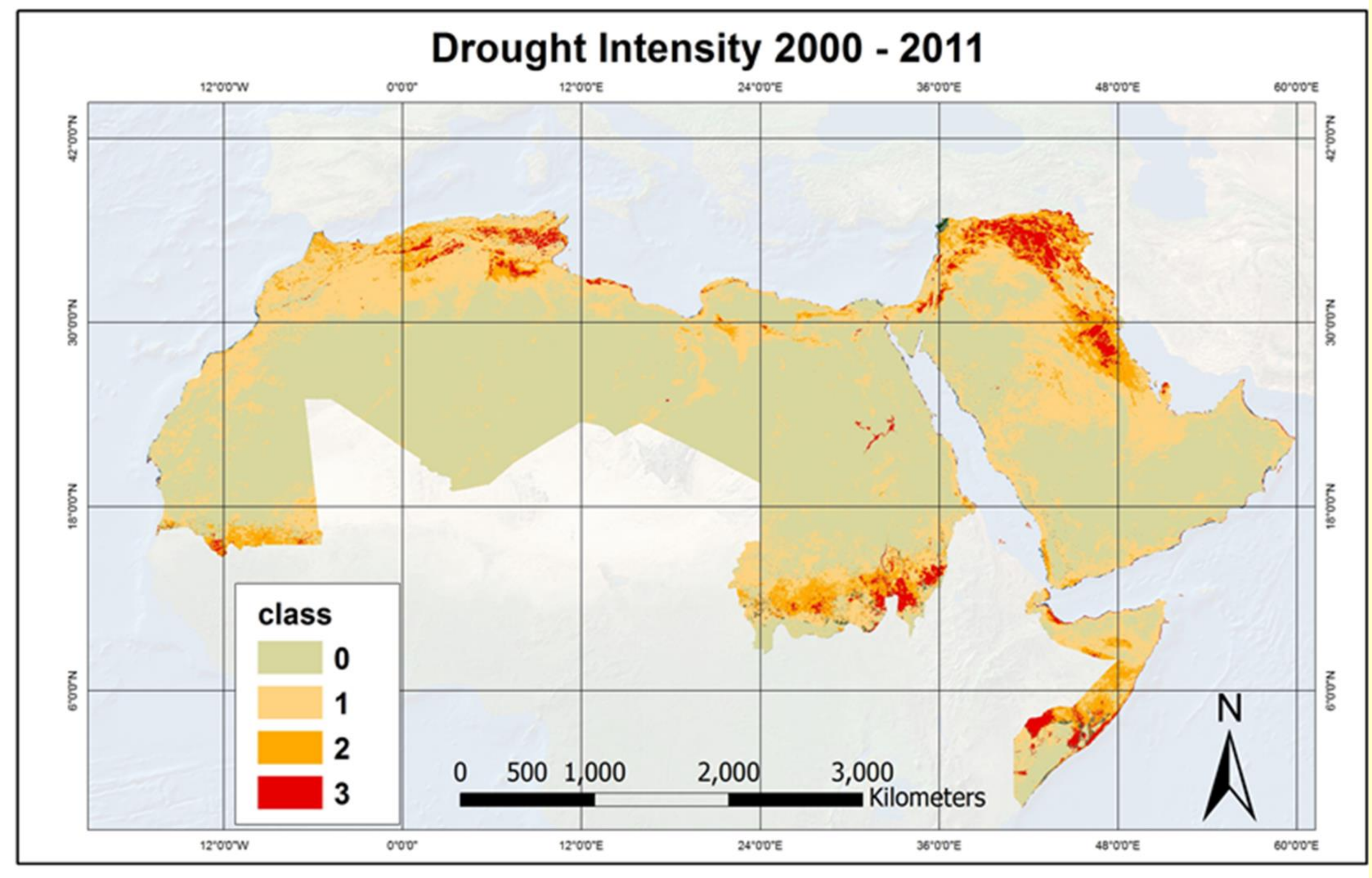


Figure 3.2 a Agriculture Drought Hazard Elements in the Arab Region
Agriculture Drought Intensity

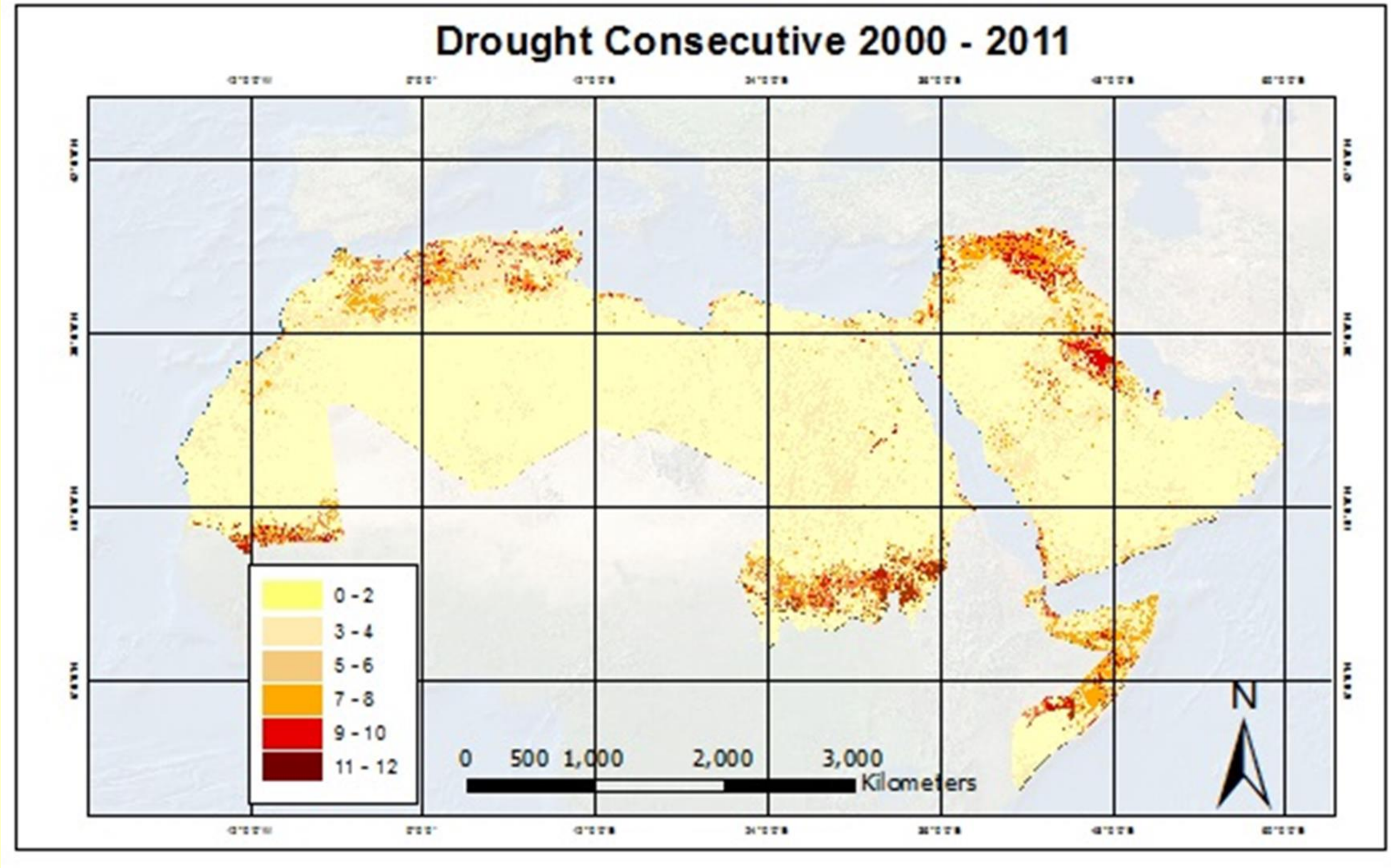


Figure 3.2 b. Agriculture Drought Hazard Elements in the Arab Region
Agriculture Drought Consecutive

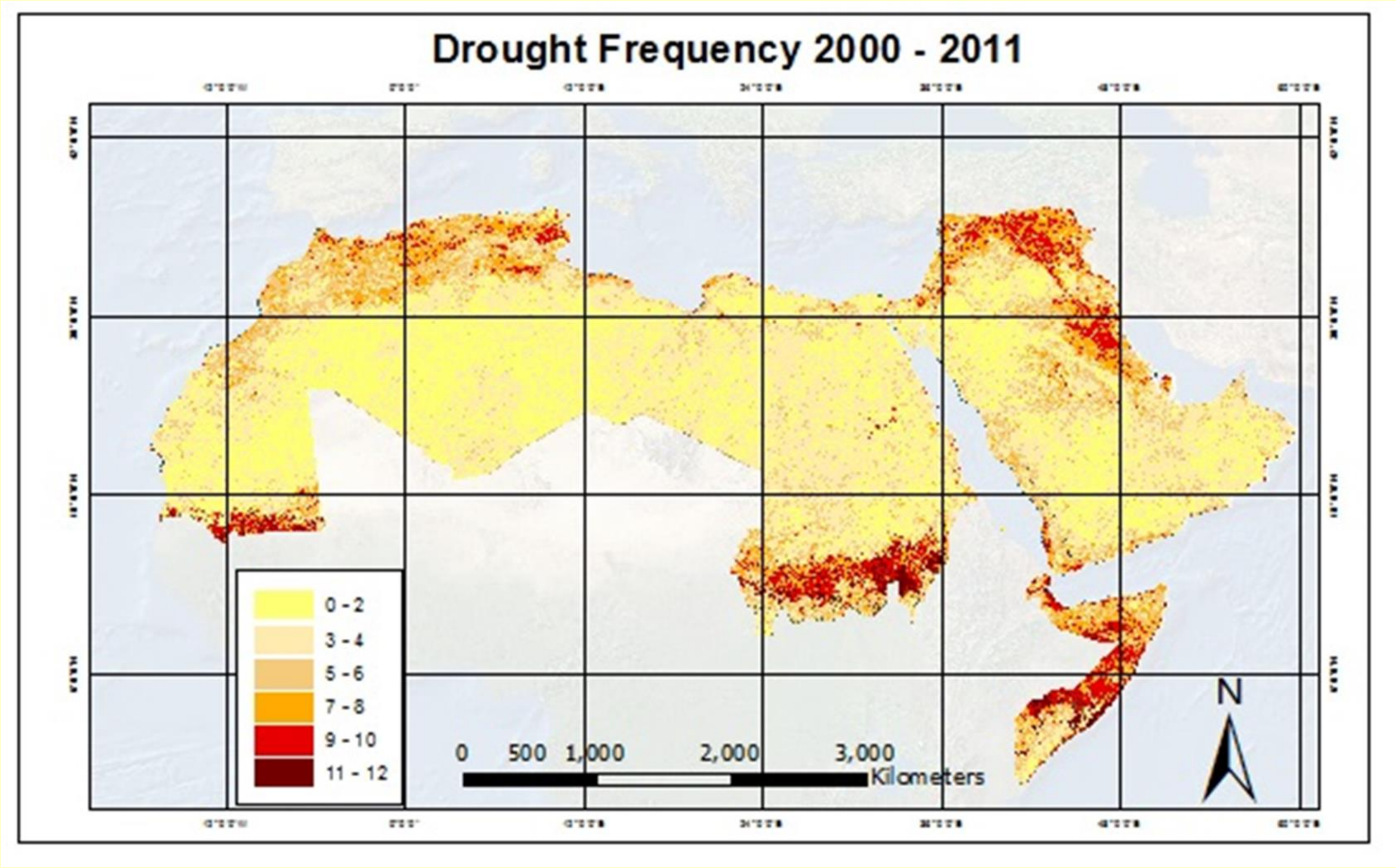


Figure 3.2 c. Agriculture Drought Hazard Elements in the Arab Region
Agriculture Drought Frequency

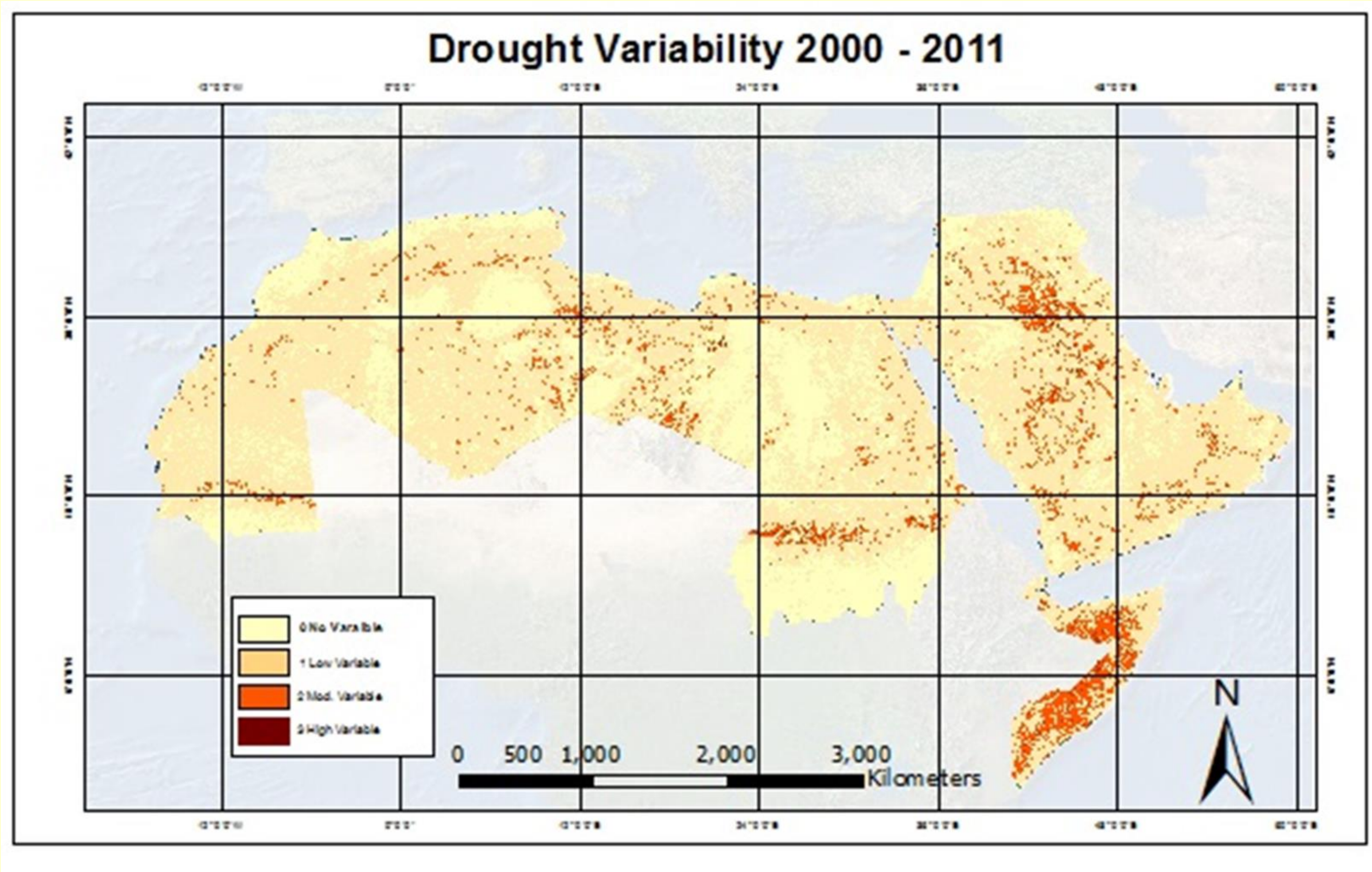


Figure 3.2 d. Agriculture Drought Hazard Elements in the Arab Region
Agriculture Drought Variability

Table 3.3. Severity and Total ADH Coverage on the Study Area during the period 2000/2011.

Country	ADH Severity			ADH total Coverage (1+2+3)	High Severity (1+2)
	Sevier = 1	Moderate =2	Slight =3		
Lebanon	15.16	24.67	49.79	89.62	39.83
Gaza Strip	9.69	35.09	44.82	89.6	44.78
Qatar	18.15	33.34	34.88	86.37	51.49
Morocco	2.9	31.14	50.18	84.22	34.04
Kuwait	47.12	26.71	9.29	83.12	73.83
West Bank	3.8	19.96	57.23	80.99	23.76
Syria	19.87	30.02	29.9	79.79	49.89
Tunisia	10.6	20.17	39.03	69.8	30.77
Iraq	21.95	27.31	19.61	68.87	49.26
Djibouti	9.08	38.74	20.51	68.33	47.82
Somalia	18.56	34.01	3.96	56.53	52.57
Western Sahara	0.17	12.43	31.08	43.68	12.6
Saudi Arabia	4.09	11.5	24.12	39.71	15.59
U. Arab Emirates	0.14	6.69	32.85	39.68	6.83
Sudan	1.74	13.21	18.35	33.3	14.95
Yemen	1.87	11.8	15.79	29.46	13.67
Jordan	3.65	6.44	18.64	28.73	10.09
Algeria	3.34	9.41	12.77	25.52	12.75
Mauritania	1.03	9.61	14.13	24.77	10.64
Oman	0.18	3.4	15.85	19.43	3.58
Libya	0.6	2.86	13.34	16.8	3.46
Egypt	0.89	3.09	11.92	15.9	3.98
Total	**4.01**	**11.91**	**17.88**	**33.79**	**15.92**

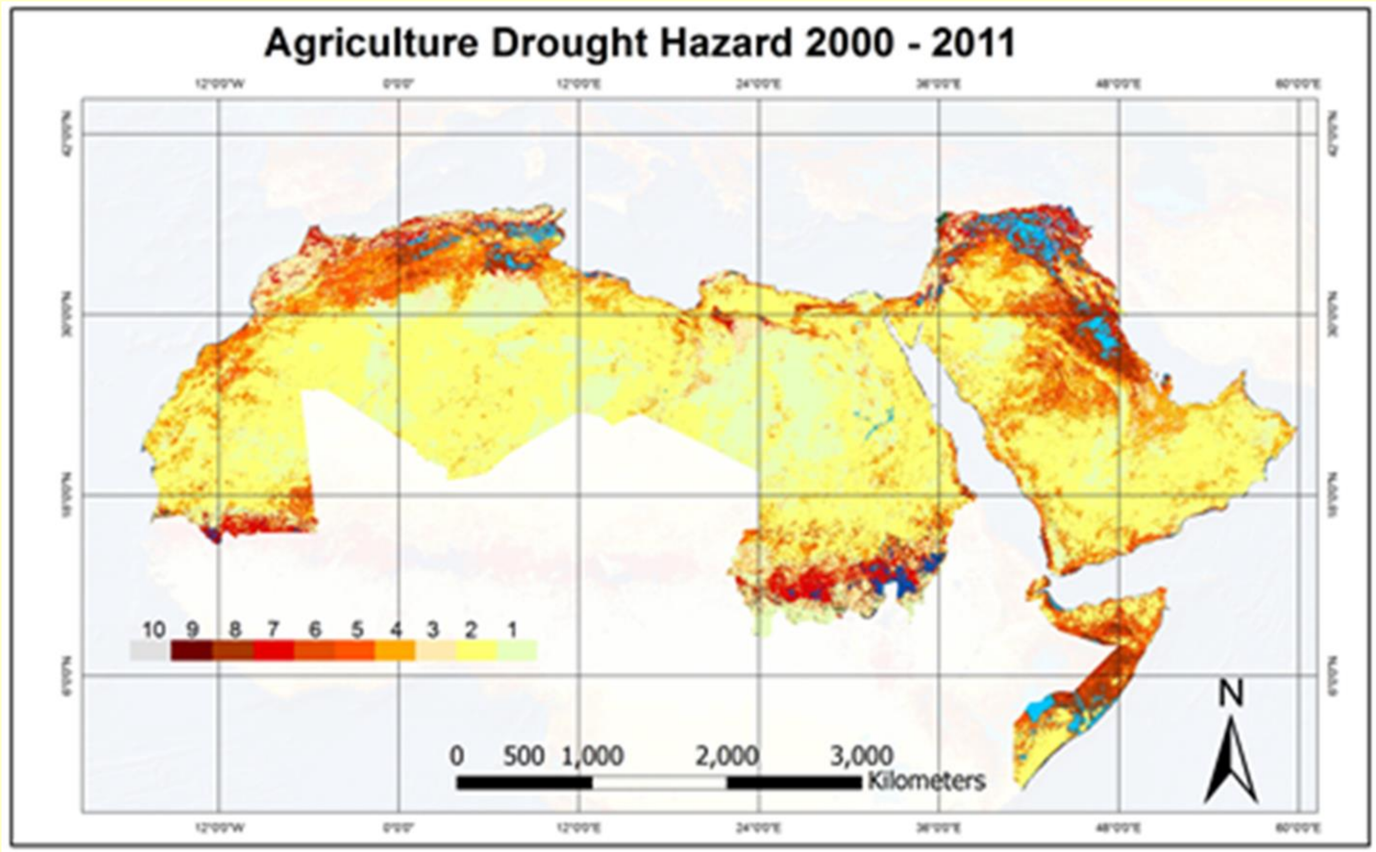


Figure 3.3. Agriculture Drought Hazard in the Arab Region

Table 3.4. The total Affected Population by ADH in Arab Region

Country	Total Population	Affected Population		Level of Affection					
		Total		Highly		Moderately		Slightly	
	Person	M Person	%	M Person	%	M Person	%	M Person	%
Palestine	4332801	3.79	88.8	0.47	13.1	1.18	28.95	2.14	46.85
Lebanon	4140289	3.66	88.4	0.62	14.9	0.98	23.7	2.06	49.8
Morocco	32309239	28.49	88.2	1.08	3.4	8.28	25.6	19.13	59.2
Kuwait	2646314	2.18	82.5	1.02	38.7	0.80	30.2	0.36	13.5
Qatar	1951591	1.60	82.2	0.23	11.7	0.69	35.1	0.69	35.4
Syria	22530746	18.15	80.6	4.51	20	7.26	32.2	6.39	28.3
Iraq	31129225	22.41	72	6.85	22	9.19	29.5	6.38	20.5
Djibouti	774389	0.55	70.6	0.07	9.1	0.32	41.7	0.15	19.8
Algeria	35406303	24.70	69.8	2.97	8.4	8.65	24.4	13.08	37
Tunisia	10732900	7.49	69.8	1.18	11	2.26	21	4.06	37.8
Jordan	6508887	3.94	60.5	0.44	6.8	0.76	11.7	2.74	42.1
Benin	9598787	5.20	54.2	0.98	10.2	1.57	16.4	2.65	27.6
U A Emirates	5314317	2.88	54.1	0.01	0.1	0.64	12	2.23	42
Western Sahara	522928	0.26	50.1	0.00	0.3	0.08	14.6	0.18	35.2
Sudan	34206710	16.76	49	1.28	3.7	7.20	21.1	8.28	24.2
Somalia	10085638	4.76	47.2	1.41	14	2.91	28.9	0.44	4.4
Mauritania	3359185	1.45	43.2	0.09	2.7	0.64	19.1	0.72	21.4
Saudi Arabia	26534504	11.03	41.6	0.79	3	3.17	12	7.06	26.6
Yemen	24771809	10.15	41	1.23	5	4.31	17.4	4.61	18.6
Libya	6733620	2.48	36.8	0.28	4.2	0.74	11.1	1.45	21.6
Oman	3090150	0.98	31.6	0.04	1.3	0.20	6.5	0.74	23.8
Egypt	83688164	21.39	25.6	1.42	1.7	5.02	6	14.95	17.9
TOTAL	360368496	194.3	53.9	26.97	7.48	66.85	18.55	100.47	27.88

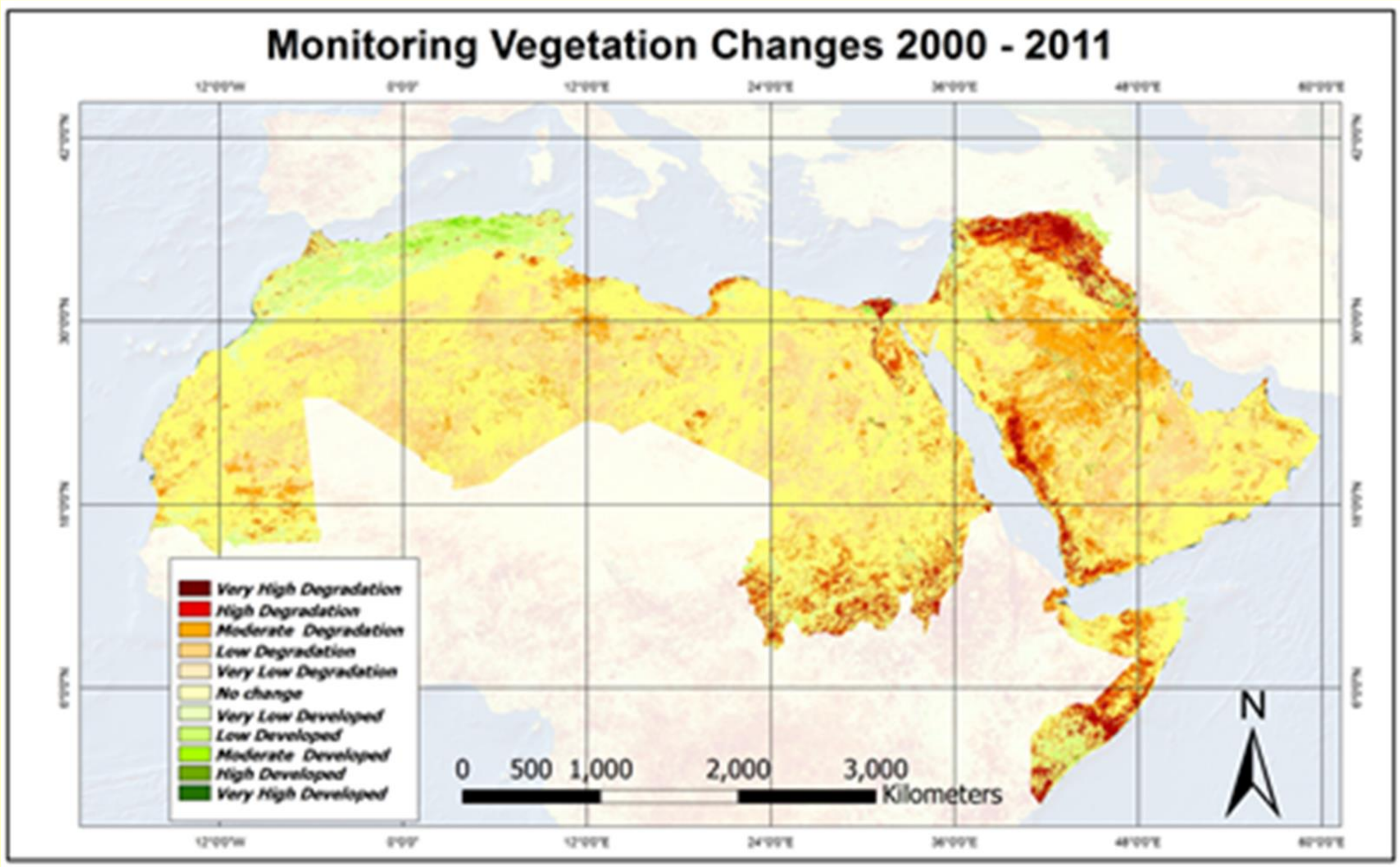


Figure 3.4. Monitoring Vegetation Changes 2000 - 2011

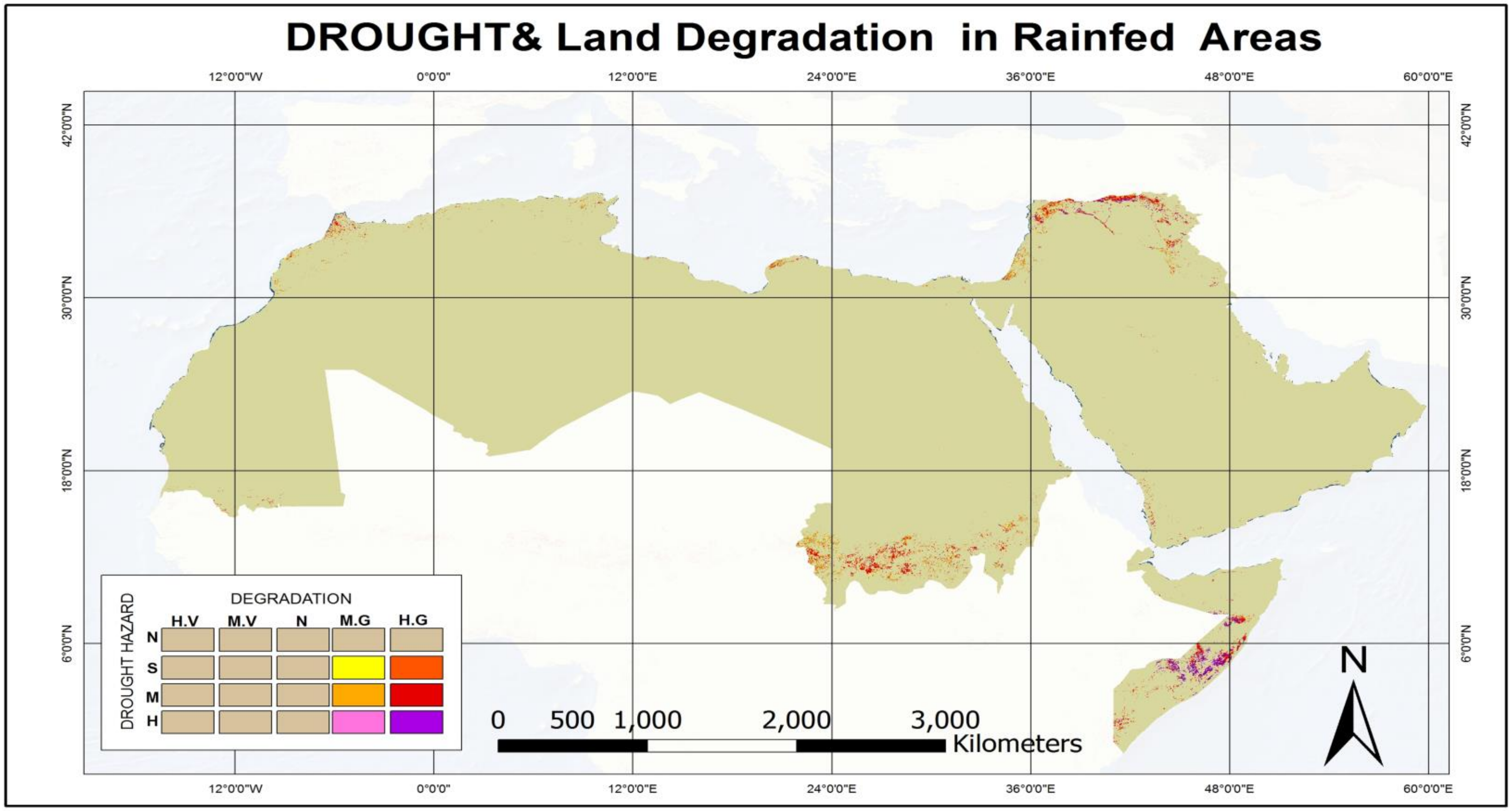


Figure 3.5. Agriculture Drought Hazard combined with Land Degradation in Arab Region

Table 3.5. Land Degradation in the Arab Countries.

Country	Total Area	vh_deg (1)	h_deg (2)	m_deg (3)	hot spots (1-3)		l_deg (4)	vl_deg (5)	Deg Total	
	Hectares	%	%	%	%	Hectares	%	%	%	Hectares
Kuwait	1781800	1.9	13.2	29.6	44.7	796464.6	31.8	6.5	83	1478894
Djibouti	2318000	2.9	30.6	35.8	69.3	1606374	10.4	2.5	82.2	1905396
Saudi Arabia	214969000	1.5	4.3	23.1	28.9	62126041	28.5	11.3	68.7	147683703
Comoros	186000	20	14.9	15.3	50.2	93372	9	5	64.2	119412
Iraq	43432000	13.2	15.9	21.9	51	22150320	10.1	3	64.1	27839912
Syria	18363000	15.8	20.2	15.6	51.6	9475308	8.6	2.9	63.1	11587053
Somalia	62733700	9	14.1	16	39.1	24528877	8.1	3	50.2	31492317
Egypt	100145000	1.4	2.3	7	10.7	10715515	19.6	17	47.3	47368585
Yemen	52796800	2.5	6.7	11.2	20.4	10770547	17.4	8.5	46.3	24444918
Qatar	1158600	0.4	1.9	11	13.3	154093.8	21.1	11.5	45.9	531797.4
Libya	175954000	0.1	0.7	5.4	6.2	10909148	21.9	17.7	45.8	80586932
Bahrain	75000	0.9	3.1	20.2	24.2	18150	16.1	0.8	41.1	30825
Algeria	238174000	0.1	0.2	2.6	2.9	6907046	22.1	15.5	40.5	96460470
Palastine	600000	4.65	9.54	13.84	28.03	168180	8	3.37	39.4	236400
Oman	30950000	0.3	1.1	8.1	9.5	2940250	19.1	9.4	38	11761000
Mauritania	103070000	0	0.8	8.1	8.9	9173230	17.2	10.8	36.9	38032830
UAE	8360000	0.8	1.3	3.9	6	501600	13.2	16.1	35.3	2951080
Sudan	186148400	**0.74**	1	**13.21**	14.95	27829186	**13**	5.35	**33.3**	61987417
Jordan	8878000	0.3	1.5	7.5	9.3	825654	13.1	6.7	29.1	2583498
Tunisia	15536000	0.7	2	10.3	13	2019680	9.2	5.1	27.3	4241328
Morocco	44630000	0.5	0.6	2.5	3.6	1606680	6.8	4.1	14.5	6471350
Lebanon	1023000	1.6	2.8	2.7	7.1	72633	1.6	0.8	9.5	97185
Total million Ha	1337.88	21.02	112.00	186.89.	205.39		161.5	69.04	599.89	
Total %	100	1.57	8.37	13.97	15.35		12.08	5.16	44.84	

3.5.2. Exposing Land Use to combined ADH and LD.

The total affected land used areas (Rangelands, Rainfed croplands and Forests) by combined ADH and LD are covering approximately 66.36 million hectares that represent 4.96 % of the total Arab region area. Countries and its local communities that depend on such areas for earning their leaving could be considered under a real threat.

The detailed impacts of combined ADH and LD on Rangelands, Rainfed croplands and Forests could be summarized as follows:

- Impacts on Rangelands: The total affected area by combined ADH and LD is covering 44 million hectares represents 3.26% of Arab Region area, and effected countries could be ranked as follows: Sudan, Somalia, Iraq, Syria, Mauritania, Saudi Arabia, Yemen, Libya, Djibouti, Morocco, Algeria, Jordan, Tunisia, Palestine, Oman, Egypt, Lebanon, Qatar, UAE, Kuwait, Western Sahara and Comoros.
- Impacts on Rainfed Croplands: The total affected areas by combined ADH and LD is covering 20.6 million hectares represents 1.54 % of the total studied area, and countries could be ranked as follows: Somalia, Sudan, Syria, Iraq, Jordan, Morocco, Yemen, Mauritania, Saudi Arabia, Algeria, Libya, Egypt, Tunisia, Palestine, Lebanon, Oman, UAE, Kuwait, Djibouti, Qatar, Bahrain, Comoros and Western Sahara
- Impacts on Forests: The total affected Forests area by combined ADH and LD is covering 1.78 million hectares represents 0.14 % of the total studied area, and effected countries could be ranked as follows: Syria, Algeria, Sudan, Oman, Tunisia, Comoros, Jordan, Djibouti, Yemen, Somalia, Lebanon and Libya.

3.6. Assessing Production Losses by Drought and Land Degradation Hazards

The assessment of the economic vegetation losses is based on the combined impact of ADH and LD on Arab region vegetation cover that includes Rangelands, Rainfed croplands, and Forests areas, that represents 97% of the total vegetation cover.

The total estimated production Losses on vegetation could be illustrated as follows:

- About 6.9 million hectares of <u>Rainfed Croplands</u> are affected. Countries of relatively larger losses could be ranked as follows: Somalia, Sudan, Iraq, Syria, Yemen, Morocco, Saudi Arabia, Mauritania, Algeria, Egypt, Libya, Tunisia, Palestine, Jordan, Lebanon, Oman, United Arab Emirates, Djibouti, Kuwait and Qatar, as shown in (Table 3.6).
- About 8.1 million hectares of <u>Rangelands</u> are affected. Countries of relatively larger losses could be ranked as follows: Somalia, Sudan, Iraq, Syria, Mauritania, Yemen, Saudi Arabia, Djibouti, Libya, Morocco, Algeria, , Jordan, Tunisia, Oman, Palestine, Egypt, Lebanon and minor areas in Qatar, Kuwait and UAE, as shown in (Table 3.7).
- About 0.33 million hectares of Forests are affected. Countries of relatively larger losses could be ranked as follows: Sudan, Algeria, Somalia, Tunisia, Morocco, Syria, Iraq, Yemen, Saudi Arabia, Lebanon, and Oman, as shown in (Table 3. 8).

Table 3.6. Land Production Losses in Rainfed Areas

Country	High	Moderate	Slight	Total	%
Algeria	29600.27	3150.483	7111.734	39862.49	0.2
Djibouti	159.03	0	41.085	200.115	6.5
Egypt	34958.36	448.1625	2850.178	38256.7	10.1
Iraq	307202.3	5529.545	70311.68	383043.5	17
Jordan	11404.48	34.0625	1337.14	12775.68	37.2
Kuwait	18.3465	0	76.563	94.9095	0.8
Lebanon	5559.503	582.115	1496.065	7637.683	1.8
Libya	21392.3	128.43	6717.388	28238.12	1
Mauritania	27732.11	2492.968	13169.49	43394.57	0.8
Morocco	40940.85	1704.173	29253.7	71898.73	0.6
Oman	6143.814	10.7775	599.777	6754.369	2
Palestine	13184.36	5.895	957.341	14147.6	Not defined
Qatar	10.953	6.0175	65.969	82.9395	1.2
Saudi Arabia	60140.56	400.14	6674.691	67215.39	0.4
Somalia	2819162	77692.74	197126	3093981	29.4
Sudan	2170062	15556.26	392231	2577849	15.5
Syria	279401.2	3952.838	95391.21	378745.3	8.1
Tunisia	21690.46	868.43	5220.534	27779.42	0.7
United Arab Emirates	301.707	0	26.128	327.835	1.8
Yemen	93878.06	852.7225	11519.09	106249.9	2.8
TOTAL RAINFED	**5942943**	**113416**	**842177**	**6898535**	**7**

Table 3.7. Land Production Losses in Rangelands Areas

Country	High	Moderate	Slight	Total	%
Somalia	6100973.45	677424.77	75200.42	6853598.64	24.03
Sudan	4472988.58	622930.52	1590428.53	6686347.63	12.03
Iraq	1655012.27	53136.62	194955.48	1903104.38	44.86
Syria	739397.79	22462.31	111869.1	873729.2	18.84
Mauritania	450115.39	139557.21	102411.56	692084.16	2.06
Yemen	170037.59	11291.87	60080.2	241409.66	1.66
Saudi Arabia	142214.29	9032.59	85322.76	236569.63	0.34
Djibouti	144031.16	8340.09	15746.57	168117.82	10.02
Libya	63901.5	13494.21	44122.31	121518.02	1.36
Morocco	48011.2	9044.37	28899.34	85954.91	0.83
Algeria	73016.25	3809.13	8297.6	85122.98	0.41
Jordan	22887.89	5105.94	16429.01	44422.84	0.7
Tunisia	18103.6	2605.41	11766.13	32475.14	0.79
Oman	8751.65	1729.26	7200.32	17681.22	1.08
Palestine	4991.18	1540.48	9134.13	15665.79	
Egypt	3602.89	2777.08	3494.24	9874.21	2.93
Lebanon	1779.42	115.54	1071.62	2966.57	2.33
Qatar	310.31	538.77	139.18	988.26	6.34
Kuwait	364.59	353.71	13.14	731.45	2.58
United Arab Emirates	220.39	22.3	363.96	606.65	3
Total RANGELANDS	**8019738**	**907887.41**	**2291751**	**11219376**	**4.23**

Table 3.8. Land Production Losses in Forests Areas

Country	High	Moderate	Slight	Total	%
Sudan	214647.6	105997.7	3953.9	324599.2	0.63
Algeria	288304.3	202.7	164.4	288671.3	20.2
Somalia	6378.4	5116.9	54.6	11550	2.19
Tunisia	2937.3	265.4	8.4	3211.1	0.25
Morocco	1972	919.1	124.6	3015.6	43.37
Syria	1422.6	763.4	532.1	2718	0.86
Iraq	868.8	248.8	71.7	1189.3	1.19
Yemen	207.8	151.9	0	359.8	6.73
Saudi Arabia	300.6	0	37.8	338.4	0
Lebanon	266.6	8.4	2.4	277.3	0.28
Oman	0	6.3	0	6.3	0.21
Total FORESTS	302658	7682.78	995.888	311337	2.95

- In total for all Arab countries about 14.26 million hectares of Vegetation Cover, are affected.. Countries of relatively larger production land losses in Arab Region could be ranked as follows: Somalia, Sudan, Iraq, Syria, Mauritania, Algeria, Yemen, Saudi Arabia, Djibouti, Morocco, Libya, Tunisia, Jordan, Egypt, Palestine, Oman, Lebanon, Qatar, United Arab Emirates, Kuwait, as shown in (Table 3.9).

Table 3.9. Total Land Production Losses in Vegetation Cover Areas

Country	High	Moderate	Slight	Total	%
Somalia	8926514	760234.4	272381	9959129	55.62
Sudan	6857698	744484.5	1986613	9588796	28.16
Iraq	1963083	58914.97	265338.9	2287337	63.05
Syria	1020222	27178.55	207792.4	1255192	27.8
Mauritania	477847.5	142050.2	115581.1	735478.7	2.86
Algeria	390920.8	7162.313	15573.73	413656.8	20.81
Yemen	264123.5	12296.49	71599.29	348019.3	11.19
Saudi Arabia	202655.5	9432.73	92035.25	304123.4	0.74
Djibouti	144190.2	8340.09	15787.66	168317.9	16.52
Morocco	90924.05	11667.64	58277.64	160869.2	44.8
Libya	85293.8	13622.64	50839.7	149756.1	2.36
Tunisia	42731.36	3739.24	16995.06	63465.66	1.74
Jordan	34292.37	5140.003	17766.15	57198.52	37.9
Egypt	38561.25	3225.243	6344.418	48130.91	13.03
Palestine	18175.54	1546.375	10091.47	29813.39	0
Oman	14895.46	1746.338	7800.097	24441.89	3.29
Lebanon	7605.523	706.055	2570.085	10881.55	4.41
Qatar	321.263	544.7875	205.149	1071.2	7.54
United Arab Emirates	522.097	22.3	390.088	934.485	4.8
Kuwait	382.9365	353.71	89.703	826.3595	3.38
Total VEGETATION COVER	14265339	1028986	3134924	18429249	14.18

A key challenge for understanding and addressing these risks is to bring together the science of climate change and drought risks on one hand, and emerging resilience based development policy responses on the other, through mutual interest in cooperation of the LAS and UNDP on Drought and Drylands.

As shown in Box "1", Box "2" and in figure (3.6), the increasing consequences of drought on environment stress (e.g. more Desertification reduced Biodiversity, water scarce, increased days of dust storms and forest fire areas, etc..). That will increase social vulnerability (poverty, unemployment, change land use pattern and its production, effect public services and the slandered of leaving, etc…) and increase instability in local communities and national as well (e.g. food shortage, conflicts, displacements and migration, crimes, etc..)

Estimated Losses in Rainfed Production		Estimated Losses in Rangeland Production		Estimated Losses in Forests Production		Total Production Losses from total Vegetation Cover	
Million Ha	%	Million Ha	%	Million Ha	%	Million Ha	%
14.47	14.6	40.22	15.24	1.4	2.3	56.09	12.62

BOX 1. Agriculture Production Losses in the last 12 years _ by Drought

Estimated Losses in Rainfed Production		Estimated Losses in Rangeland Production		Estimated Losses in Forests Production		Total Production Losses	
Million Ha	%	Million Ha	%	Million Ha	%	Million Ha	%
6.9	7	18.07	6.8	0.63	0.9	27.01	6.07

BOX 2. Agriculture Production Losses in the last 12 years due to Drought and L.D.

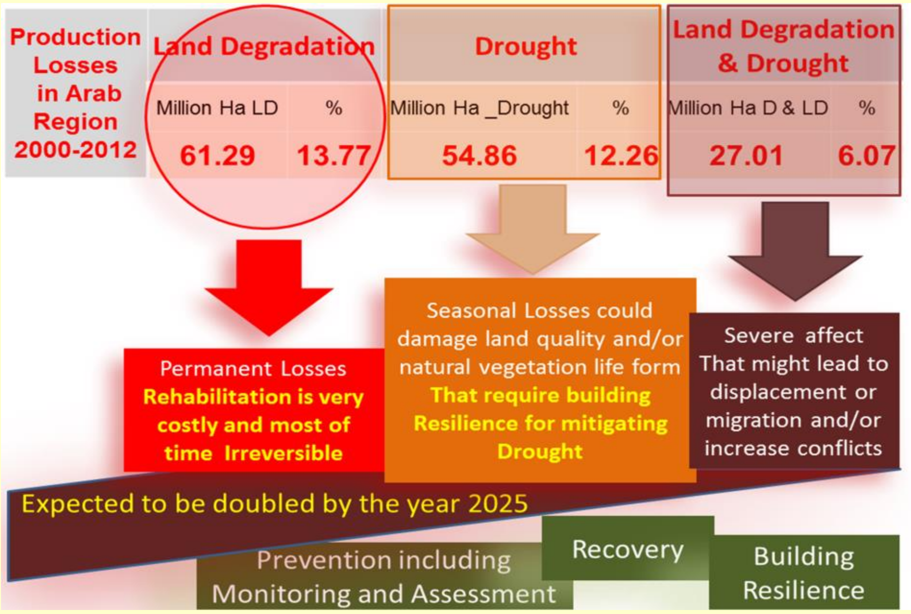


Figure 3.6 Summary of Agriculture Cover Production Losses in Arab Region

This framework, as shown in figure (3.7), is based firstly on drought indices for analyzing long-term drought trends and satellite data from the last fifteen years to reconstruct past agricultural droughts. By measuring monthly differences in productive capacity of vegetation and crop patterns, this allows a characterization of intensity, variability frequency and persistence of agricultural drought in any given area. With this information, it is possible to identify the exposure of areas of rain-fed agriculture, rangeland, forests, irrigated croplands, individuals and cattle to agricultural drought as well as the amount of drought-affected areas experiencing land degradation, and to further estimate expected annual average losses, in multi-resolution and scales that allow working in Multi levels (global, regional, national and local communities), (Erian et al., 2012).

Agriculture Production is likely to be affected by Agriculture drought hazard, Land degradation and combined phenomena's .

Increase in
Environmental stresses
Social Vulnerability
Are likely increasing
FOOD INSECURITY
And lead to
Migration, and Displacement,
Conflicts and instability

There for Changes in Landscape of food security due to increased hazards, Exposure and Vulnerability in National and Community levels
Could be one of the major challenges that affect Arab Region Stability .

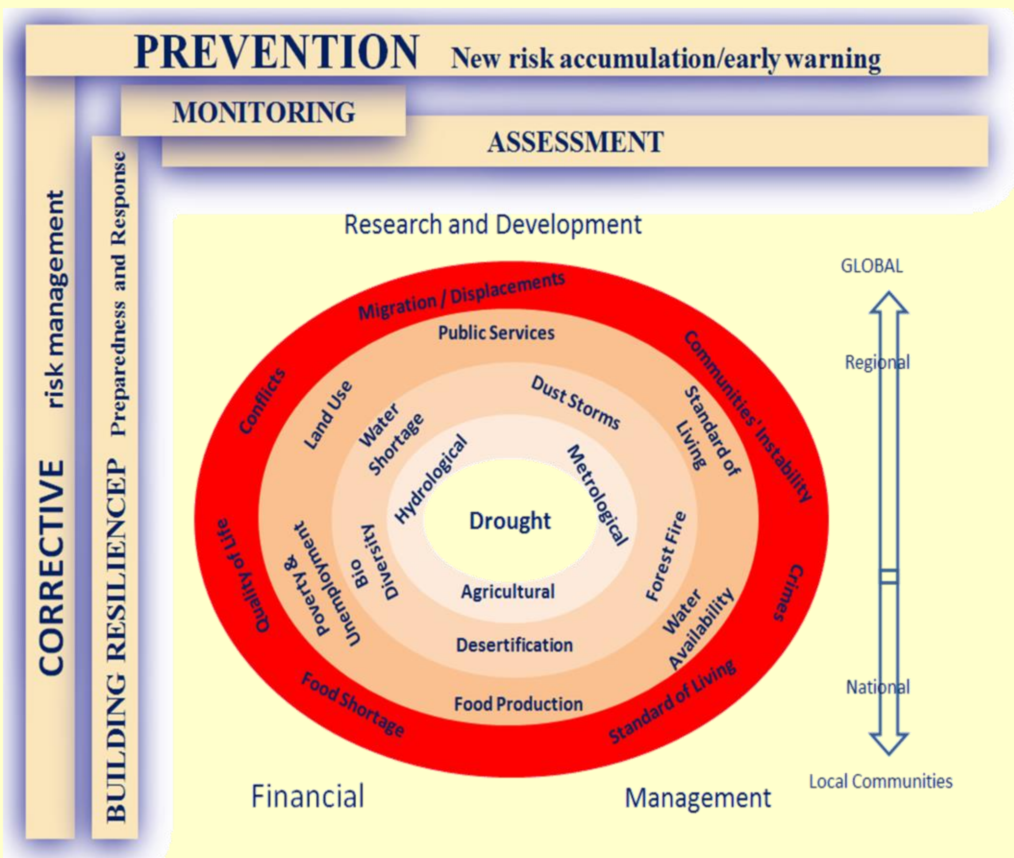


Figure 3.7. Framework for the Water, Food, and Social Vulnerability Nexus

This scientific analysis is then coupled with a resilience based framework to development policy to assess resulting social vulnerabilities and development responses that can reduce risks while building long-term resilience of development results.

3.7. Conclusion:

- Drought is extremely serious problem in the Arab region, and will be an increasingly serious threat for all Arab countries that already are suffering from increased conflicts, displacements and instability, alongside growing fragility of ecosystem services, with trends of land degradation, soil depletion and reduced water security.
- The Arab region is under growing food insecurity, increasingly food gab, and increased drought at a time when 28% of its population is already under in poverty. Drought and desertification across much in area with a high sensitivity of vegetation cover and crops to climate force that usually resulted in rapid land use changes and high vulnerability to land degradation. We must expect a continuing and increasing interplay between climate, land, water, food, migration, urbanization, and economic, social, and political stress. Due to the complexity of the events it is very difficult to analyze and to draw precise causal arrows.
- In this context, the Author(s) would like to explore this risk-resilience nexus with a view to enhancing abilities to prevent impacts of future drought cycles on human development trends in the Arab region and how the influence of drought and/or climate change could affect Arab states, especially it becomes more and more dependent on their water security and food security on other countries, at the time global climate change may create a major burden to their stability. Taken into consideration that the top nine wheat importers are all in the Middle East, and that 65% at least of the fresh water is coming from surrounding countries. As the region's population continues to climb, water availability per capita is projected to plummet; rapid urban expansion across the Arab world increasingly risks overburdening existing infrastructure and outpacing local capacities to expand service. Already as explained in the below case study, a country like Syria conflict has been accelerated by long drought that caused socio-economic difficulties in the rural areas.
- The focus on policies and actions that are prioritize prevention of future risk accumulation and the exacerbating factors to underlying social tensions and challenges in the Arab region. Principles for managing risk may require the following:

    - The sustainability of development and resilience of people, nations and the environment depend on sound risk management, which needs planning and investments that goes beyond the reduction of existing risk and includes the prevention of new risk accumulation.
    - Prevention and reduction of disaster risk- are an international legal obligation and constitute a safeguard for the enjoyment of human rights.
    - The increasingly trans-boundary and global characteristi3 of risk drivers require further cooperative efforts in their assessment and management.

- The availability of open source and open access science-based risk information and knowledge is instrumental to cost-benefit analysis, transparent transactions, accountability and the development of partnerships with stakeholders.

– Disaster risk reduction needs to embrace three complementary and strategic goals, namely:
  - Risk prevention and the pursuit of development pathways that minimize disaster risk generation;
  - Risk reduction, i.e. actions to address existing accumulations of disaster risk; and
  - Strengthened resilience, i.e. actions that enable nations and communities to absorb loss and damage, minimize impacts and bounce forward.

Chapter4. Drought and Conflict in Syria

4.1. Introduction

Syria is part of the historical region of Fertile Crescent area that is part of history of drought. If we looked to the history of the region we could recognize that in about 2200 BC, a temporary climate shift created 300 years of reduced rainfall and colder temperatures, which forced people to abandon their rainfed fields in what is now northeast Syria. As people migrated to the south or turned to pastoralism to survive, whole cities were deserted and covered in the dust of drought), (Weiss and Bradley 2001) as shown in, (figure 4.1).

Figure 4 1 Historical damaged civilization in Syria by drought (4000 years ago) – Area affected are in blue color

But in our today world, despite technological gains, the ability of climate affected people to migrate in the face of these challenges is limited partly because of borders that are difficult to cross and property rights that are difficult to leave behind or attain in new locations. But in conflict like in Syria the countries are forced to receive large displacement.

The ongoing crises in Syria is now crossing more than Three years after the first what started as peaceful protests against the regime in Dara'a in March 2011, and has degenerated into a bloody conflict. Despite the political reasons, in July 2013, the United Nations (UN)[17] estimated that more than 100,000 people had died since March 2011, while millions of officially registered and unregistered refugees are scattered from Egypt to Turkey and beyond, and an estimated 4.25 million people are internally displaced. Three years after the onset of the conflict there, Syria has become the world's leading country of forced displacement, with more than 9 million of its people uprooted from their homes.

[17] UN stop updating death toll in Syria conflict since July 2013.

As of today, 2,563,434 Syrians have registered as refugees in neighboring countries or are awaiting registration. With displacement inside Syria having reached more than 6.5 million, the number of people in flight internally and externally exceeds 40 per cent of Syria's pre-conflict population. At least half of the displaced are children, (as in figure 4.2, after UNHCR 2014). The on-going drought will cause Syria and neighboring countries (Lebanon , Jordon and Iraq) a great risk and instability that may affect them soon. This spring the ice was milted early in Lebanon and most lakes was only left with 1/3 of its normal capacity, drinking water and water for summer cultivation are affected badly and if drought in the season 2014/2015 continued like that we might expect a real humanitarian disaster and more conflicts to rise.

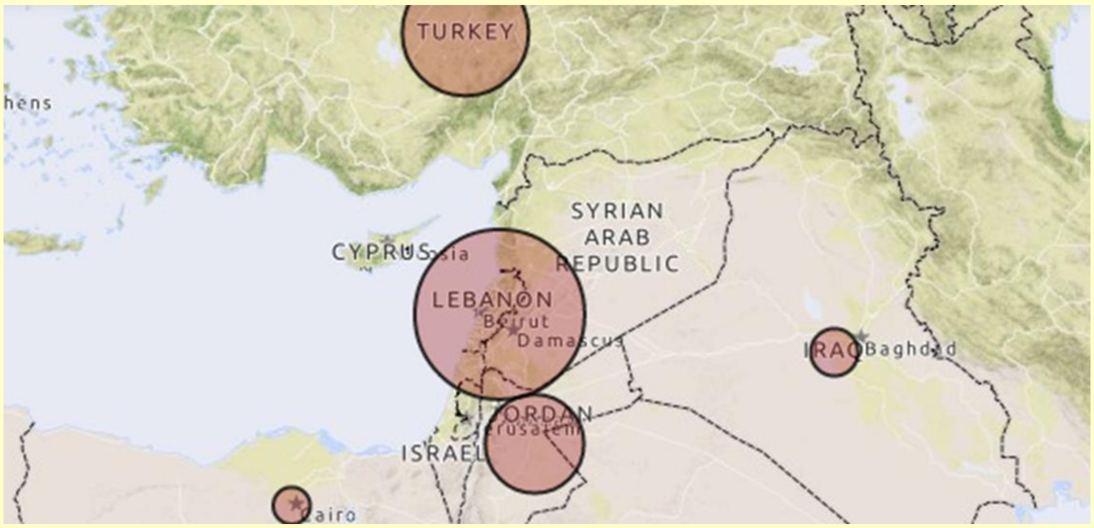


Figure 4.2 Syria Regional Refugee Distributions, after UNHCR

As in other Arab countries, the uprising in Syria was triggered by a series of social, economic and political factors, including, in this case, growing poverty caused by rapid economic liberalization and the cancellation of state subsidies after 2005, a growing rural–urban divide, widespread corruption, rising unemployment, the effects of a severe drought between 2006 and 2010 and a lack of political freedom. More recently, media and analysts have also suggested that climate change plays an indirect role in the Arab Spring and the Syrian uprising[18], that was mentioned earlier by Erian et al (2010) and Erian (2011), when he described the drought impact as cause for political instability in Syria as poverty and unemployment increases in rural communities.

> Pre-Crises/Conflict in Syria requires a better understanding for the environment Stresses caused by climate change (Climate Bio-Physical Stress), and Social Stresses and how they impacted Syria Pro Conflicts? and what development obstecles we should expect in the near future?.

18 T. Friedman, 'The Scary Hidden Stressor', The New York Times, 2 March 2013; C.E. Werrel and F. Femia (eds.), The Arab Spring and Climate Change, Center for American Progress, Stimson, The Center for Climate and Security (2013); F. Femia and C.E. Werrel, 'Climate Change Before and After the Arab Awakening: The Cases of Syria and Libya', in Werrel and Femia, The Arab Spring and Climate Change, pp.23–38; S. Mohtadi, 'Climate Change and the Syrian Uprising', Bulletin of the Atomic Scientists, 16 Aug. 2012.

Syria today under the crises is not only facing drought but also severe crises that reduced its capability. We could summarize the main challenges facing agriculture and food security as presented in (FAO 2014).

- Syria is facing extreme food insecurity as ≈ 6.3 million people are highly vulnerable to food insecurity and in critical need of food and agriculture support, the report illustrated that many families report reducing their number of meals and opting for cheaper and less nutritious foods.
- Agricultural production downfalls, A little has been invested to protect and support recovery of the agriculture sector . Latest assessments confirm low 2012/13 cereal production and anticipate low output for 2013/14 due to reduced areas under cultivation and adverse climatic conditions. These factors – coupled with the decreased capacity of rural farming populations to generate income and access food in highly affected areas – increasingly hinder food security.
- Agriculture- restricted access to land due to violence; internal population displacement; reduced availability and increased cost of farming inputs based livelihoods face severe constraints across the value chain from production to market, due to factor like restricted access to land due to violence; internal population displacement; reduced availability and increased cost of farming inputs
- The significant drop in food production in Syria and disruptions in trade have negatively affected food availability in neighboring countries and heavily impacted small-scale producers and workers along the supply chain of most agricultural commodities.
- Food price increases and removal of government subsidies have reduced the real income and purchasing power of poor households, forcing a change in dietary consumption and increasing malnutrition levels in host communities.

With a view to the future pre crises, a development to the agriculture sector should take place as soon peace is retrieved, but a need will emerge in the future to bridge the science of future drought risk forecasting and scenarios for Syria, with any future efforts to support resilience based development responses to in the post-crisis period.

This paper explores this risk-resilience nexus as a means of building sustainable responses that address recovery needs while also taking into account future drought risks. This helps strengthen resilience of communities and engages emerging resilience-based approaches and framework as a means of bridging humanitarian and development responses to the crisis.

4.2. Characterizing Drought Crises in Syria.

Syria recently hit by an intense and prolonged drought episode as a consequence of the very low values of precipitation registered during the two hydrological years comprised between 2007 and 2009. This drought event had major socio-economic impacts in several countries located within the affected area, namely; Iraq, Jordan, and Iran beside to Syria. The economic impact was mostly due to the steep decline in agricultural productivity in the highly populated areas of the Euphrates and Tigris river basins (Shean, 2008a,b,c). The occurrence of the two strongest prolonged droughts in the last decade (1997-2000 and 2005-2009) raises some concerns that this could become the norm, rather than the exception, in the future.

According to Trigoa (2010), the most affected part of the Fertile Ceresin region by the drought are eastern Syria and Northern Iraq and Iran, which correspond to the major grain-growing areas of these countries. With the exception of the irrigated areas within the Euphrates and Tigris basin, the vast majority of crops in these regions are non-irrigated and thus dependent on winter precipitation

In Syria, where the rainfall represents 68.5% of the available water sources, the precipitation concentration index (PCI) for the period (1960-2006) has been studied in Al Jazerah region (area tht include 3 governorates in the North Eastern part) , and the study show sever decrease in annual rainfall quantities that has been estimated by (27.7%) in Kamishli, (19.2%) in Tel-Abiad and (26%) in Hassakah and related to the decreasing in spring and winter rainfall quantities; (Skaff and Masbate, 2010).

The model-derived climate sensitivity of the Euphrates, Upper Tigris and Greater Zab river discharges (Smith et al. 2000) shows that for Euphrates River, an increase or decrease in precipitation by 25% raises or lowers the discharge profile while keeping its shape unchanged. The annual discharge rises to 40655 M cm or drops to 15751 M cm /y compared to the reference value of 27048 M cm. This is a 50% rise and a 42% drop, nearly twice the imposed percentage change in precipitation. Knowing that regional modeling studies expected a reduction of rainfall in mid-21st century Evans, (2008) , figure (4 3) around 40-50 mm in the upper Euphrates and Tigris basin which is 14 about 7% of average rainfall, it is expected to have about 11% drop in Euphrates river discharge.

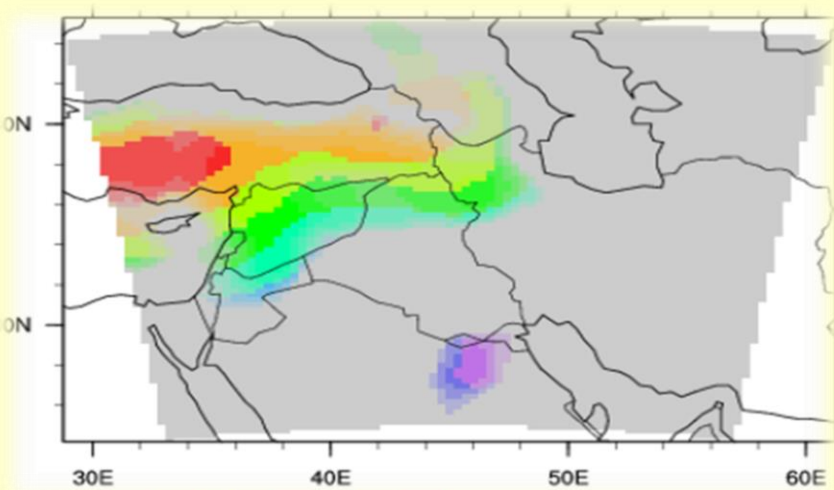


Figure. 4.3. Demonstrates an the change in precipitation by amount and significance.
(the probability (significance) of the change is calculated as a t-test between the precipitation now and the precipitation simulated in mid-21st. century),after (Evans, 2008).

Other studies (Lehner et al, 2001 and EEA, 2004) also expected around 10 to 25% reduction in river runoff in the upper Euphrates and Tigris basin in 2070 versus 2000 which prove the previous argument. .Kitoh et al. (2008), presented even more pessimistic results in their projections of rainfall and stream-flow in the 'Fertile Crescent' of the Middle East. They found that the annual discharge of the Euphrates River will decrease significantly (29%–73%), as will the stream-flow in the Jordan River.

Thus countermeasures for water shortages will become much more difficult. This negative trend of precipitation during the past century and beginning of 21 century is of a similar magnitude as that predicted by most of the GCM for the Mediterranean Region in the coming decades.

The drought that shacked Syria is showing an advanced case of what have been indicated by Mariotti et al., (2008) and IPCC (2012), and we are quoting:

> " *there is medium confidence that droughts in Mediterranean will intensify in the 21st century, the 20th century simulations indicate that the 'transition' toward drier conditions has already started to occur and has accelerated around the turn of the century towards the larger rates projected for the 21st century"*.

The Studies that have been conducted using different indices related to drought soil moisture show increases in the proportion of the overall increase in areas affected by drought; (Burke and Brown, 2007). Regional climate simulations highlight the Mediterranean region as being affected by more severe droughts, consistent with available global projections; (Giorgi, 2006; Beniston et al, 2007; Mariotti et al., 2008; Planton et al., 2008).

The study of Giorgi, (2006) using the standardized precipitation index SPI, for east Mediterranean shows that, the entire region has negative trends of annual SPI and annual precipitation. Countries that most affected by the decrease of SPI are Jordan, Syria, Lebanon and Palestine; (Göbel and De Pauw, 2010).

Simulated precipitation regimes depict a globally drier Mediterranean in 2030–2060, with a 10–20% drop in annual rainfall, a drier Mediterranean in 2031– 2060 translates into about one week of additional dry days along the coast and in the already dry southeast basin; Over land areas in the northern part, up to and over 3 weeks of additional dry days; thus, if the effects of ozone are to be included in an assessment of crop yields in the Mediterranean under a future climate scenario, the results are likely to be greater yield reductions; (Giannakopoulos et al, 2009 and Dai, 2010).

The region is subject to frequent agriculture (soil moisture) droughts and rainfed crops are strongly affected by precipitation fluctuations; mainly in the areas were annual rainfall range between 120/150 – 400 mm, they are considered moderately to sever vulnerable areas to drought; (Erian et al, 2006).

In Syria, where the rainfall represents 68.5% of the available water sources, the precipitation concentration index (PCI) for the period (1960-2006) has been studied in Al Jazerah region, and the study shows sever decrease in annual rainfall quantities that has been estimated by (27.7%) in Kamishli, (19.2%) in Tel-Abiad and (26%) in Hassakah and related to the decreasing in spring and winter rainfall quantities; (Skaff and Masbate, 2010).

This negative trend of precipitation during the past century and beginning of 21 century is of a similar magnitude as that predicted by most of the Global Circulation Models for the Mediterranean Region in the coming decades.

The long term metrological drought using the Standardized Precipitation-Evapotranspiration Index (SPEI) studies that carried out by Erian et al (2014) illustrate that drought was showing a relatively slight short cycles of drought during the first and second decades (1961-1980) and slight wet to normal classes in between those cycles but drought frequency increased gradually in the third decade (1981-1990) for long consecutive period of years, and that the year 1984 was a turnover in drought frequency, consecutive and intensity.

In the next decade's drought started continuing to increase in frequency, consecutive and intensity, figure (4. 4) is showing detailed curves in 3 different locations and table (4.1) is showing changes in drought trend between different decades.

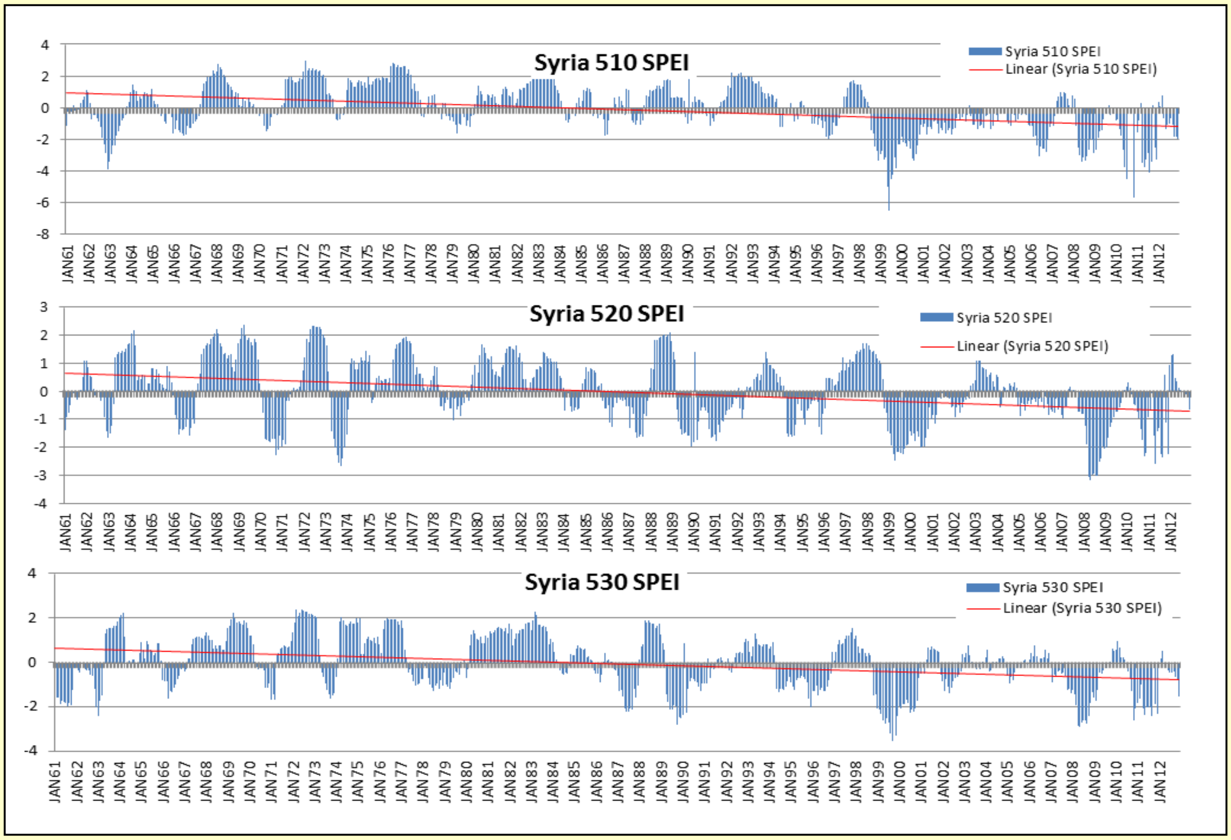


Figure 4.4. Average SPEI for all studied years with trend

Table 4.1. Drought Trend in Syria

Decade	Drought Severity	Negative coverage in %	Positive (Wet) %
1962 - 1970	13.26	16.65	83.35
1971-1980	71.77	79.47	20.53
1981 - 1990	8.34	100	0
1991 - 2000	56.54	97.94	2.06
2001 - 2012	37.11	89	11

During the year 2008, Some 1.3 million people (206000 households) of a population of 22 million, almost 6% of the total population, have been severely affected by drought, of which 800,000 have lost almost all their livelihoods and face extreme hardship as a result of a severe reduction in rainfall and increasing in potential-evapotranspiration that has lasted more than four agriculture seasons (2007/2008 – 2010/2011). This has crippled agriculture in eastern and north eastern Syria; the livelihoods of the farmers who depend on only one crop are at risk - they have nothing else to support them and they may have to migrate out of the affected areas; (Erian et al., 2011, Kattana, 2011 and UNISDR, 2011). Migration estimates that between 40,000 to 60,000 families have left, toward Syria's cities such as Aleppo, Damascus and Deir ez Zour or to Lebanon in search of work and for new sources of income, in one of the largest internal displacements in the Middle East in recent years (Nashawatii, 2011 and Erian, 2010).

4.3. Characterizing Syria Socio- economy Vulnerability

4.3.1. Socio-economic in Syria before Conflict.

During the years before the conflict till 2011 and from the FAOSTAT/ country profile data we could evaluate Syria capacity as follows, see (table 4.2).

Table 4.2. Syria main Capacity Characterization.

Evaluation Element	Main Economical Capacity Characteristi3									
Code	EcA	EcB	EcC	EcD	EcE	EcF	EcG	EcH	EcI	EcJ
Value	107600	-2	5,10	16.9	17	12.3	12	4800	808	32.9
Class	3	7	5	3	3	3	3	2	4	2
Evaluation Element	Main Population Capacity Characteristi3									
Code	PoA	PoB	PoC	PoD	PoE	PoF				
Value	121.67	61	-0.79	-27.82	61.6	-0.8				
Class	3	1	1	1	7	5				
Evaluation Element	Main Land use Capacity Characteristi3									
Code	LuA	LuB	LuC	LhD	LuE	LuF				
Value	25.4	-0.64	5.39	23.75	2.61	11.63				
Class	1	5	6	3	6	3				
Evaluation Element	Main Water Availability Capacity Characteristi3									
Code	WaA	WaB	WaC	WaD						
Value	46.1	19.95	95	1,05						
Class	6	5	7	2						

According to the information at 2011 Syria was rated as Moderate Capacity level with main limitation in water availability, moderate vulnerability to drought with high coverage of ADH (75

– 85%), moderate drought hazard severity, **moderately affected vegetation cover** and moderate capacity. As the conflict started we could re-classify Syria to Extreme Vulnerability, to drought with high coverage of ADH moderate drought hazard severity, **severely affected** vegetation cover and very Low to low capacity. That will require special program for land recovery and building resilience to coupe with drought and land degradation hazards severity, (Erian et al 2012).

All this capabilities is not any more the same, the country is under instability but Sub-regional Strategy and Action Plan should start now for building and strengthening resilient livelihoods for agriculture and food and nutrition security in areas affected by the Syria crisis. The study of the drought in Syria and surrounding countries should get priority as the crises could explode; in fact Lebanon is in marginal level of instability and Iraq already suffering from the impacts of Syria Crises that started while the country still approximately divided.

4.3.2. Socio- economic Impacts and Risks in Syria Eastern Region

The eastern region of Syria (Hassakah, Deir al-Zor and Raqqa governorates), as shown in figure (4.5) are considered as the most important areas of agricultural production in Syria and most affected by drought. About 7.6 million hectares that represent 41% of the total area ofSyria, with total population number of about 3.5 million people, representing 17% of the population of Syria. Eastern region represent 22.4% of the total rural population in Syria and 30% of the agricultural sector, **(**Kattana, 2011).

Figure 4 5. Syria Governorates

<u>The Major impacts of drought could be described as follows:</u>

<u>a). Rural livelihoods:</u>

- The severe shortage of rainfall that has lasted more than four agriculture seasons (2007/2008 – 2010/2011) has crippled agriculture in eastern and Northeastern Syria; farmers who depend on only one crop are in trouble - they have nothing else to help them and they have to move; (Erian et al, 2011; Kattana, 2011; UNISDR, 2011 and FAO, 2011).

- Increased respiratory infections, particularly because of the atmosphere nebular (dusty), particularly in the north-eastern areas lack of water (for drinking and domestic use) or provided by a non-secure health, leading to a variety of digestive diseases tract and diarrhea (especially in children), and kidney disease; (FAO, 2011).
- A rise in the rate of borrowing in rural households in the three provinces between 2006 and 2010 estimated by 350%; (Erian et al , 2010).

b). Agricultural production:

- The eastern part of Syria represent 31.75% of the total rainfed areas of Syria and due to drought has been declined from 1.12 to 0.98 million hectare, during the years from 2000 to 2009; (Kattana, 2011).
- The region is contributing by 58% of the total wheat production, 68-78% of the total cotton production, 62-72% of the total yellow corn production and 22% of the total sugar beet production, and have 30% of the goats, 36-41% of the sheep and 31-34% of the cows, tables (4.3), (4.4), (4.5) and (4.6), (Kattana, 2011).
- Rainfed wheat area normally amounts to more than 0.8 million hectares, and is extremely reliant on timely rainfall during the growing season, wheat production has dropped in the eastern part of Syria by 25.9% during the years 2000-2009, and total production from 2.6 to 2.1 million ton during the years 2005-2009 and reaching to 1.2 and 1.9 million ton in 2008 and 2009 respectively. During the agriculture season 2007–2008 and due to severe drought in the Syria, 75% of the country's farmers suffered total crop failure, where, wheat production dropped by 39.8% from 0.43 to 0.25 million ton from the year 2000 to the year in Al-Hassaka governorate in the eastern part, (Kattana, 2011).
- Barley production which considered an important crop for rainfed areas in the country, and used as fodder for animals has decreased in the last years 2005-2009 up to 40%, beside the absence of natural pastures and at the same time feed prices have doubled, which resulted in the sale of animals, accompanied by a large fall in price of ewes sold or slaughtered as well as young animals in the market; animals weight loss in beside physical deterioration; lower in the amount of newly born young because of Low fertility rate, declining birth rate, low rate hike to zero; and. Breeders forced to sell a large proportion of female babies beside the high mortality rate of adult ewes and young animals, (FAO 2011).
- The estimated number of sheep population has dropped from 2.47 million head at the year 2005 to 1.5 million head at the year 2009 and the livestock population was 50 percent below the pre-drought level more than a year after the drought ended; (Kattana, 2011 and Erian et al, 2011).

c). Migration:

- During the years 2007 to 2011, Some 1.3 million people (206000 households) of a population of 22 million have been severely affected by the disaster, of which 800,000 have lost almost all of their livelihoods and face extreme hardship. Migration out of the affected areas has increased, with estimates indicating that between 40,000 to 60,000 families, with 35,000 from "Hassakeh governorate" alone have driven to urban settlements on so called mass migration toward Syria's cities such as Aleppo, Damascus and Deir ez Zour in search of work and for new sources of income, many ending up with difficult laboring work. in one of the largest internal displacements in the Middle East in recent years; (Nashawatii, 2011 and Erian et al , 2010).

- Most of the houses on villages are left empty and less than 10% are occupied by elder people and children, The younger generations left seeking work, many left to Lebanon or Jordon, as workers in the sectors of construction or agriculture. Women left to work in the western part of Syria, for packing vegetables in "Tartous" greenhouses; (Erian et al., 2011).

d). Ecosystem Decline:

- Due to drought that increased in frequency, intensity and duration, the deficit in available water has been estimated of about 651 million M^3 during the years 1995-2005, and still increasing with expectation to rise to 2077 million M^3 by the year in 2030 only because of population growth and the increasing pace of development; (Nashawatii, 2011).
- Decline in availability of irrigation water in the Hassakeh governorate is largely due to the hydrological drought of Khabour River, this has led to the decline in irrigated areas, the water scarcity has led to increasing pressures on ground water resources and brought the water crisis to critical levels, (FAO, 2011 and Mora, 2011).
- Increase of moderate and severe land degradation that estimated during the period from 1999 to 2007 by 34.8% of the total area of Syria; (A3AD, 2009).

Table 4.3 Main Yield Production between the years 2005 – 2009 in '000 ton

Wheat						
Year	**2005**	**2006**	**2007**	**2008**	**2009**	**Difference 2005 – 2009**
All Syria	4669	4932	4041	2139	3702	-20.71
Raqa	632	580	560	345	524	-17.09
Dier Ezzor	410	333	319	243	267	-34.88
Hassaka	1603	1898	1472	609	1136	-29.13
Eastern Part	2645	2811	2350	1197	1926	-27.18
East to All %	56.65	56.99	58.16	55.95	52.04	
Cotton						
Year	**2005**	**2006**	**2007**	**2008**	**2009**	**Difference 2005 – 2009**
All Syria	1022	686	711	698	652	-36.20
Raqa	228	144	168	193	197	-13.60
Dier Ezzor	104	80	96	95	104	0.00
Hassaka	387	241	273	258	215	-44.44
Eastern Part	719	465	537	546	515	-28.37
% East to All	70.4	67.8	75.5	78.3	79	
Sugar Beet						
Year	**2005**	**2006**	**2007**	**2008**	**2009**	**Difference 2005 – 2009**
All Syria	**1096**	**1438**	**1366**	**1105**	**733**	-33.12
Raqa	169	225	246	226	250	47.93
Dier Ezzor	80	80	74	46	52	-35.00
Hassaka	0	0	0	0	0	0.00
Eastern Part	249	305	320	272	302	21.29
East to All %	22.7	21.2	23.4	24.6	21	
Yellow Corn						
Year	**2005**	**2006**	**2007**	**2008**	**2009**	**Difference 2005 – 2009**
All Syria	187	159	177	281	183	-2.14
Raqa	67	37	50	123	65	-2.99
Dier Ezzor	60	58	62	61	31	-48.33
Hassaka	5	3	5	19	2	-60.00
Eastern Part	132	98	117	203	98	-25.76
East to All %	**68.7**	**61.7**	**65.9**	**72**	**54.9**	

Table 4.4 Area and Production in Hassaka, Dier Ezzor and Raqa

Crop		2000	2008	Difference	
Eastern Region (Raqa, Dier Ezzor and Hassaka)					
Wheat	Area in '000 Ha	885.813	866.406	-19.407	-2.19%
	Yield in '000 Ton	1588.076	1176.714	-411.362	-25.90%
Cotton	Area in '000 Ha	194.891	135.18	-59.711	-30.64%
	Yield in '000 Ton	756.045	538.19	-217.855	-28.82%
Hassaka					
Wheat	Area in '000 Ha	735.39	630.11	105.3-	-14.32
	Yield in '000 Ton	1030	608.9	421-	-40.87
Cotton	Area in '000 Ha	96.021	56.141	39.88-	-41.53
	Yield in '000 Ton	428.8	258.08	170.7-	-39.81
Dier Ezzor					
Wheat	Area in '000 Ha	87.364	152.1	64.736	74.10
	Yield in '000 Ton	367.651	335.644	-32.007	-8.71
Cotton	Area in '000 Ha	68.623	48.839	-19.784	-28.83
	Yield in '000 Ton	219.3	192.935	-26.365	-12.02
Sugar Beet	Area in '000 Ha	5.153	4.554	-0.599	-11.62
	Yield in '000 Ton	152.6	203.695	51.095	33.48
Raqa					
Wheat	Area in '000 Ha	63.061	84.2	21.139	33.52
	Yield in '000 Ton	190.425	232.17	41.745	21.92
Cotton	Area in '000 Ha	30.247	30.2	0.047	0.16
	Yield in '000 Ton	107.946	87.178	-20.768	-19.24
Sugar Beet	Area in '000 Ha	3.639	4.752	1.113	30.59
	Yield in '000 Ton	118.27	87.178	-31.092	-26.29

Table 4.5. Decline in Yield /Ton in Hassaka Governorate

Hassaka Areas		**2004**			**2009**			**in Rainfed Crops Losses**	
		Irrigated	**Rainfed**	**Total**	**Irrigated**	**Rainfed**	**Total**	**Decline**	**%**
WHEAT									
Hasaka main sub divisions	**Hassaka**	436664	78233	514897	224123	5274	-72959	-72959	93.26
	Kamishly	220664	150654	371318	174527	31995	-118659	-118659	78.76
	Malkic	137665	162921	300586	88257	121360	-41561	-41561	25.51
	Ras El Ain	495888	44915	540803	485047	5238	-39677	-39677	88.34
Hassaka Gov.		1290881	436723	1727604	971954	163867	1135821	-272856	26.48
Total Syria		3392660	1144799	4537459	3037582	664202	3701784	-480597	41.98
BARLEY									
Hasaka sub divisions	**Hassaka**	9566	229943	239509	23153	156387	179540	-73556	31.99
	Kamishly	38	43380	43418	3155	111493	114648	68113	-157.0
	Malkic	50	6072	6122	644	20300	20944	14228	-234.3
	Ras El Ain	30	69577	69607	3145	57326	60471	-12251	17.61
Hassaka Gov.		9684	348972	358656	30097	345506	375603	-3466	0.99

Total Syria		43214	1247360	1290574	61811	1228409	1290220	-18951	1.52
LENTILS									
Hasaka main sub divisions	**Hassaka**	102	3399	3501	784	4242	5026	843	-24.80
	Kamishly	43	23988	24031	1640	8653	10293	-15335	63.93
	Malkic	0	16938	16938	995	4100	5095	-12838	75.79
	Ras El Ain	181	1921	2102	2065	884	2949	-1037	53.98
Hassaka Gov.		326	46246	46572	5484	17879	23363	-28367	61.34
Total Syria		353	137066	137419	5615	95106	100721	-41960	30.61

Table 4.6 Animals between the years 2005 – 2009 in '000 head

Cows						
Year	**2005**	**2006**	**2007**	**2008**	**2009**	**Difference 2005 – 2009**
All Syria	1083	1121	1168	1109	1085	-0.38
Raqa	20	20	22	21	21	0.96
Dier Ezzor	227	235	247	257	282	2.96
Hassaka	101	103	110	97	85	0.00
Eastern Part	348	358	379	375	388	1.46
East to All %	**36**	**34**	**32**	**32**	**32**	
Goats						
Year	**2005**	**2006**	**2007**	**2008**	**2009**	**Difference 2005 – 2009**
All Syria	**1296**	1420	1561	1579	1508	7.21
Raqa	170	183	199	178	171	-1.22
Dier Ezzor	75	81	86	75	78	-5.06
Hassaka	153	182	228	211	175	0.00
Eastern Part	398	446	512	464	425	3.34
East to All %	**31**	**31**	**33**	**29**	**28**	
Sheep						
Year	**2005**	**2006**	**2007**	**2008**	**2009**	**Difference 2005 – 2009**
All Syria	**19651**	**21380**	**22865**	**19237**	**18336**	-5.21
Raqa	2585	2734	2860	2262	2151	-10.18
Dier Ezzor	2980	3197	3437	2875	2471	-3.91
Hassaka	2476	2812	300	1700	1536	0.00
Eastern Part	8042	8742	6597	6837	6158	-6.02
East to All %	41	41	29	36	34	

4.4. Agriculture Drought Hazard in Syria

4.4.1. Agriculture Monthly and Seasonally Drought .

The analyses of 80 monthly MODIS satellites image throughout the agricultural seasons prepared monthly Vegetation Condition Index (VCI) and Temperature Condition Index (TCI). Both VCI and TCI were than used for preparing monthly Vegetation Healthy Index (VHI) maps. The classes of the VHI are corresponding to the severity of monthly agricultural drought (monthly Agriculture Drought Intensity), figure (4 6) is showing the VHI of the month of April on the deferent studied seasons.

4.4.2. Agriculture Drought Intensity

- The Ten overall seasonally agriculture drought intensity maps were then produced, the seasonal ADI map of the 2007/08 is shown in figure (3 8), for illustrating results and table

(4.7) shows areas in hectare and percentage of levels of ADI severity for the different seasons Seasonally highest coverage of drought (the sum of the three levels of severity of drought) as follows: (season 07-08), (08-09 season), (season 05-06), (00-01 season), (season 09 -10), (season 02-03), (04-05 season), (season 06-07), (01-02 season), (03-04 season) and at percentage of 91.5, 73.6, 57.5, 56.6, 39.3 0.35 , 29.6, 28.4, 15.6, 12.7, respectively

- Seasonally coverage drought severity levels could be grouped as follows: relatively high severity seasons (season 07-08 and 08-09) and moderately severity seasons (season 05-06 and 00-01) and the seasons between the low to moderate severity seasons (season 09-10 and 02-03 and 04 - 05 and 06-07), and lower severity seasons (season 01-02 and 03-04).

The seasonal Agriculture Drought Intensity (SADI) was then calculated from the monthly, the monthly ADI of the 2007/08 is shown in figure (4.8), for illustrating results.

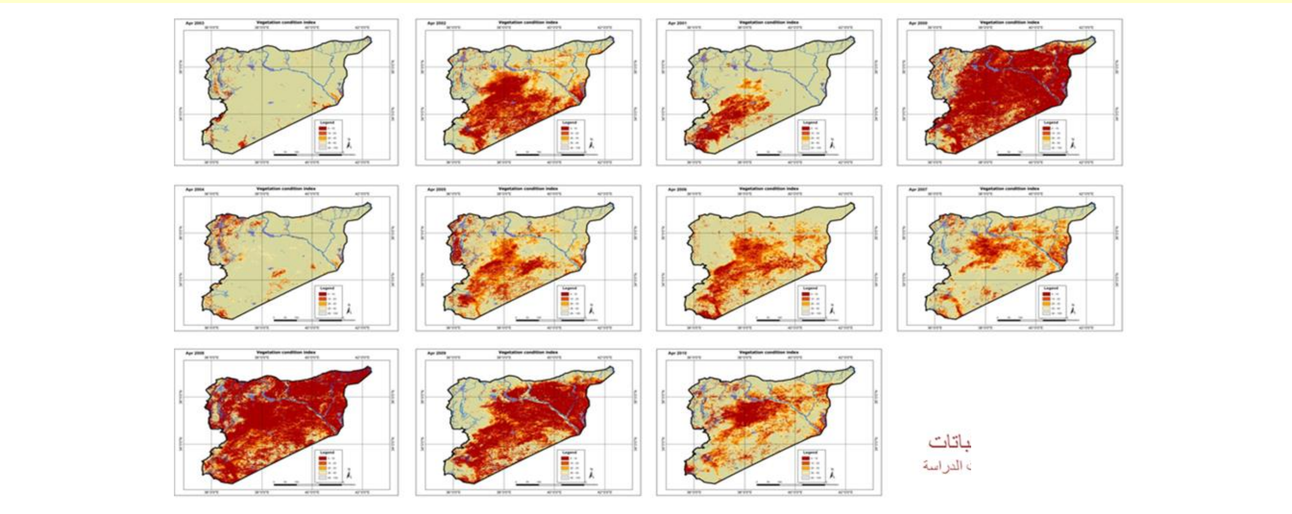


Figure 4 6. VHI in the month of April for the different studied years

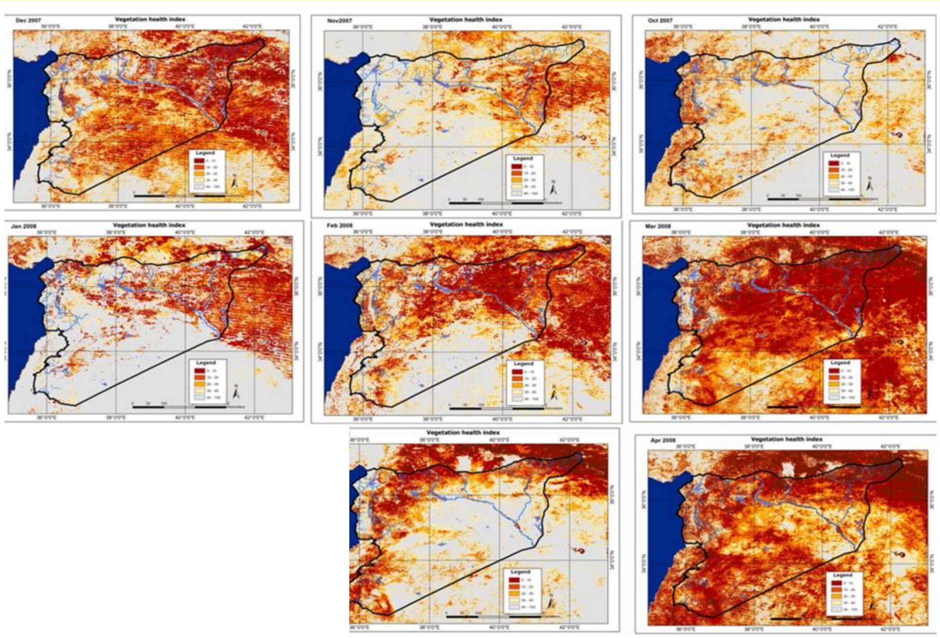


Figure 4.7 The Monthly ADI of the Agriculture Season 07/08

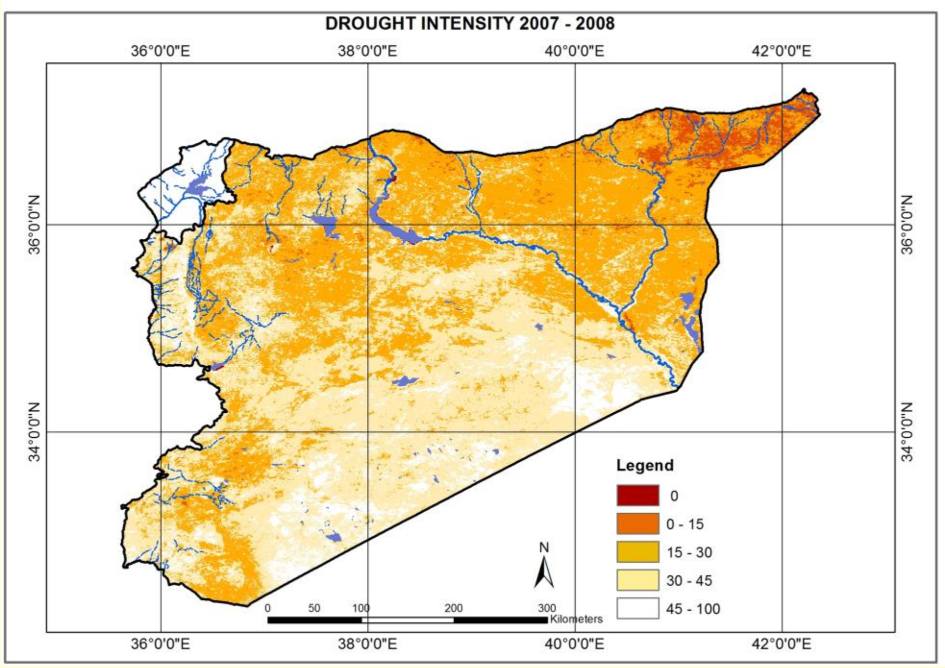


Figure 4 8. ADI of the Agriculture Season 2007/08

Table 4 7. Agriculture Drought Intensity Severity of the different Seasons.

Agriculture Season	Not Effected		Slightly Effected		Moderately Effected		Severally Effected	
	Area Ha	%	Area Ha	%	Area Ha	%	Area Ha	%
01 - 00	8113152	43.4	8096768	43.3	2327134	12.4	165100	0.9
02 - 01	9521941	50.9	2779050	14.9	39829	0.2	92309	0.5
03 - 02	12024203	64	6218866	33	373492	2	85877	0
04 - 03	16342981	87.4	2198802	11.8	93678	0.5	66836	0.4
05 - 04	13163180	70.4	5264585	28.1	186020	1.0	88594	0.5
06 - 05	7837659	42	9938778	53	835933	4	89879	0.5
07 - 06	13397762	71.6	4893934	26.2	326185	1.7	84619	0.5
08 - 07	1581339	8.5	8751532	46.8	7709674	41.2	659485	3.5
09 - 08	4948258	26.5	8487253	45.4	5031212	26.9	235604	1.3
10 - 09	11346366.3	60.7	6809332.4	36.4	453239.3	2.4	93526.2	0.5

From the above table seasons could be arranged in terms of:

- Seasonally coverage drought severity levels (Moderate and Severe) as follows: (Season 07-08), (season 08-09), (season 00-01), (season 05-06), (season 09-10), (season 06-07), (season 02-03), (season 04-05), (season 03-04), (season 01-02) and at percentage of 44.7, 28.2, 13.3, 4.5, 2.9, 2.2 0.2, 1.5, 0.9, 0.7, respectively.

The overall Agriculture Drought Intensity map (ADI) for the studied seasons was calculated and presented in figure (4 9). The results shows that large areas are exposed to severity of the drought, the slight intensity is covering area of about 13.3 million hectares that represents 72% of the Syria total area, while area of about 0.47 million hectares that represent 2.6% of the Syria is suffering severity of moderate and to high severity, and areas of about 4.74 million hectares that represents 25.61% of the Syria total area is not effected.

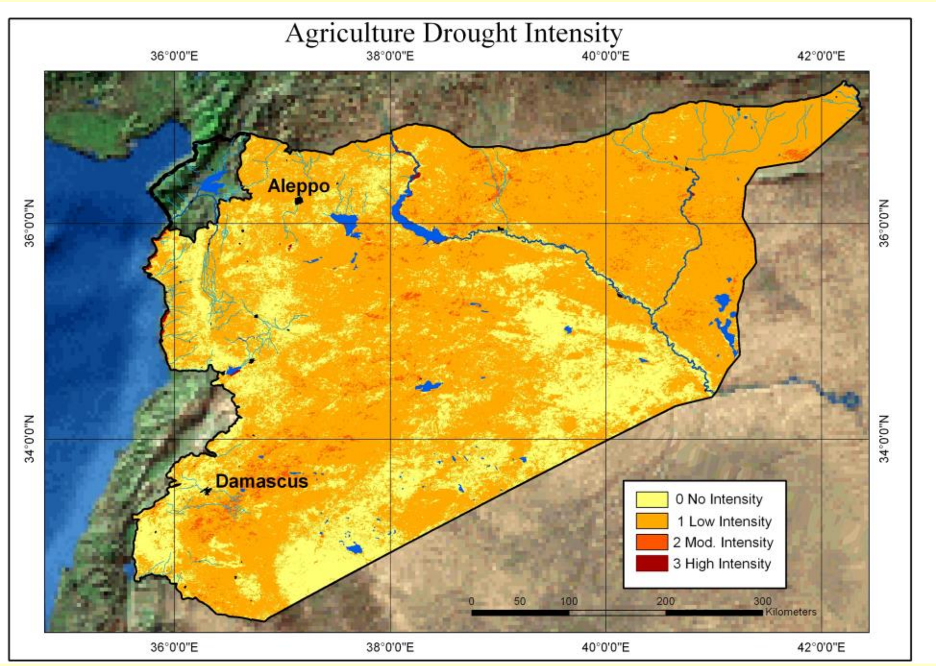


Figure 4 9. Agriculture Drought Intensity Map of Syria for the period 2000 - 2010

4.4.3. Agriculture Drought Variability.

First step in preparing the Agriculture Drought Variability (ADV) map is producing the Normalized Difference Vegetation Index NDVI map and the average maximum reflectance for the studied years called " Magnitude map", as shown in figure (4 10) the subtraction of annually Phase map from overall Magnitude map gives the fluctuation of agricultural drought for the different studied years, and the putting them in classes reflect the Agriculture Drought Variability map of the region, as shown in (figure 4 11). The results shows that 14.4 million hectares represent 78% of the total Syria area is affected by drought variability, the slight variability is covering area of about 2.4 million hectares that represents 13% of the Syria total area, while area of about 12 million hectares that represent 65% of the Syria are suffering by drought variability of moderate to high severity.

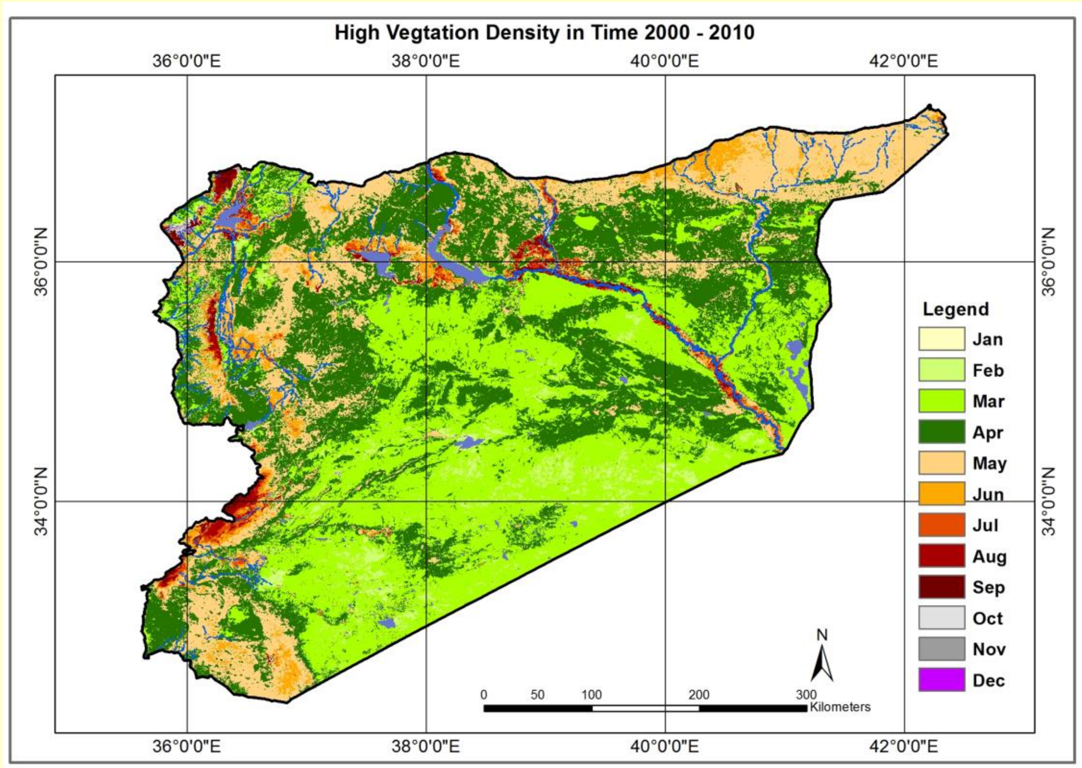


Figure 4.10. Magnitude Map of Syria for the period 2000 - 2010

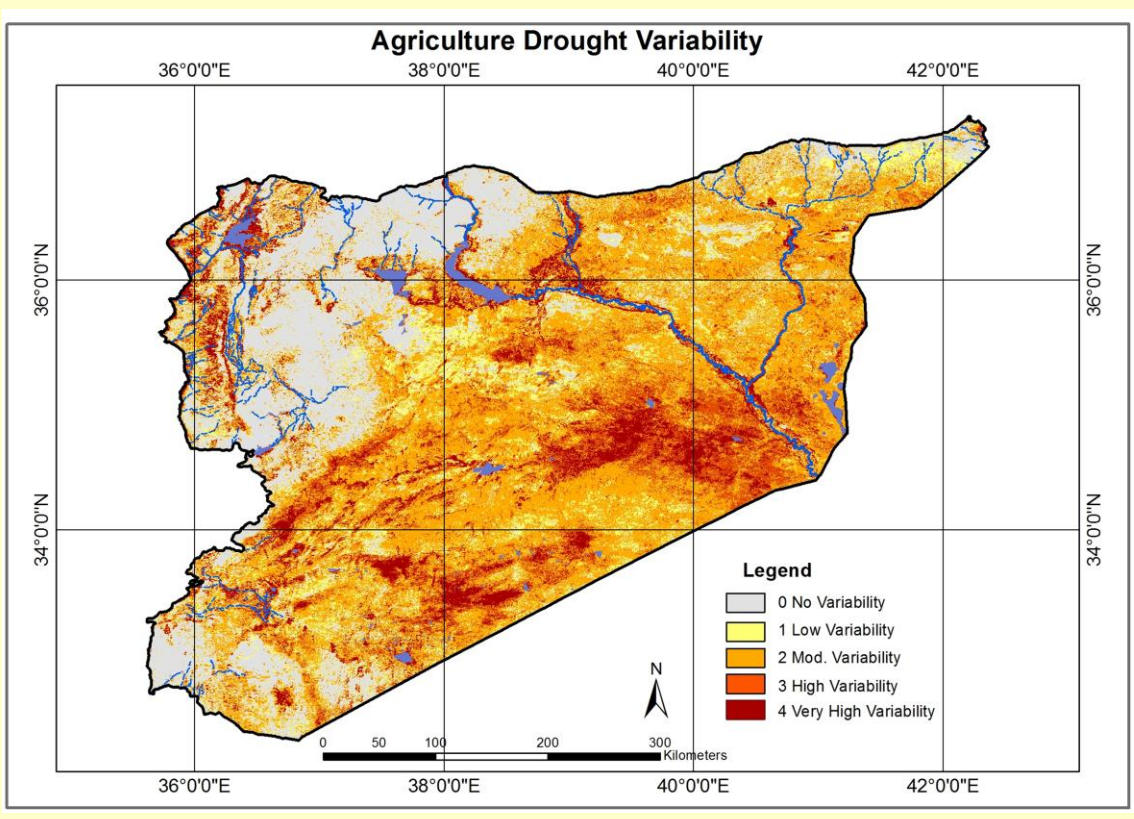


Figure 4.11. Agriculture Drought Variability Map for the period 2000 - 2010

4.4.4. Agriculture Drought Frequency

The Agriculture Drought Frequency (ADF) was calculated and the resulted map is shown in figure (4 12), the results shows that areas that suffers frequently from agriculture drought (between 3 to 5 years) covered 53.2% of the total area of Syria and occupied area of about 9.86 million hectares, and areas suffers for 6 or more years covers 19.4% of the total area of Syria and occupied an area of 3.6 million hectares crops, and that area of about 27.4% that covers 5 million hectares that is not suffering for more than two years.

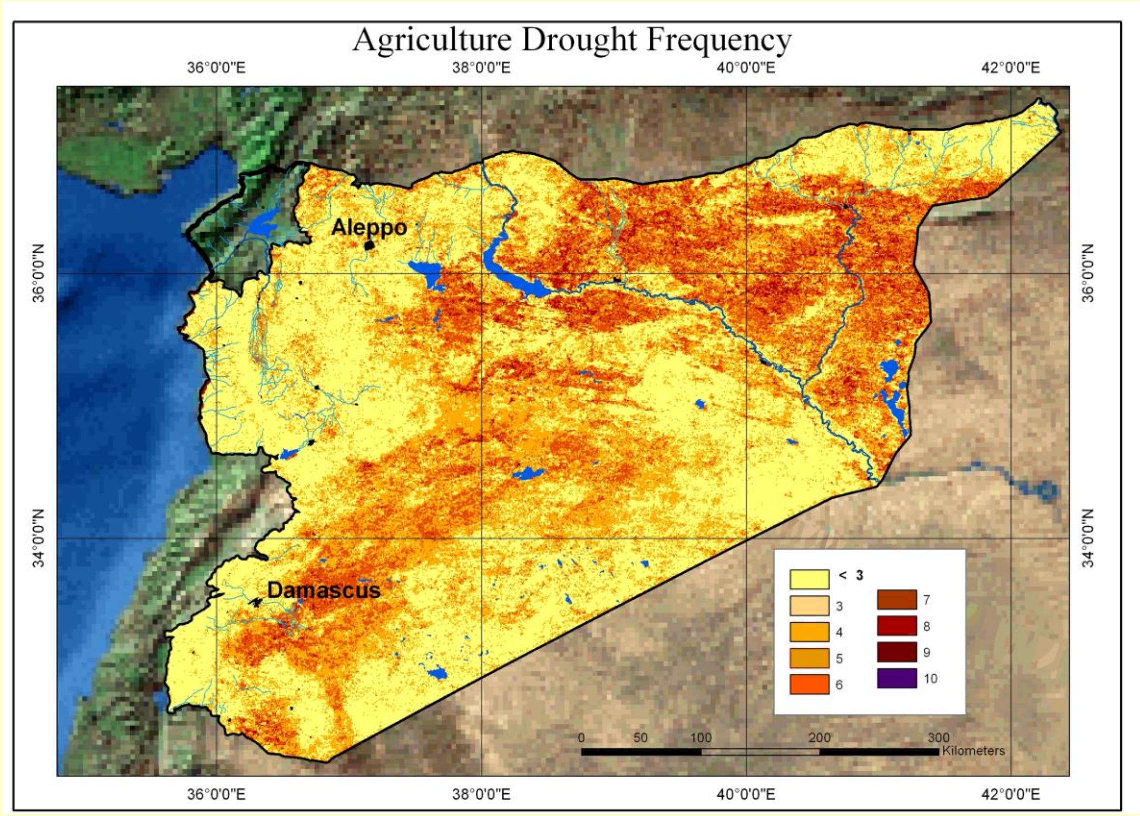


Figure 4 12 Agriculture Drought Frequency Map of Syria for the period 2000 - 2010

4.4.5. Agriculture Drought Consecutive Duration

The Agriculture Drought Consecutive (ADC) was calculated and the resulted map is shown in figure (3 12), the results shows that areas suffered continues drought for 3 to 5 years covered 32.14% of the total area of Syria and covers 5.95 million hectares, and areas with 6 years and more of continuous drought covered 2.26% of the total area of Syria while areas suffered one or two years, covered 12 million hectares.

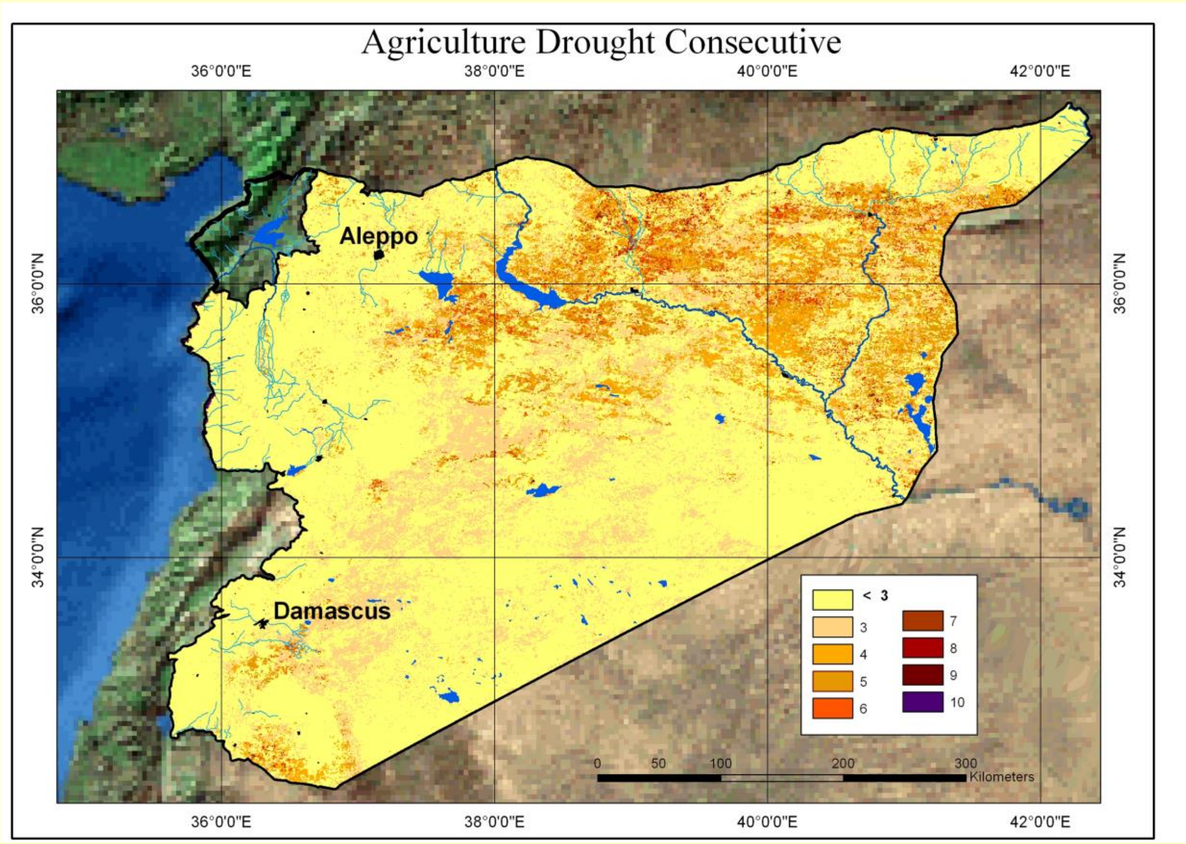


Figure 4 13. Agriculture Drought Consecutive Map of Syria for the period 2000 - 2010

4.4.6. Agriculture Drought Hazard

The preparation of the Agriculture Drought Hazard (ADH) map is done by crossing the previously produced maps namely: agriculture drought intensity" ADI" agriculture drought variability "ADV", agriculture drought frequency "ADF" and agriculture drought consecutive "ADC", as shown in (Figure 4. 14). The results show that 74.4% of the total area of Syria is affected by ADH, the slight hazard is covering area of about 9.47 million hectares that represents 51.17% of Syria total area, while area of about 3.95 million hectares that represent 21.3% of Syria is suffering moderate severity, area of about 2.78 million hectares that represent 1.5% of Syria is suffering Severally severity and areas of about 4.73 million hectares that represents 25.55% of the Syria total area is not effected. The detailed ADH classes are shown in (Table 4.8).

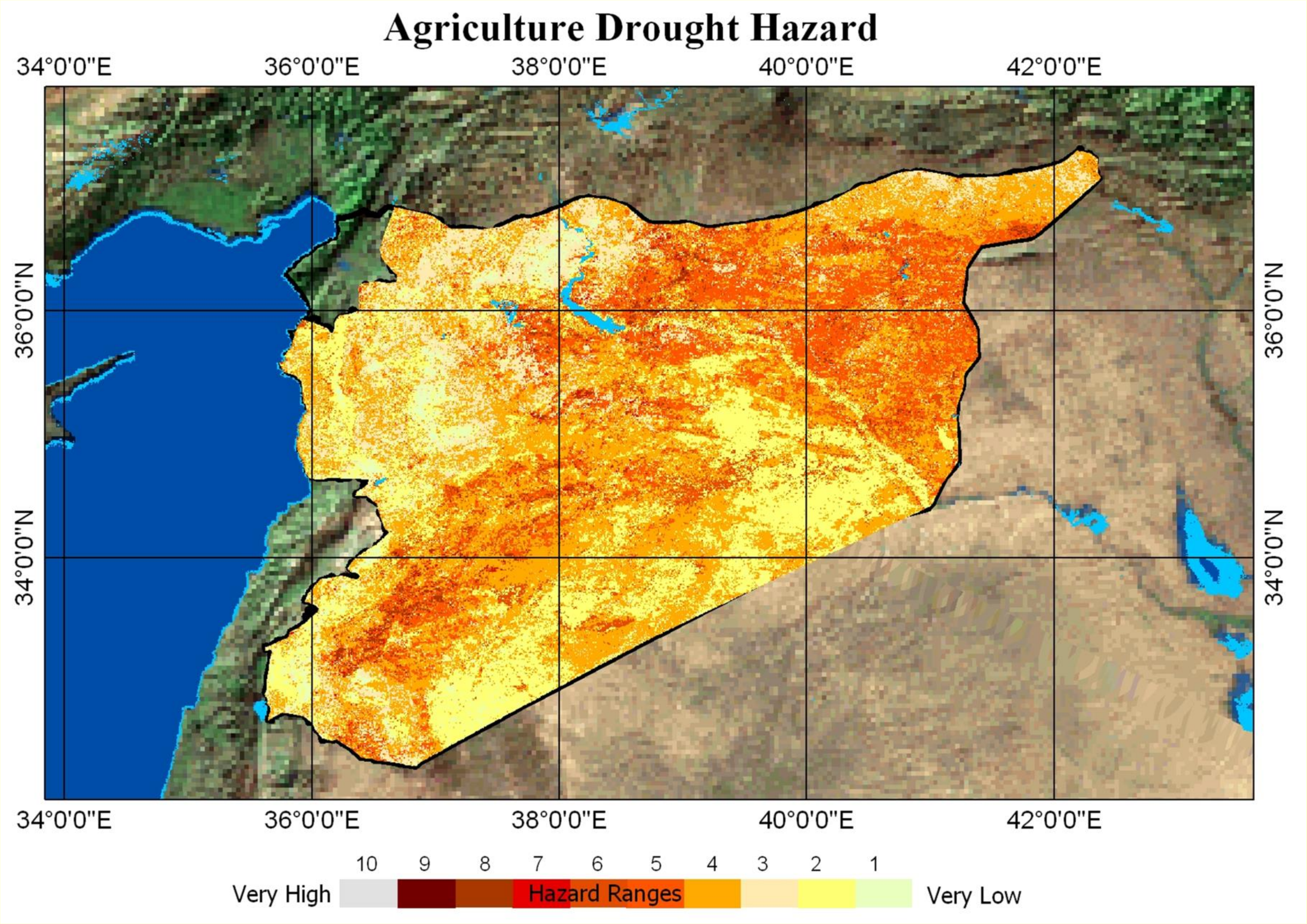


Figure 4 13 Agriculture Drought Map of Syria

Table 4 8. Agriculture Drought Hazard is Syria for the period 2000 – 2010.

Drought Level	Area in Ha	%	Area in Ha	%	Levels of ADH
1	767593.9	4.15	4730626	25.55	No Hazard
2	3963032.3	21.40			
3	2186339.5	11.81	9474576	51.17	Slight ADH
4	7288236.4	39.36			
5	3070340.0	16.58	3947120	21.31	Moderately ADH
6	759395.77	4.10			
7	117384.6	0.63			
8	268451.2	1.45	278492.2	1. 51	Severely ADH
9	4708.7	0.03			
10	5332.3	0.03			
11	1377.6	0.01	1377.6	0.01	Areas covered by ICE
12	85807.9	0.46	85807.9	0.46	Water Bodies

4.4.7. ADH in the Syrian Governorates

The distribution and levels of the agricultural drought hazard in Syria different governorates is shown in table (4.9) and illustrate that Syrian governorates could be ranked according to 3 major criteria's:

- The first ranking criteria is ADH coverage percentage: Syrian governorate could be ranked as follows: Hassakah (98.5%), Raqa (87.8%), Aleppo (82%), Daraa (73.2%), Hama (72.7%), Homs (70.4%) , Deir ez-Zor (68%), Sweidaa (64%), Tartous (62.4%), Damascus (61.5%)), Idlib (59.5%), Latakia (53.3%), and Qanetra (27%).
- The Second criteria is ADH severity level: Syrian governorate could be ranked as follows: Al-Hassakah (38.9%), Deir ez-Zor (30%), Damascus (21.6%), Daraa (20.6%), Aleppo (17.2%), Homs (16.4%), Sweidaa (12%), Hama(9.3%), Latakia (8.3%), Tartous (4.9%), Idlib (2%) and almost zero in Qanetra.

Table 4 9. Levels of Agricultural Drought Hazard in Syria Different Governorate

Governorates	Unit	Severe (1)	Moderate (2)	Slight (3)	Non	Total (1+2)	Total (1+2+3)
RAQA	Ha	94491	766517	717585	220406	861008	1578593
	%	5.3	42.6	39.9	12.3	47.9	87.8
HASSAKA	HA	51752	848309	1E+06	37021	900061	2280058
	%	2.2	36.7	59.6	1.5	38.9	98.5
DIER EZZOR	Ha	30072	736913	970980	820366	766985	1737965
	%	1.2	28.8	38	32.1	30	68
DAMASCUS	HA	56949	333143	723593	695086	390092	1113685
	%	3.1	18.4	40	38.4	21.6	61.5
DARAA	Ha	14114	60589	191560	97720	74703	266262.9
	%	3.9	16.7	52.6	26.8	20.6	73.2
ALLEPO	HA	281792	281792	1E+06	361374	343929	1862862
	%	3.1	14.1	64.8	18	17.2	82
HOMS	Ha	43778	773917	3E+06	2E+06	817695	3535376
	%	1	15.4	54	30	16.4	70.4
SWEIDAA	HA	2483.9	83118	346187	237105	85602	431788.5
	%	0	12	52	35	12	64
HAMA	Ha	8697.9	84846	649793	281391	93544	743337.3
	%	1	8.3	63.4	27.5	9.3	72.7
LATTAKIA	HA	4349.7	16681	114741	119459	21031	135771.5
	%	1.7	6.6	45	46.8	8.3	53.3
TARTUS	Ha	3589	5717	110650	72498	9305.7	119955.5
	%	1.9	3	57.5	37.7	4.9	62.4
IDLEB	HA	156.3	10509	306470	216291	10666	317135.2
	%	0	2	57.5	40.5	2	59.5
QANETRA	Ha	40	615	35900	99054	655	36555
	%	0	0	27	73	0	27

4.5. Consequences and Building Resilience

4.5.1. Consequences

- Mediterranean region is strained by unequal water allocation and ecological fragility as population and economi3 grow, even though, an area in more severe drought increases much more than the area in less severe drought, and this could have serious consequences as the impact of drought on socioeconomi3 increases with the severity of drought; Burke and Brown, 2007. Even drought causing further degradation of the region's natural resources base is likely, unlikely the size of risks associated with drought remain less well understood, losses and impacts are not systematically captured; (UNISDR 2011).
- Countries of the Mediterranean suffering now from the increased drought frequency, intensity and duration are likely to suffer more clear and significant drought losses and impacts on agricultural production, rural livelihoods, migration, urban, economic sectors and ecosystem decline
- Water resources are dwindling by population increase regardless of drought in most Mediterranean countries; Water scarce was estimated to reach severe levels by the year 2025; (El- Quosy, 2009). The already on-going and growing critical situation caused by

hydrological drought and soil moisture (agriculture) drought, will reflect extremely severe in water scarce, and contribute to the likelihood of conflicts by causing displacement and migration, increasing competition for scarce resources and exacerbating ethnic tensions; (Barnett and Adger, 2007; Reuveny, 2007; and UNISDR, 2011).

- The continuous increasing gap between countries demands for water for serving its sustainable development and available water resources in many Mediterranean countries, The increasingly serious drought conditions throughout the entire Mediterranean region. Syria, Jordon, Palestinian Territories, Lebanon and Iraq have all reported water shortages that are sure to affect both their ecosystem stability and national security; El-Quosy, 2009.
- Poor rural households with livelihoods that depend on rainfed agriculture are more vulnerable to drought and less able to absorb and buffer the losses. Consequences include increased poverty, reduced human development and negative impacts on health, nutrition and productivity; (de la Fuente and Dercon, 2008; UNISDR, 2009).
- Drought impacts in some areas is irreversibly, people abandoned their lands, houses and looking for new life in other areas that could offer them other opportunity and alternative chances. Their migration becomes permanent because farmers and Bedouins failed in obtaining economical yield or feeding their animals, to gain sufficient income to sustain their family's needs. The rain is not enough anymore in amount and variability to sustain crop production and all scenarios showing a more moderate to severe drought in the near future, accompanied by increasing temperatures, disruption of the hydrological cycle, resulting in less and more erratic rainfall that will aggravate even further the already critical state of water scarcity ;(Abou-Hadid, 2006).
- A strong relationship between droughts and animal death. Projected temperature increases, combined with reduced precipitation would lead to increased loss of domestic herbivores during extreme events in drought-prone areas; Batima,, 2003.Impacts on animal productivity due to increased variability in weather patterns will likely be far greater than effects associated with the average change in climatic conditions. Lack of prior conditioning to weather events most often results in catastrophic losses in confined cattle feedlots; (Hahn et al., 2001). with economic losses from reduced cattle performance exceeding those associated with cattle death losses; (Mader, 2003).
- In dry regions, there are risks that severe vegetation degeneration leads to positive feedbacks between soil degradation and reduced vegetation and rainfall, with corresponding losses of pastoral areas and farmlands; (Zheng et al, 2002). The impacts of drought can only be partly attributed to deficient or erratic rainfall, as drought risk appears to be constructed over time by a range of drivers. These include: poverty and rural vulnerability; increasing water demand due to urbanization, industrialization and the growth of agribusiness; poor soil and water management; weak or ineffective governance; and climate variability and change; (UNISDR 2011).
- Increased respiratory infections, particularly because of the atmosphere nebular (dusty), particularly in the north-eastern areas lack of water (for drinking and domestic use) or provided by a non-secure health, leading to a variety of digestive diseases tract and diarrhea (especially in children), and kidney disease; (FAO 2011).

4.5.1. Building Resilience

Countries of the Mediterranean, suffering now from the increased drought frequency, intensity and duration are likely to suffer more drought losses and impacts on agricultural production, rural livelihoods, migration, urban, economic sectors and ecosystem decline. They are in need for:

a) Strengthen commitment for comprehensive disaster risk reduction through CCA and DRR in national policies, legal frameworks, development plans and actions; decentralize resources, community participation; develop capacities to identify, assess and monitor drought risks through national/local multi-hazard risk assessment; build capacities/systems to monitor, archive, and disseminate data; regional early warning system and networks.
b) Build resilience through knowledge, advocacy, research and trainings by making information on drought risk accessible to all stakeholders; through educational material, curricula, approaches up to date; public awareness.
c) Integrate disaster risk reduction into emergency response, preparedness and recovery by making preparedness plans, contingency plans; recovery and reconstruction activities inclusive of all society groups and at all administrative levels; allocate budget locally for emergency; and coordination between national and local entities for timely information exchange during hazardous events and disasters.
d) Integrate activities in the national_strategy for CCA and DRR, that includes; drought risk loss insurance; improved water use efficiency; adopting and adapting existing water harvesting techniques; conjunctive use of surface and groundwater; upgrading irrigation practices on both the farm level and on the delivery side; developing crops tolerant to salinity and heat stress; change of cropping patterns; altering the timing or location of cropping activities; diversifying production systems into higher value and more efficient water use options; and capacity building of relevant stakeholders.
e) In recent years two severe drought cycles were recognized in Syria, the first one took place starting from the agriculture season of 1997/1998 till the agriculture season 2000/2001and the second one started on the winter agriculture season of 2005/2006 for five years seasons of drought. The two cycles changed the shape of Syria and lead the country into years of instability. Syria is one example that illustrating the relations between increased natural forces of such as "drought and land degradation" with increased political, social and economic pressures such as poverty, displacement, conflicts. It shows how the severely deplaned natural resources and increased environmental hazards could accelerate or create media for political instability.

Chapter 5: Assessing Agriculture Drought Hazard in South America Drylands

5.1. Drylands a Puzzling Ecosystem

Drylands are arid, semi-arid and dry sub-humid areas. In the context of sustainable development the term generally excludes hyper-arid areas (deserts). When land degradation occurs in the world's drylands, it often creates desert-like conditions. In environmental terms, drylands are charac-terized by:

• Low, infrequent, irregular and unpredictable precipitation;
• Large variations between day and night-time temperatures;
• Soil containing little organic matter, and a lack of water; and
• Plants and animals adapted to climatic variables (drought-resistant, salttolerant,heat-resistant, and able to cope with a lack of water).

Drylands cover 41 percent of the earth's terrestrial surface. They are home to a third of all humanity, and have some of the highest levels of poverty, yet in most countries they have long been neglected by investment and sustainable development interventions. Drylands , include desert, grassland and savanna woodland biomes, and considered one of the world's major ecosystems that long-running fear of destruction and rising expectations of a 'tipping point' in climate change. The drylands have long lived with uncertainty and the threat of unsustainability, where moisture is scarce for all or part of the year, and soils for the most part infertile.

The distribution of the world's drylands shows that they occur in every continent, but are most extensive in Africa. The dryland system is shown in (Table 5.1).

Table 5.1 The Dryland System

Sub-type	Aridity Share Index	Share of global area Percent	Share global Population Percent	Rangeland Percent	Cultivated Percent	Other Percent*
Hyper-arid	<0.05	6.6	1.7	97	0.6	3
Arid	0.05-0.20	10.6	4.1	87	7	6
Semi-arid	0.20-0.50	15.2	14.4	54	35	10
Dry subhumid	0.50-0.65	8.7	15.3	34	47	20
Total		41.3	35.5	65	25	10

*Includes urban
The aridity index is the ratio of precipitation to potential evapo-transpiration.5
Source: Safriel et al., 2005.

Drylands are disproportionately prevalent in poor countries, but they have been relatively marginalized from development processes and political discourse. This has allowed profound misunderstanding of drylands environments to become entrenched, leading to inappropriate and even detrimental interventions based on perceptions dominated by land degradation, (figure 5.1). Drylands must be central in strategies to achieve global sustainability, as the six major challenges to global sustainability such as: (1) poverty, inequity and human well-being; (2) globalization; (3) private-public balance in development; (4) environmental damage; (5) conflict and competition for resources; and (6) poor governance, all have their manifestations in the drylands, (Mortimore et al 2009)[19].

The world as a whole has a stake in the health of dryland systems and that changing drylands will lead to a changing the world, not only because of their physical extent but on account of our increasing understanding of their interactions with global climatic, economic and geopolitical systems. Such forces are re-integrating drylands with global futures. Nowhere is this more obvious than in climate change, (Mortimore et al 2009).

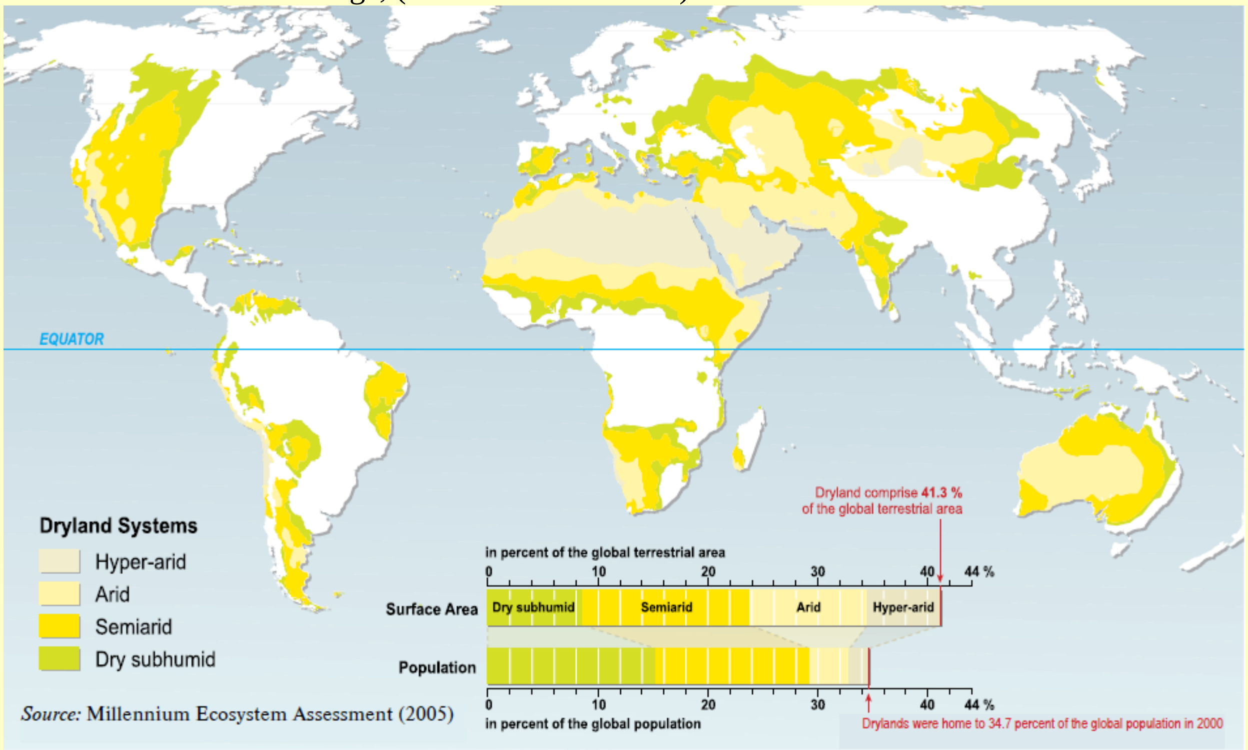


Figure 5.1 Distribution of the world's drylands according to aridity zones (UNEP, 1992).

Although drylands have effects on food prices, but loss of land croplands and in rangeland its impacts are poorly understood. The following issues are the major reasons that could answer an important question, about the importance of drylands, taking into consideration that the 'health' of the ecosystems is contingent on that of the human systems, (Mortimore et al 2009).

- Poverty is shockingly broad and deep in drylands, and ecosystem management is linked. Dryland ecosystems are considered to be under threat, (Adeel et al., 2005[20]; Safriel et al., 2005[21]). Land use change, which is at the heart of ecosystem change, is driven by policy, legislation, institutions and development interventions. A growing understanding of dryland dynamics only serves to underline their importance in the global system.

---

[19] Mortimore, M. with contributions from S. Anderson, L. Cotula, J. Davies, K. Faccer, C. Hesse, J. Morton, W. Nyangena, J. Skinner, and C. Wolfangel (2009). Dryland Opportunities: A new paradigm for people, ecosystems and development, IUCN, Gland, Switzerland; IIED, London, UK and UNDP/DDC, Nairobi, Kenya. x + 86p.

[20] Adeel, Z., Safriel, U., Niemeijer, D. and White, R. 2005. Ecosystems and human well-being: Desertification synthesis. Millennium Ecosystem Assessment. World Resources Institute, Washington, DC.

[21] Safriel, U., Adeel, Z., Niemeijer, D., Puigdefabregas, J.,White, R., Lal, R., Winslow, M., Ziedler, J., Prince, S.,Archer, E., and King, C. 2005. Chapter 22: Dryland systems. In: Hassan, R., Scholes, R. and Ash, N. (eds.) Millennium Ecosystem Assessment. Vol. 1. Ecosystems and human well-being: Current state and trends. World Resources Institute, Washington, DC. pp. 623-662.

- In dryland areas biodiversity is richer than sometimes thought, and both farmers and herders take an intense interest in natural diversity and agro-diversity, which takes on special significance during food shortages, (Faye et al., 2001)[22].
- Geopolitical instability in some drylands cannot go unnoticed, and is alerting policy makers to linkages between security and ecology, (Brown et al., 2007)[23]
- Climatic interactions between drylands and global circulation systems (e.g., the export of Saharan dust to South America, the Caribbean, and even Europe; links between sea surface temperatures and African rainfall; el Niño effects on tropical rainfall) and geopolitical interconnections (e.g., effects of poverty on illegal migration to Europe; insecurity in ocean shipping lanes; international costs of dealing with food emergencies; terrorist incubation in misgoverned and impoverished dryland countries) are but a few reasons why the North cannot afford to ignore the drylands of developing countries.
- Dryland biomes - compared with other major biomes – are poor, remote and degraded, and apart from having tourist potential, do not really matter globally.
- Drylands are on the edges of deserts and the deserts are expanding ('desertification') owing to human misuse of the environment (overgrazing, deforestation and over cultivation).
- Drylands are of low biological productivity if compared to other major biomes areas, they yield a satisfactory return on investment owing to high risks resulting from low and variable rainfall, they have in general a little economic value except to provide subsistence to those who live there.
- Drylands are weakly integrated into markets and because of their remoteness, poverty and low biological productivity, will remain
- Dryland communities are conservative and resistant to modernization and institutional change. Governance, rights and institutions are of only local importance and can safely be ignored in favour of new technologies.
- Risk and vulnerability resulting from uncertainty and environmental change can be adequately countered by standard development policy. new approaches to risk management are emerging, which build on local and customary practice and directly confront variability.

Draylands are poorly understood, and the question will remain about its opportunities and sustainable development framework, A strategy is needed that will achieve three aims: enhancing the economic and social well-being of dryland communities, enabling them to sustain their ecosystem services, and strengthening their adaptive capacity to manage environmental (including climate) change, (Mortimore et al 2009).

The main integrated strategy for dryland peoples and their ecosystems is proposed, based on the following major issues:

[22] Faye, A., Fall, A., Mortimore, M., Tiffen, M. and Nelson, J. 2001. Région de Diourbel: Synthesis. Drylands Research Working Paper 23e. Drylands Research, Crewkerne, UK.

[23] Brown, O., Hammill, A. and McLeman, R. 2007. Climate change as the 'new' security threat: implications for Africa. International Affairs 83(6): 1141-1154.

- Upgrading the knowledge base, improving knowledge sharing, and closing the gap between science and development practice in order to make best use of technology and to foster sustainable management. This includes improving understanding of dryland ecosystems (e.g., seasonality, variability, ecosystem services such as water, and human or social systems).
- Reassessing the total economic value of ecosystem services, to correct systemic undervaluation in national planning and policy, and improve well-being.
- Promoting sustainable public investments in natural resources, to reverse decades of relative neglect, provide better incentives for private investment, and recognize the contribution of small-scale environmental investments.
- Turning the growth of markets into an opportunity to remove barriers to participation, and to use more efficient, accessible and equitable markets as a pathway to sustainable development
- Supporting institutional changes to strengthen rights to natural resources, reform inequitable distribution, better manage risk, and increase resilience in the human ecological system.

5.2. Reviewing Drought in South America

Mean annual temperature in the countries of the northern Andes (Venezuela, Colombia, Ecuador, Peru) has increased by about +0.8 °C during the 20th century. Vuille and Bradley (2000) documented the tendencies of air temperature anomalies from 1939 to 1998 for the tropical Andes from 1°N to 23°S in relation to the 1961-1990 mean, and they found a positive tendency of +0.11 °C per decade for this period.

Droughts can be due to many climactic events on of which can be the change in weather patterns during an ENSO event (El Niño/La Niña-Southern Oscillation, or ENSO, a climate pattern that occurs across the tropical Pacific Ocean on average every five years). This alters regions of high and low pressures around the globe. This results in high surface pressures that prevent the areas of precipitation from moving into its region and lead to drought conditions, depriving the area and ecosystem of rainfall.

Droughts generally occur in the western Pacific during ENSO events, an area normally rich in rainfall. However, droughts in many other regions of the world, including southeastern Africa, India, China and northeastern region of the South American continent, have been linked to El Niño. ENSO results in drier conditions in Northeast Brazil during the Northern Hemisphere winter, the climatic impact of El Niño is drier conditions in Central America, Colombia and Venezuela. During the 1997/1998 El Nino caused severe droughts and forest fires in northeast Brazil. (World Meteorological Organization 1999) The dry spells observed in the La Plata Basin, was studied using daily data supplied by 98 stations during variable periods between 1900 and1998. (Naumann et al 2008) From this it appears that the 1988 drought is considered to be the one of the longest dry spell in the basin. Water deficits translate to Argentinean economic losses of more than four billion dollars.

In 2005 large sections of southwestern Amazonia experienced one of the most intense droughts of the last hundred years. (Marengo et al 2007) The drought severely affected human population along the main channel of the Amazon River and its western and southwestern tributaries, the Solimões (also known as the Amazon River in the other Amazon countries) and the Madeira River, respectively. The river levels fell to historic low levels and navigation along these rivers had to be suspended. The causes of the drought were not related to El Niño but to:

1) The anomalously warm tropical North Atlantic,

2) The reduced intensity in the northeast trade wind moisture transport into southern Amazonia during the peak summertime season, and

3) The weakened upward motion over this section of Amazonia, resulting in reduced convective development and rainfall.

The drought conditions were intensified during the dry season into September 2005 when humidity was lower than normal and air temperature were 3º - 5º warmer than normal. Because of the extended dry season in the region, forest fires affected part of southwestern Amazonia. Rains returned in October 2005 and generated flooding from February 2006.

One of the worst droughts in 50 years occurred in 2008 and 2009, which devastated crops, dry rivers and springs, and killed cattle in Argentina, a phenomenon also impacted on socio-economic and productive communities and regions. La Niña 2008-2009 depleted water reserves not only in Argentina but also in Paraguay, Uruguay and Brazil. According to the Meteorological Weather Service of Argentina (SMN), during 2008 observed rainfall values were below normal in most of the humid and semi-humid region of the country (the Pampas), comparing with the main value of the period 1961-1990.

The accumulated rainfall in the center of the region represented only 40-60% of the normal values, and in some locations values of precipitation were the lowest of the last 47 years.

"Drought has cost Argentina 30% of its corn exports. "Extremely dry conditions and very high temperatures during December 2011 and the first half of January 2012, coinciding with the key period of corn flowering, have diminished production drastically. More rains will be needed for the second season "safrinha" corn crop, an increasingly important crop for South America", that is the kind of reports that become common about South America prepared by US officials in Buenos Aires, (Figure 5.2).

The forecast for the corn crop, estimates as low as 17m tons, is in line with an emerging consensus, but substantially below the USDA's forecast of a 26.0m-tonne harvest. Ideas that corn buyers will be forced to turn from Argentina, the second-biggest corn exporter. The forecast for Argentina's soybean crop was also cut by 4.5m tones to 46.5m tons, and for Brazilian soybeans by 2m tons to 70m tons. The Brazilian corn estimate was left unchanged at 61m tons. Allendale pegged the Argentine soybean crop at 49m tons, and the Brazilian one at 72m tons. The Brazilian corn harvest was estimated at 60m tons.

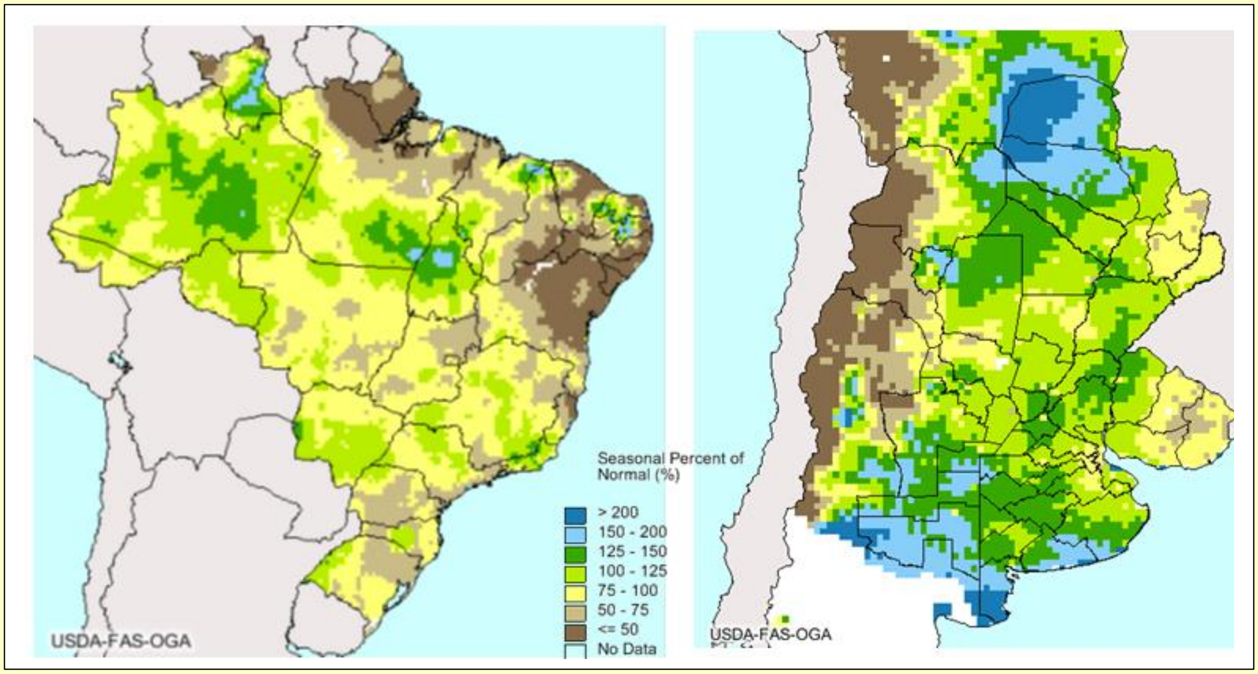


Figure 5.2. Seasonal Percentage from Normal

European Commission monthly reports, in September 2013[24], highlighted the drought impacts in many South America countries as Follows:

- Argentina – Forest fires and drought: The provinces of Santa Fe, Formosa and Salta are being affected by protracted drought which is causing severe damages in agricultural and livestock production. Animal mortality is high, streams and lakes are almost dry and it is most probable that the harvest figures will drop considerably. While in the Province of Córdoba is being affected by forest fires, more than 500 persons have been evacuated, while 40,000 hectares of forest have been devastated by the fire, and an uncounted number of animals have died.
- Bolivia – Drought: 247,000 hectares of land have been affected by droughts, frost and fires in more than a half of the Bolivian territory. Drought is affecting 51 municipalities in the departments of Chuquisaca, Santa Cruz, Cochabamba, La Paz and Tarija.
- Paraguay – Drought: The Chaco region is being affected by a severe drought and the state of emergency has been declared in the departments of: President Hayes, Boqueron and Alto Paraguay, at least 15,000 families have been affected.

[24] European Commission 2013 http://eeas.europa.eu/delegations/ecuador/documents/echo_ayuda_humanitaria/20131009_monthlyreport_09_2013_es.pdf

5.3. Reviewing Land Degradation in South America

Contrary to popular perception, desertification is not the loss of land to desert or through sand-dune movement. Desertification refers to land degradation in arid, semi-arid and sub-humid areas resulting from various factors, including climatic variations and human activities. When land degradation happens in the world's drylands, it often creates desert-like conditions. Land degradation occurs everywhere, but is defined as desertification when it occurs in the drylands.

The soil of degraded land has less capacity to support plant growth, resulting in the loss of vegetation and economic productivity. Despite the fact that animals and plants are able to adapt to the drylands, desertification has serious consequences for the environment. It is often caused by human activities, such as overgrazing, over-cultivation, deforestation and poorly planned irrigation systems. Extreme climatic events, such as droughts or floods, can also accelerate the process.

Desertification occurs because dryland ecosystems are extremely vulnerable to over-exploitation and inappropriate land use. Poverty, political instability, deforestation, overgrazing and improper irrigation practices can all undermine the productivity of the land. There is no linear process of cause and effect leading to land degradation in the drylands, but its drivers, which interact in complex ways, are known. Such drivers are climatic, especially low soil moisture, changing rainfall patterns and high evaporation. Most of them are human-related, and include poverty, technology, global and local market trends and socio-political dynamics. It is important to note that poverty is both a cause and consequence of land degradation. Other consequences of desertification include:

- Diminished food production, soil infertility and a decrease in the land's natural resilience;
- Increased downstream flooding, reduced water quality, sedimentation in rivers and lakes, and silting of reservoirs and navigation channels;
- Aggravated health problems due to wind-blown dust, including eye infections, respiratory illnesses, allergies, and mental stress;
- Loss of livelihoods forcing affected people to migrate.

There is a fine line between drylands and deserts – once crossed it is hard to return. It is much more cost-effective to prevent drylands from degradation than to reverse it. Restoring soil lost by erosion is a slow process. It can take 500 years for 2.5 centimetres of soil to form but only a few years to destroy it. UNEP in 1993 suggested that desertification and drought account for USD 42000 million income lost worldwide every year, equivalent to all official aid to Africa in 2009.

Soil erosion afflicts the Andean region of Peru, which makes up about 30 percent of the country. Soil erosion has been shown to reduce maize yields by 2 percent on plots of sloped land.

While the cost of establishing terraces to reduce the effects of erosion is estimated at US$364 per hectare, the net present value of plots with terraces is about US$984 per hectare. The cost of action (that is, creating terraces) is actually even lower when looked at as a long-term investment. The cost of salinity in the irrigated crops of the arid and semiarid coastal region (about 34 percent of the land) was also evaluated using rice yields. Crop simulation results showed that salinity reduced rice yields by 22 percent in Peru, which led to a loss of US$402 per hectare. The cost of desalinization methods was US$69 per hectare, which is only 17 percent of the cost of not taking any action.

In South America, soil erosion is the main threat for land and this problem affects 68 percent of the land resources. Heavy rains and unsuitable agricultural practices on the slopes of hills and mountains are important causes in the loss of agricultural potential .

Deforestation has caused the degradation of about 100 million ha in South America, of which almost 70 million have been due to animal grazing. In the case of watersheds, deforestation is a key factor in the region. This process is very severe on western slopes (faldeo) of the Andes, here it principally affects tropical forests known as the "Yungas," which extend from Colombia to Argentina,(Hugo 2008)[25].

In South America, it has been determined that the high environmental costs of agriculture are related to soil erosion, the loss of soil fertility, the degradation of lands by animal grazing, and excessive use of pesticides. Agriculture on unsuitable lands and/or with inappropriate techniques is characterized by a series of effects which includes:

- Increasing erosion of slopes due to deforestation, over-grazing, and inappropriate agricultural practices linked to both subsistence economies and large-scale business developments;
- Increase in the surface runoff and evaporation, reduced infiltration, and dramatic increase of erosion;
- Silting-up of rivers, diversion and impairment of river beds, and increased flooding
- frequency in the middle and lower courses during the rainy season;
- Drying-up of rivers and reduction of ground water during the dry season;
- Rapid silting up of reservoirs.

Soil degradation is also produced by the fragmentation of water systems, intense urbanization, uncontrolled pollution, and construction of large engineering projects, all fueled by an exponential growth of the human population and the lack of planning in the development process (Abramovitz, 1996)[26].

a) Land Degradation in Argentina:

Soil does not receive enough consideration since it supports Argentina's agricultural activity. Almost 60 million ha are affected by water and wind erosion to either a moderate or severe level. Economic losses due to soil degradation are estimated to be nearly 700 million dollars per year. Intensity of the summer rains, low levels of water infiltration into the prevailing clay soils, and practice of conventional agriculture are the main causes of soil degradation. The direct

[25] Hugo G 2008.Trends in Land Degradation in South America, Direccion, Meteorologica de Chile, Santiago, Chile

[26] Abramovitz. 1996. Imperiled Waters, Impoverished Future: The Decline of Freshwater Ecosystems. World Watch Paper, 128, marzo, Washington, D.C.

causes of wind erosion in the semiarid region are the lack of crop rotations, the reuse of inappropriate cultivation implements, over-grazing of natural and cultivated fields, deforestation of unsuitable lands for agriculture, and a common practice in this region, the tilling of unsuitable lands with ill-suited agricultural practices. In the beginning of the 1990s, it was estimated that 20 percent of the national territory was affected by water and wind erosion (nearly 60 million ha). It has been estimated than each year between 200,000 and 650,000 ha of land are eroded (Casas, 2001)[27].

Among the main causes of accelerated erosion in Argentina are:

- The advance of the agricultural frontier on marginal lands without using the correct techniques;
- Intensification of yearly cultivations without considering the aptitude of the land, conservation measures, and necessary management;
- Uncontrolled elimination of vegetation, particularly deforestation; over-grazing of pasturelands; and deliberate and accidental fires.
- Excessive cultivation without crop rotation, improper handling of organic matter and agricultural waste, and inappropriate farming systems.
- The consequences are the creation of tillage pans, reduced infiltration, and increased risk of water erosion.
- Soil salinization is also a serious problem in Argentina, affecting both irrigated and dry-farmed land, in several areas, over 60 percent of irrigated land has salinized soils.

b) Land Degradation in Bolivia

The area affected by degradation covers 41 percent of the national territory and is mainly located in the Departments of Oruro, Potosí, Chuquisaca, Tarija, La Paz, Cochabamba, and Santa Cruz. land degradation is increasing and threatening, and is fundamentally expressed in an intense process of erosion that produces the loss of capability in agricultural and forest soils, the destruction of the productive base of the country, and the aggravation of poverty.

Land degradation has serious economic consequences. Annually, 40 thousand ha of national territory lose productive capacity due to the effect of degradation. In addition to obvious environmental implications, this situation affects the economic development of the agricultural and forest sectors, which causes the loss of approximately 50 million dollars per year and represents 4% of the total output of the sector. According to data provided by land use and coverage maps, 82 percent is covered by pasture and forest lands susceptible to be used in more intense forms, which entails a potentially high risk of erosion and/or degradation of these ecosystems (Benites, et al., 2003)[28]. The continued use of the land has led to water erosion of the soil and to overgrazing. In some sectors of the Cochabamba valleys, irrigation and semiarid climate have generated salinization of soils.

[27] Casas, R. 2001. La Conservación de los Suelos y la Sustentabilidad de los Sistemas Agricolas en la Republica de Argentina.

[28] Benites, J., D., Saintraint, and K. Morimoto. 2003. Degradación de suelos y producción agrícola en Argentina, Bolivia, Brasil, Chile, y Paraguay.

c) Land Degradation in Brazil:

From the 1970s, the increased pace of export cultivations caused large soil degradation. In the 5 years from 1975 and 1980, Brazil moved into third place in the world among soybean producing countries by replacing subsistence or low-impact agriculture with highly mechanized agriculture. The acquisition of agricultural machinery increased 2,000 percent between 1975 and 1995 (Merten, 1996)[29]. The long-term impact of deforestation on soil resources can be serious. The clearing of native vegetation cover for agriculture and subsequent burning exposes the land to the intensity of the tropical sun and to torrential rains. This can negatively affect the soil by increasing soil compaction, reducing organic material, leaching the few soil nutrients that exist, increasing aluminum toxicity, and thereby marginalizing agriculture. Subsequent cultivations, frequent tilling, and excessive use for cattle grazing pasture accelerates soil degradation.

d) Land Degradation in Colombia:

Soil degradation and land erosion for the decade of the 1990s, large soil removal and sedimentation in Colombia can be estimated as follows: 48 percent of the Colombian territory displayed some grade of degradation, of which 14.2 percent was very high degradation; 10.8 percent was high degradation; 8.9 percent was moderate degradation, 9.5 percent was low degradation, and 4.6 percent was very low degradation. the deforestation of the tropical humid forest from pre-Columbian times, in the watershed of the Q. Yepes River in the Sierra Nevada of Santa Marta, Colombia, the frequent use of fire and intensive grazing have caused severe erosion and reduction in fertility, which has led to the conversion of humid forest to savannas.

Due to increasing food demand, Colombia has chosen to incorporate new lands to increase production. The humid tropical regions have suffered the impact of an agricultural exploitation, which use inherited practices such as cutting and burning trees (Olmos and Montenegro, 1987)[30].

e) Land Degradation in Ecuador:

The system of resource utilization in Ecuador is a classic example of developing countries that are forced to intensively exploit natural resources, which can result in the creation of serious problems, (Byers 1990[31]; White and Maldonado, 1991[32]). A study done by De Noni and Trujillo (1986)[33], demonstrated that 12 percent of the soils in the country (31,500 km2) were exposed to active erosion. The rate of deforestation in the country is 2.3 percent per year and by extrapolating, this implies that the country would be totally deforested in the year 2025.

---

[29] Merten G. 1996. Erosión actual en el estado de Paraná, Brazil: sus causas y consecuencias económicas.

[30] Olmos, E. and H. Montenegro. 1987. Inventario de los problemas de la erosión y degradación de los suelos de Colombia. IN: Congreso Colombiano de la ciencia del suelo, 4 y Coloquio la degradación de los suelos en Colombia,9. Neiva (Colombia), 18-21 de agosto de 1987. Resúmenes. Neiva, Sociedad Colombiana de la Ciencia del Suelo. 23 p.

[31] Byers, 1990;White and Maldonado, 1991. Erosion processes in tropical watersheds: A preliminary assessment of measurement methods, action strategies, and information availability in the Dominican Republic, Ecuador, and Honduras. Development Strategies for Fragile Lands. Agency for International Development, Washington, D.C.

[32] White, S. and F. Maldonado. 1991. The use and conservation of natural resources in the Andes of southern Ecuador. In: Mountain Research and Development. 11 (1): 37-55 pp.

[33] De Noni, G. and Trujillo, G. 1986. La erosión actual y potencial en Ecuador: Localización, manifestaciones y causas. En CEDIG: La erosión en el Ecuador. Documentos de Investigación N° 6. Quito-Ecuador. 1-14 pp.

Ecuadorian societies are concerned about the degradation of the natural resources in of the Paramo zone caused by agricultural uses. Major causes for land degradation could be also related to: The use of tractors on relatively moderate slopes (25-35 degrees) has resulted in the transport of large quantities of soil downward (Kooistra and Meyles, 1997)[34]. Over-grazing on lands where cattle did not exist and the clearing of the forested parts of the slopes favor the acceleration of erosion and soil degradation in arid, semiarid, and sub-humid zones.

f) Land Degradation in Paraguay:

The pressure for land strongly emerged after 1989 due to many occupations of forested territories on the part of the farmers. The expropriation was facilitated by the land being regarded as "uncultivated" and "unused" by the owners. To counter this trend, from 1989 the landowners began a process of massive deforestation and delimitation of all estates regarded as unproductive, so that they would be classed as being "rationally managed" and therefore not subject to expropriation. This situation doubled average annual deforestation in less than a year, reaching a record level where less than 10 percent of the country's total land is still wooded, and the remaining subtropical woodland is forecast to disappear in 2010 (Kohler, 1992)[35].

g) Land Degradation in Peru:

Erosion covers an area of some 60 million ha, or 55 percent of the area of the territory, there is a fragile equilibrium in regards to erosion in the lowland jungle areas. Therefore, destroying the plant cover accelerates the erosion process in the hilly formations, which is typical of 70 percent of the physiographic scenario of the lower Amazon jungle. Erosion occurs on hillside soils without plant cover and is subject to heavy rainfall. In 2000, the deforestation affected 9.6 million ha (12.6 percent of the Amazonian forest of the country), and can be calculated on an average of 261 thousand ha deforested per year (0.35 percent/year). About 73 percent of these areas are in different stages of forest formation, known as secondary forests, and the product of various degradation actions (slash and burn agriculture, erosion, etc. (ENDF, 2001)[36].

h) Land Degradation in Uruguay:

Soil degradation constitutes a complex process whose advance is manifest reduction of soil productivity and the associated ecosystems. These successive reductions in productivity correspond to different processes in the country, mainly water erosion, as well as to the socioeconomic, institutional, legal, political, and cultural factors. In the same way, erosion represents a problem that also generates direct costs for the country, like the need to continuously replace lost nutrients, or the depreciation of land in the more affected zones.

[34] Kooistra, L. and E. Meyles. 1997. A novel method to describe spatial soil variability: A case study for a potato-pasture area in the northern Andes of Ecuador. Laboratory of soil Science and Geology, Wageningen Agricultural University, The Netherlands. 65p.

[35] Kohler, A. 1992. Erosión, Conservación y su contexto socio-económico, el caso Paraguayo- MAGGTZ. Proyecto de Planificación de Manejo de los Recursos Naturales. Hacia una Política de Uso de la Tierra el Paraguay. Asunción, ICONO SRL, Serie 3. 75-92 pp.

[36] ENDF. 2001. Proyecto FAO GCP/PER/035/NET "Apoyo a la Estrategia Nacional para el Desarrollo Forestal."

A study by Beloqui and Kaplán (1998)[37] concluded that although 30 percent of the land displays some degree of degradation, the deterioration of the soil properties is relatively low in relation to its prolonged use; nevertheless, the degradation of the structure of the surface horizons is closely related to the loss of organic matter.

i) Land Degradation in Venezuela:

Land degradation in Venezuela worsens every day, due principally to the rapid expansion of crops that utilize a great diversity of production methods and technologies that are unsuitable for the various soil types, climate, and socioeconomic conditions.

In Venezuela, like the other tropical countries, the more common problems of degradation are water erosion, sealing, compaction, salinization, and sodification, Most of the degradation problems not only depend on the intrinsic soil characteristics, but also on the very aggressive climate in the majority of areas and of the adoption of agricultural production systems and practices taken directly from other parts of the world with different climatic and socioeconomic conditions (Pla, 1988)[38]. According to FAO, deforestation in Venezuela is principally due to the demand for lands for agricultural purposes, (FAO, 2000).

During the period from 1990 to 2000, Venezuelan forests were cut at a rate of 500,000 ha per year to be converted into agricultural land and pastureland for cattle. It is precisely in the Guarico and Apure plains where over-grazing is common, because the natural pastureland is not able to maintain the existing number of animals. If the present-day rate of deforestation in these two states is constantly maintained, it is anticipated that an almost total disappearance of the forest will occur by 2020. Agriculture and livestock are the main causes of this large-scale deforestation.

The process of felling trees and the burning of the remaining vegetation for pasturelands, which later will be converted into corn and soybeans fields, along with the gradual deterioration of soils and water reserves, have caused the destruction of the majority of humid forests, dry forests, and the fertile soils suitable for the agricultural production. It is estimated that south of Lake Maracaibo, 95 percent of the forested areas have disappeared to establish low efficiency cattle-ranching. However, this activity produces 70 percent of the milk and half of the meat consumed in the country.

According to Hugo (2008), there are differences in the available statistics on the various land uses in South America; the following general trends are in agreement:

- Arable crop land and pastureland with the associated strong decrease of the forest area have increased.
- Erosion constitutes one of the most serious and generalized forms of land degradation in the region.

[37] Beloqui, C., and A. Kaplan. 1998. Los suelos del área rural de Montevideo. Un Desarrollo de los Recursos Hídricos y Promoción del Riego en el Area Rural de Montevideo. Serie Investigaciones Nº 126. CIEDUR-IMM. Montevideo (Uruguay). 25-45 pp.

[38] Pla, I. 1988. Riego y desarrollo de suelos afectados por sales en condiciones tropicales. Soil Technology. 1: 13-35 pp.

- The principal problems of soil degradation that affect the region include: water erosion, wind erosion, advancement of dunes, extraction of soil, salinization, drainage problems, loss of fertility, acidification, soil compaction, loss of soil structure, biological degradation, desiccation of fertile plains and valleys, landslides, and irreversible changes in soil use and pollution.
- Chile has undergone erosion problems caused by the conversion of areas to cattle ranching, extraction of firewood for fuels, indiscriminate use of fires, and the conversion of land to cereal and horticultural use.
- One of the most important environmental problems of the region is associated with the expansion of the cattle economy and the resulting conversion of soils from traditional cultivations to the production of cattle feed (soybean and sorghum) and the conversion of forest areas to pasturelands.

5.4. Assessing Drought in South America

5.4.1. Methodology

The major four elements used for developing the ADH map, were produced from MODIS – NDVI and MODIS – LST, images Several drought indicators have been used, after, Kogen (1995)[39] , Thenkabail et al (2004)[40] and European Commission (2006), for calculating the following monthly indices for all agriculture season's months during the years from 2000 till 2012, (Figure 5.3, after (Erian et al,2012[41]):

- The Normalized Difference Vegetation Index: NDVI were also used for identifying the main agriculture seasons in the region and for calculating VCI. Numbers of months with value for NDVI were calculated.
- Vegetation Condition Index: VCI were monthly calculated by the equation:

  VCI = (NDVI – NDVI min)/(NDVI max- NDVI min)*100,
- Temperature Condition Index, were monthly calculated by the equation:

  TCI= (BT max – BT)/(BT max- BT min)*100
- Vegetation Healthy Index: were monthly calculated by the equation

  VHI= (TCI *0.5)+(VCI*0.5)
- Calculate Agriculture Drought (AD), Intensity ADI, Variability ADV, Frequency ADF and Consecutive ADC.
- Calculate Agriculture Drought Hazard (ADH) from ADI, ADV, ADF and ADC

[39] Kogan, F.N. 2000. Contribution of remote sensing to drought early warning . In early warning systems for drought preperdiness and drought management , ed D,A. Wilhite and D.A. Wood, 75-87. Geneva: WMO.

[40] Thenkabail, P. S.; Gamage, M. S. D. N.; Smakhtin, V. U. 2004. The use of remote sensing data for drought assessment and monitoring in Southwest Asia. Research Report 85. Colombo, Sri Lanka: International Water Management Institute.

[41] Erian W., B Katlan, B. Oul.dbedy, H. Awad, E. Zaghtity and S Ibrahim, (2012). "Agriculture Drought in Africa Mediterranean and Middle East, Background paper prepared for the 2013 Global Assessment Report on Disaster Risk Reduction. Geneva, Switzerland: UNISDR.

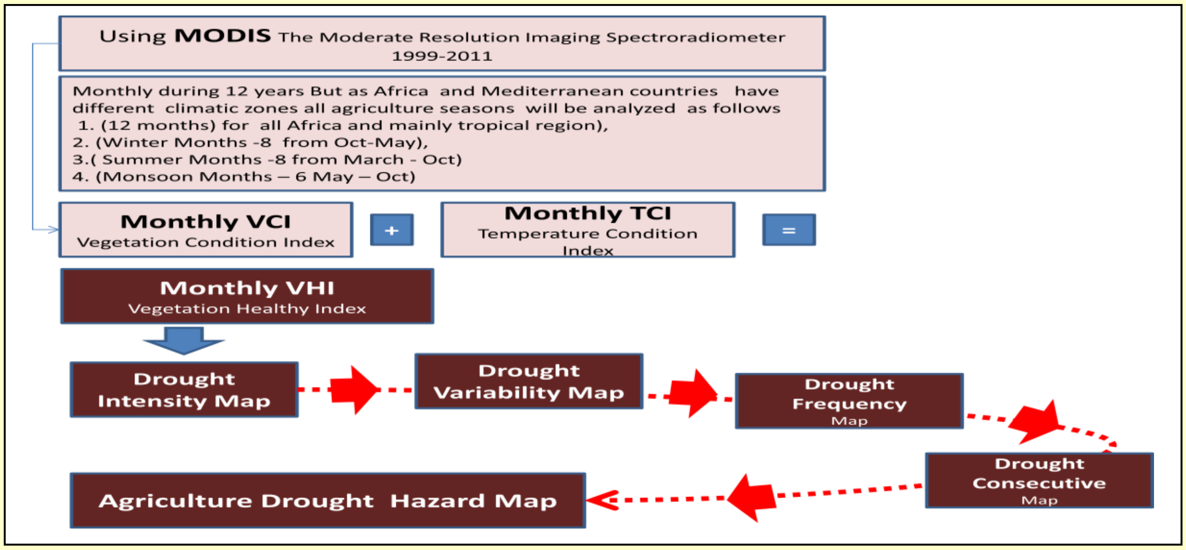


Figure 5.3. Main analysis for Producing ADH map, after (Erian et al 2012)

5.4.2. Agriculture Drought Intensity

The agriculture seasonally drought intensity maps of south America were prepared from the monthly VHI maps, and presented in table (5.1) and figures (5-4 to 5-16), the main purpose of presenting annual ADI maps is to follow the annual changes in drought intensity distribution,

The overall drought intensity map of the studied agriculture seasons where prepared from the seasonal maps, were produced and classified into 4 main classes, as follows: Slight drought intensity, class 1: 0-15% drought intensity, represents 0.75% of the study area, Moderate intensity class 2: 15-30% drought intensity, represents 2.39% of the study area, Severe intensity, class 3: 30-45% drought intensity, represents 16.47%of the study area and no intensity, (class 4: 45 - 100% drought intensity, represents 80.39% of the study area.

The ADI in South America Countries are ranked according to ADI and are shown in Table (5.2) and (Figure 5.17).

Table 5.2. The agriculture seasonally drought intensity maps of South America

Year	0-15	15-30	30-45	45-100	Total ADI	Severe ADI
	Severe (1)	Moderate (2)	Slight (3)	No ADI (4)	1+2+3	1+2
2000	3.26	6.65	24.04	66.05	33.95	9.91
2001	2.70	6.59	23.02	67.68	32.31	9.29
2002	2.95	6.15	21.66	69.24	30.76	9.1
2003	3.11	8.07	26.18	62.63	37.36	11.18
2004	1.87	3.78	18.45	75.91	24.1	5.65
2005	2.77	6.39	27.60	63.24	36.76	9.16
2006	2.05	4.43	23.01	70.51	29.49	6.48
2007	2.56	6.88	26.54	64.02	35.98	9.44
2008	2.69	8.96	31.03	57.32	42.68	11.65
2009	3.00	10.41	30.90	55.69	44.31	13.41
2010	3.50	8.31	29.98	58.21	41.79	11.81
2011	3.10	5.93	22.19	68.78	31.22	9.03

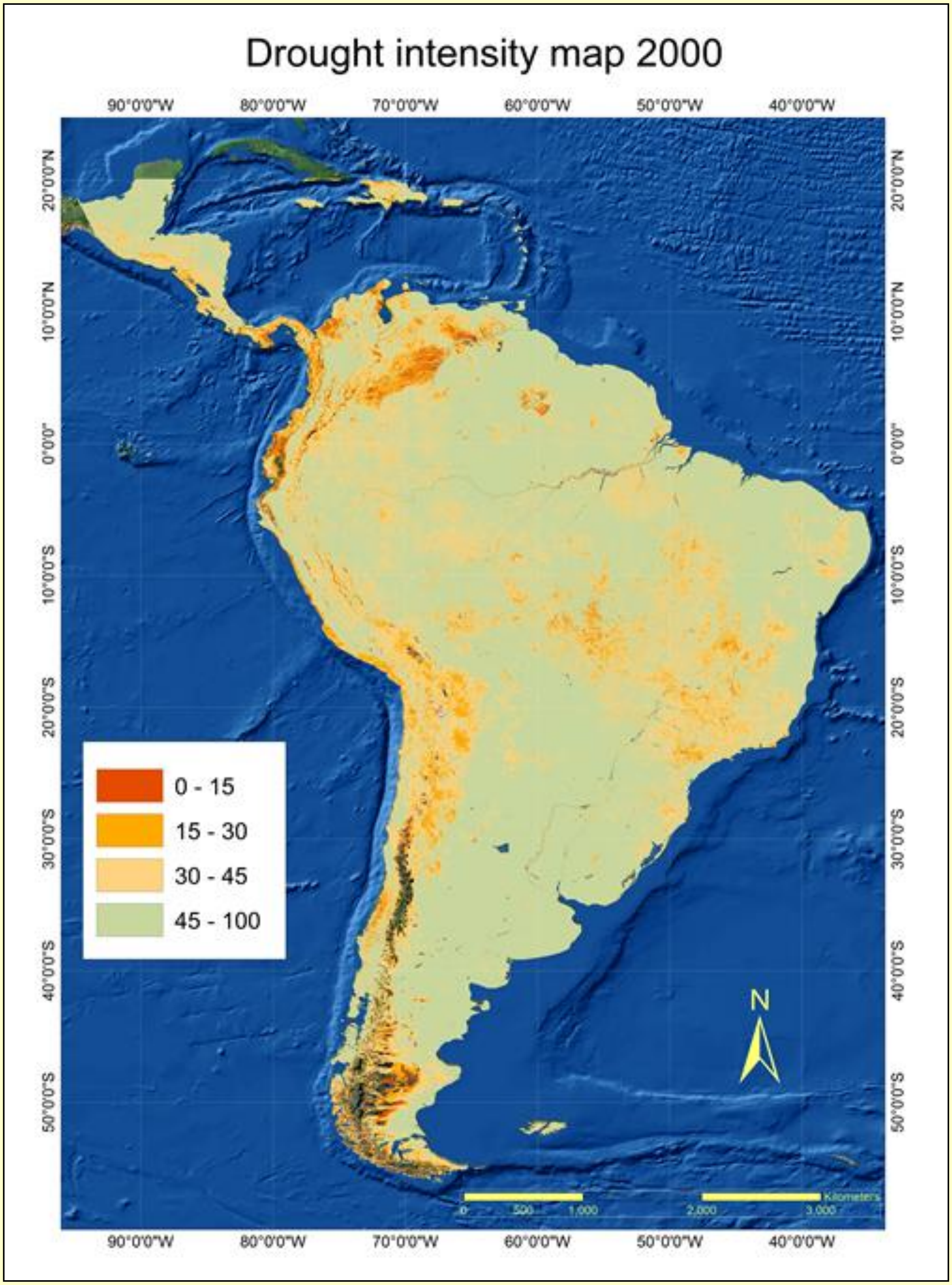


Figure 5.4. Annual Agriculture Drought Intensity in South America Countries - 2000

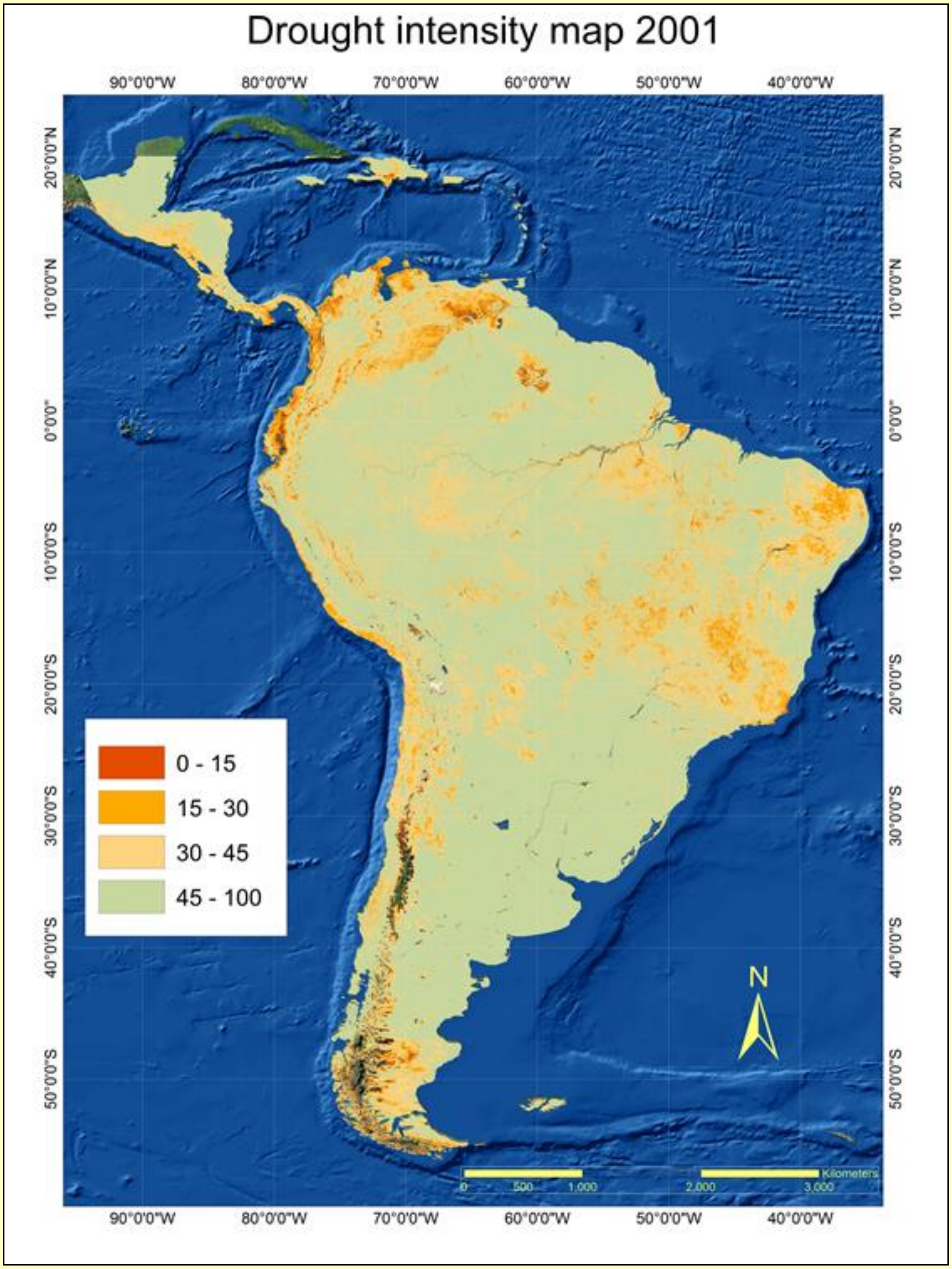


Figure 5.5. Annual Agriculture Drought Intensity in South America Countries - 2001

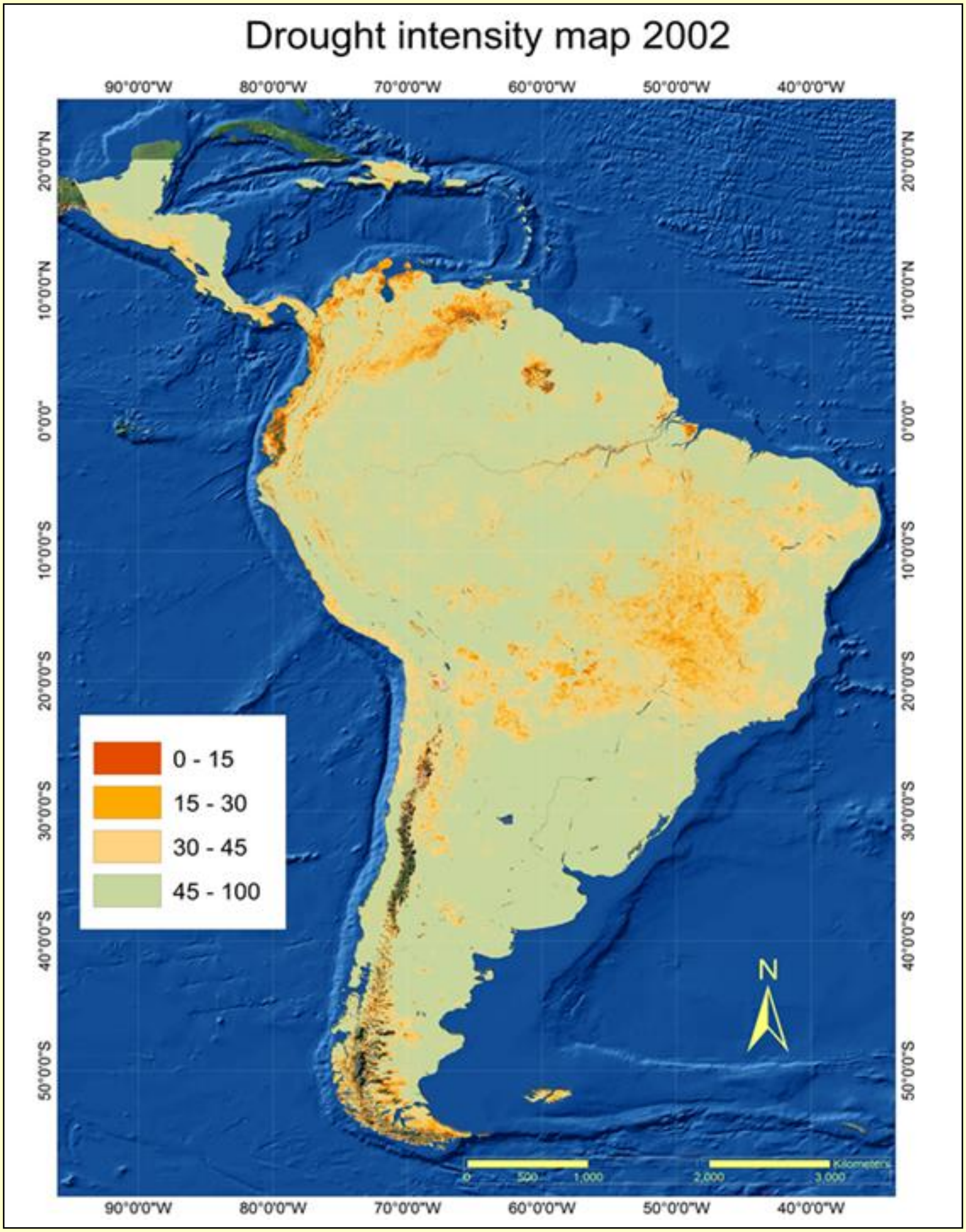


Figure 5.6. Annual Agriculture Drought Intensity in South America Countries – 2002

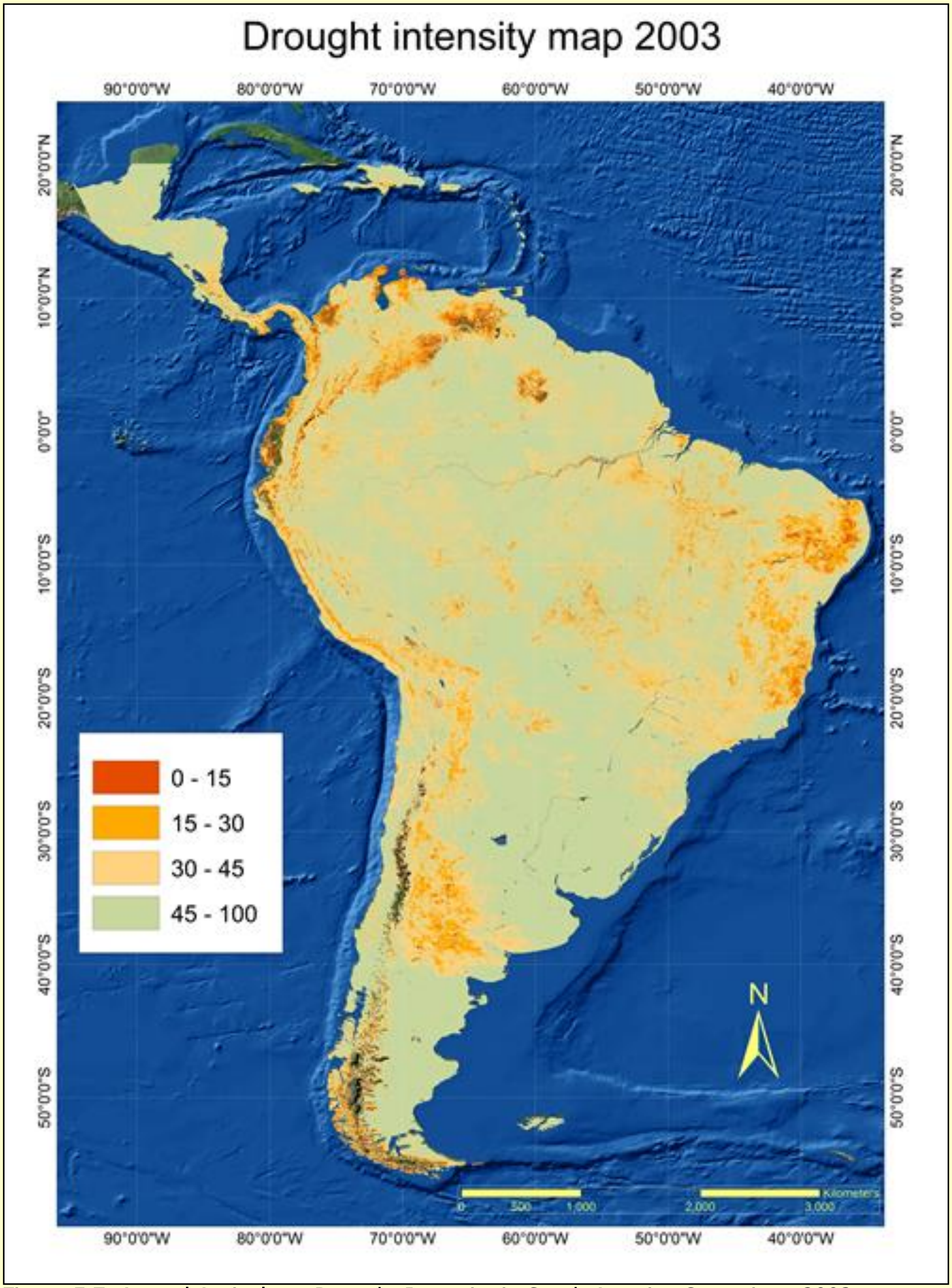


Figure 5.7. Annual Agriculture Drought Intensity in South America Countries - 2003

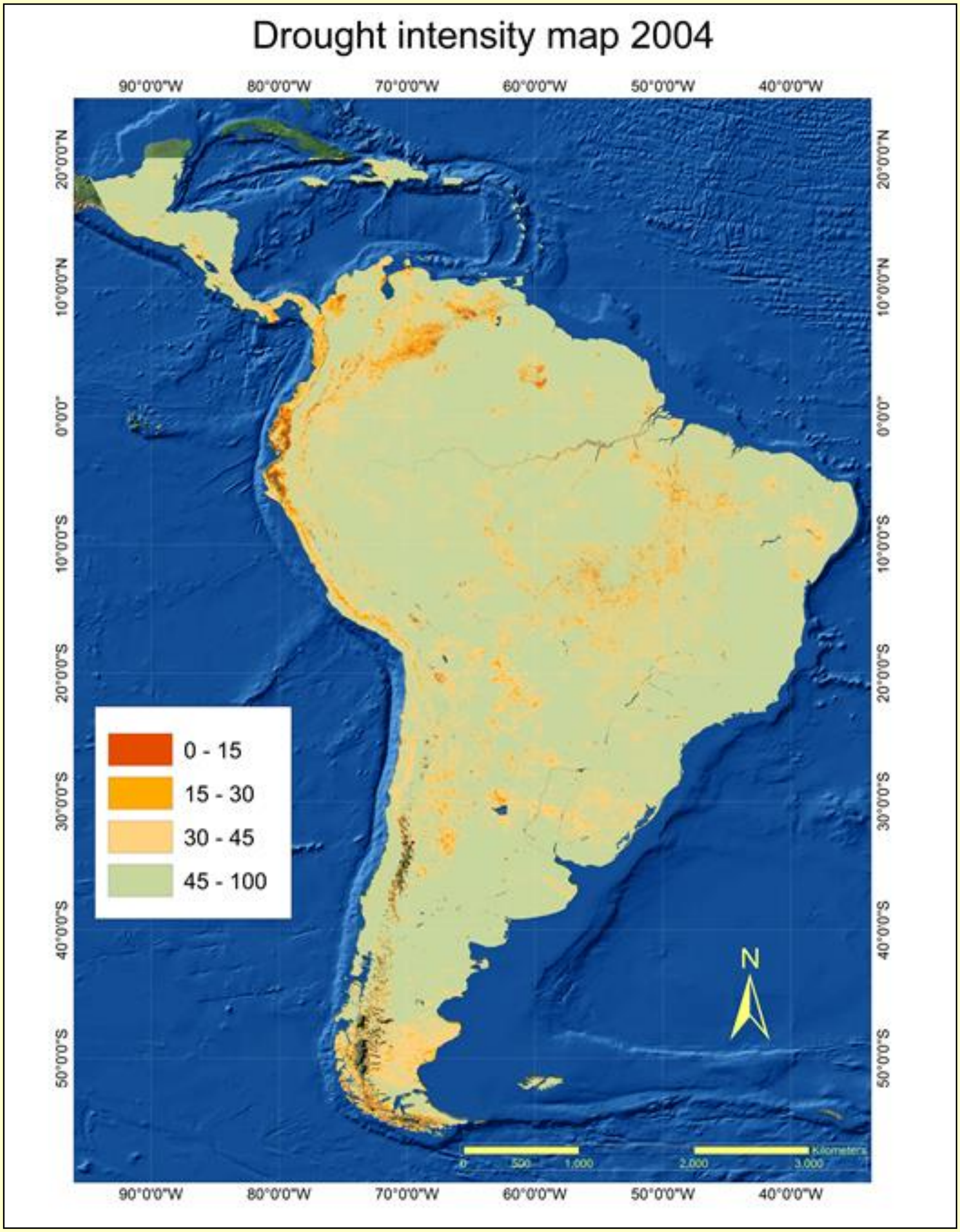


Figure 5.8. Annual Agriculture Drought Intensity in South America Countries - 2004

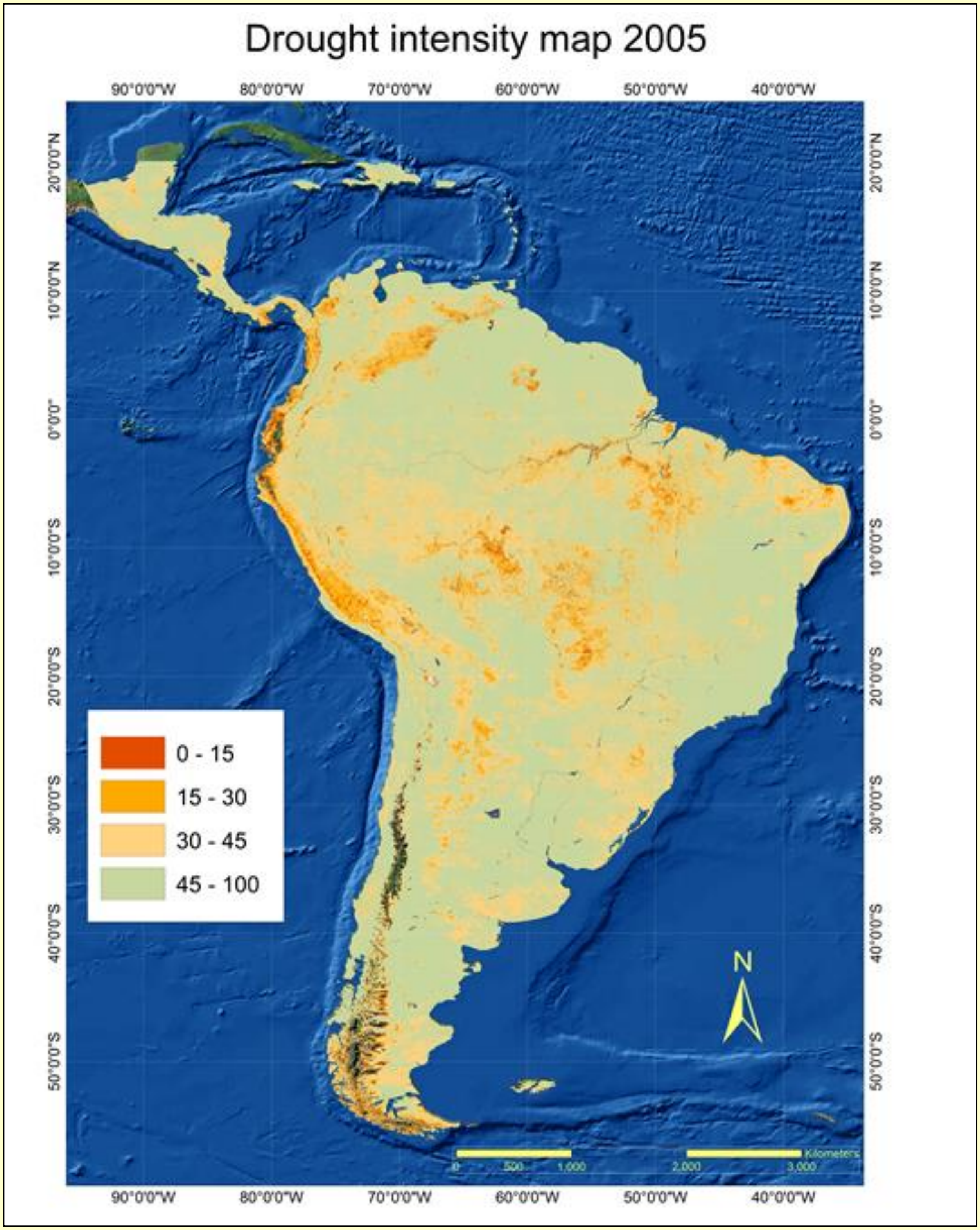


Figure 5.9. Annual Agriculture Drought Intensity in South America Countries - 2005

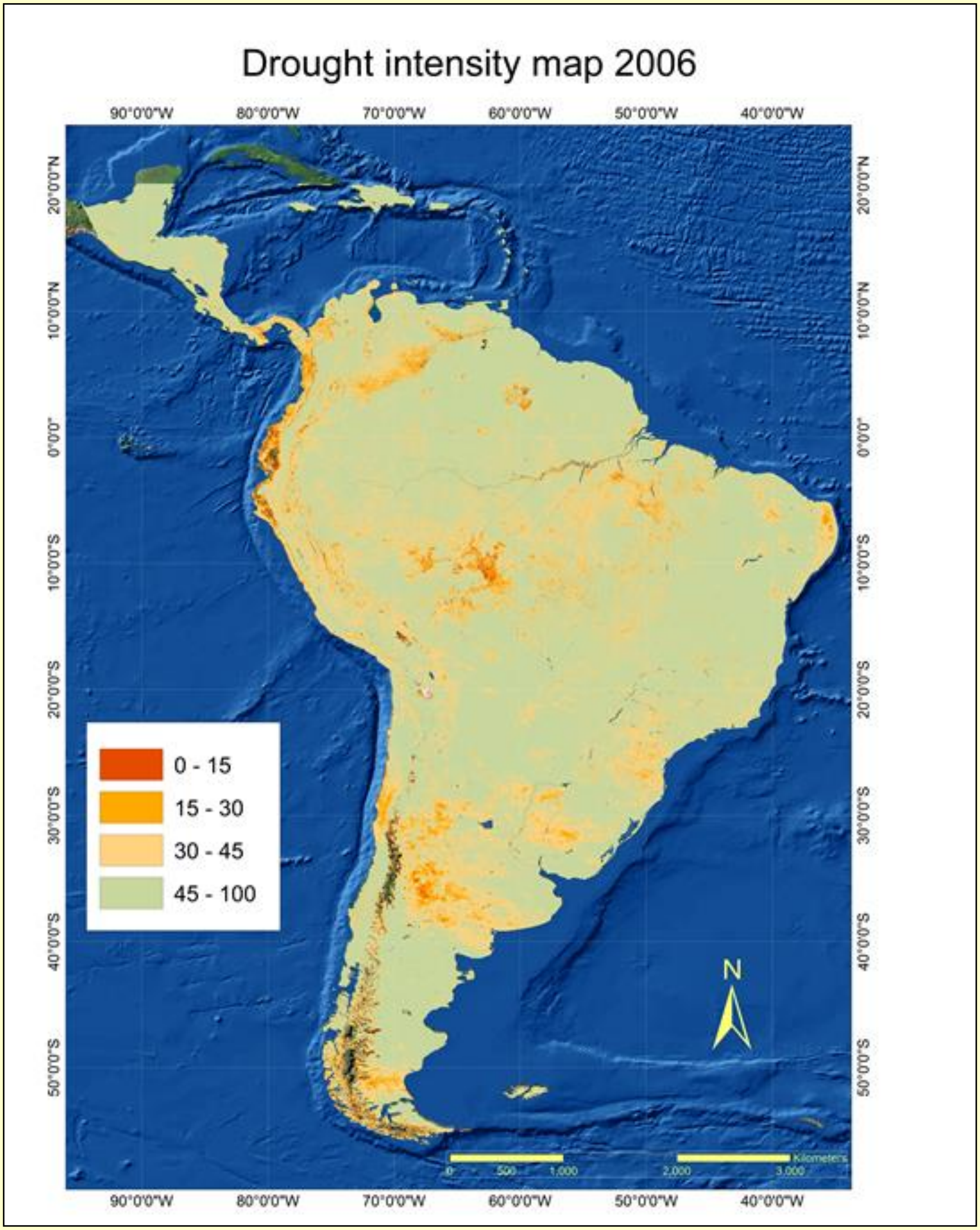


Figure 5.10. Annual Agriculture Drought Intensity in South America Countries - 2006

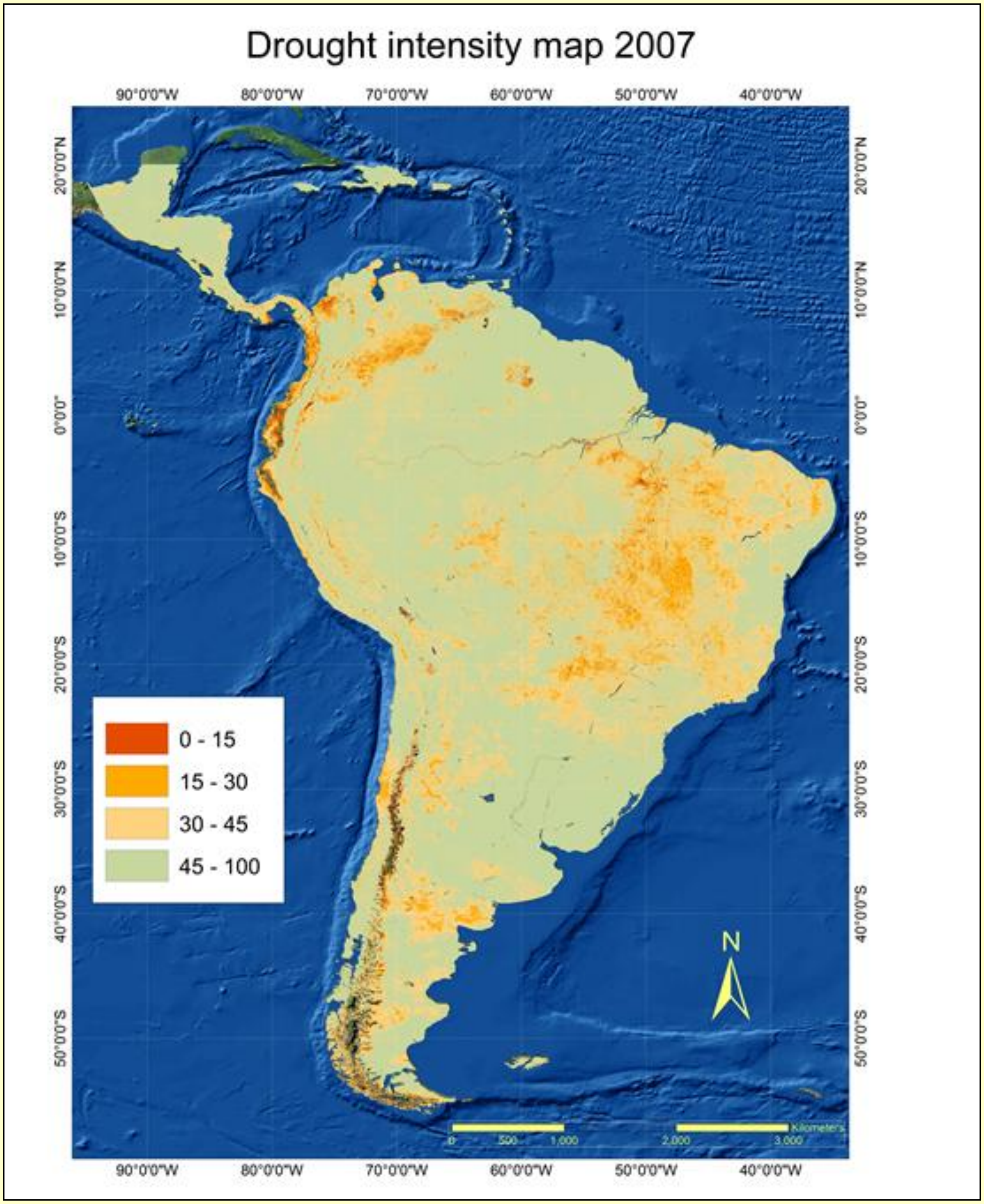


Figure 5.11. Annual Agriculture Drought Intensity in South America Countries – 2007

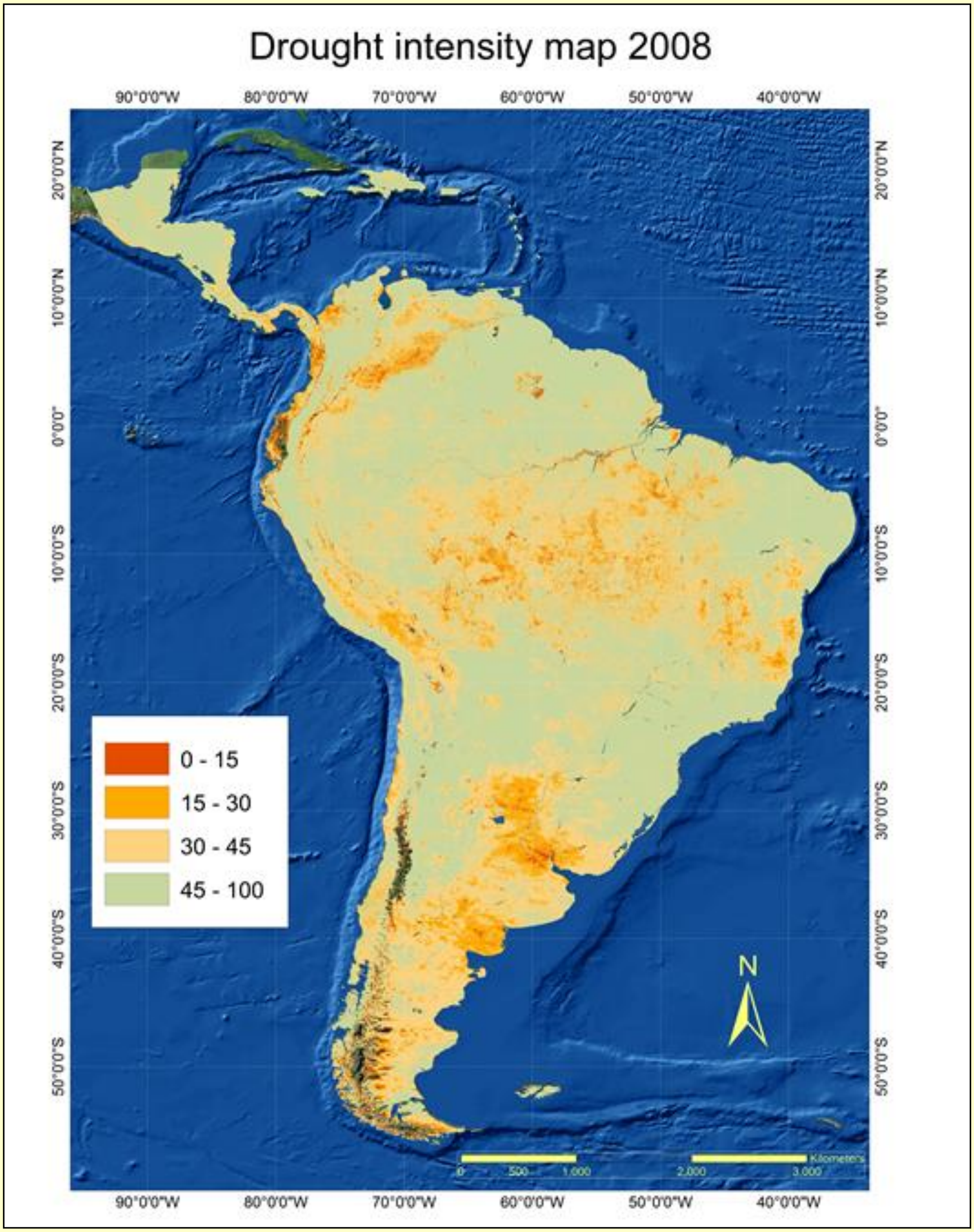


Figure 2.12. Annual Agriculture Drought Intensity in South America Countries – 2008

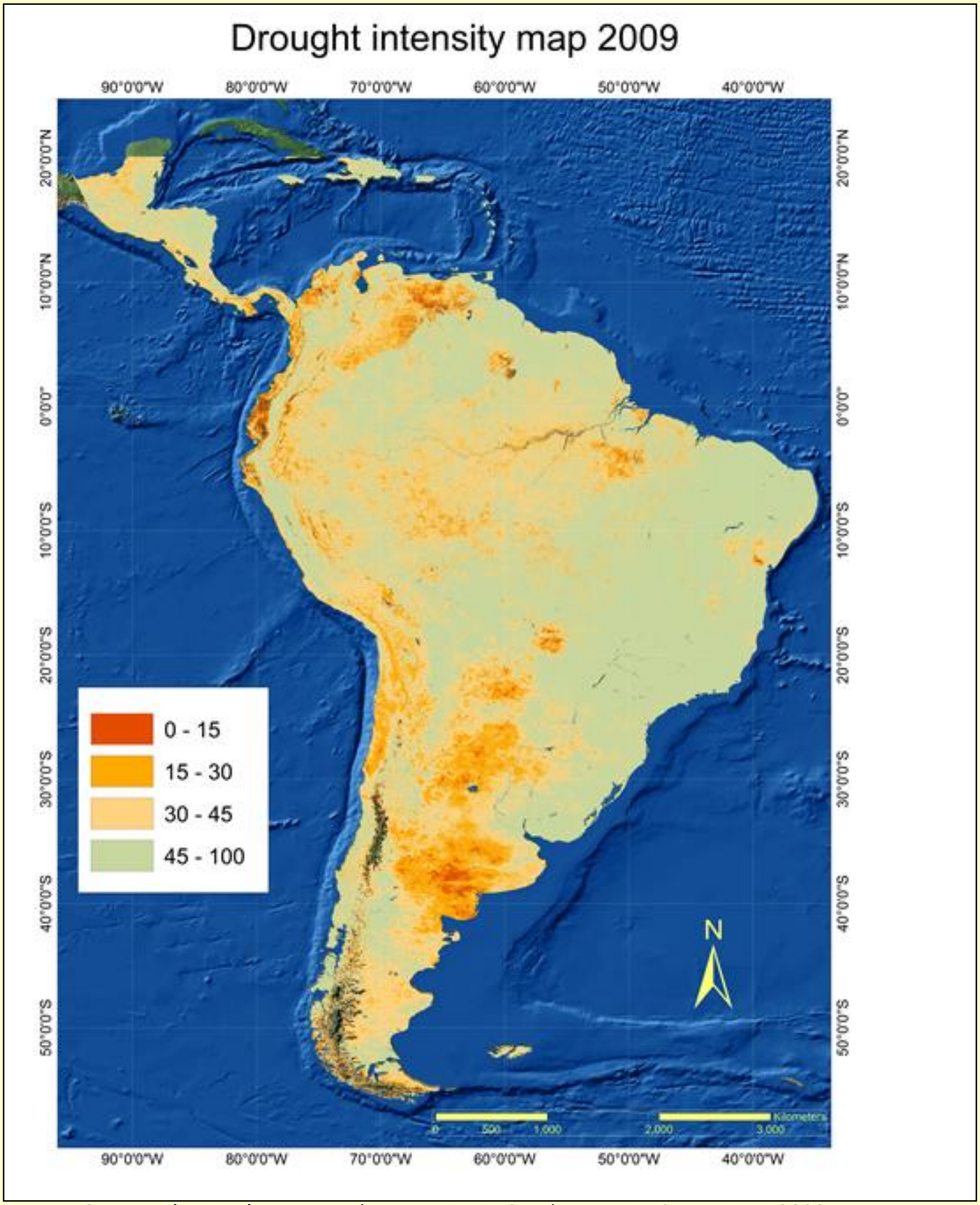


Figure 5.13. Annual Agriculture Drought Intensity in South America Countries – 2009

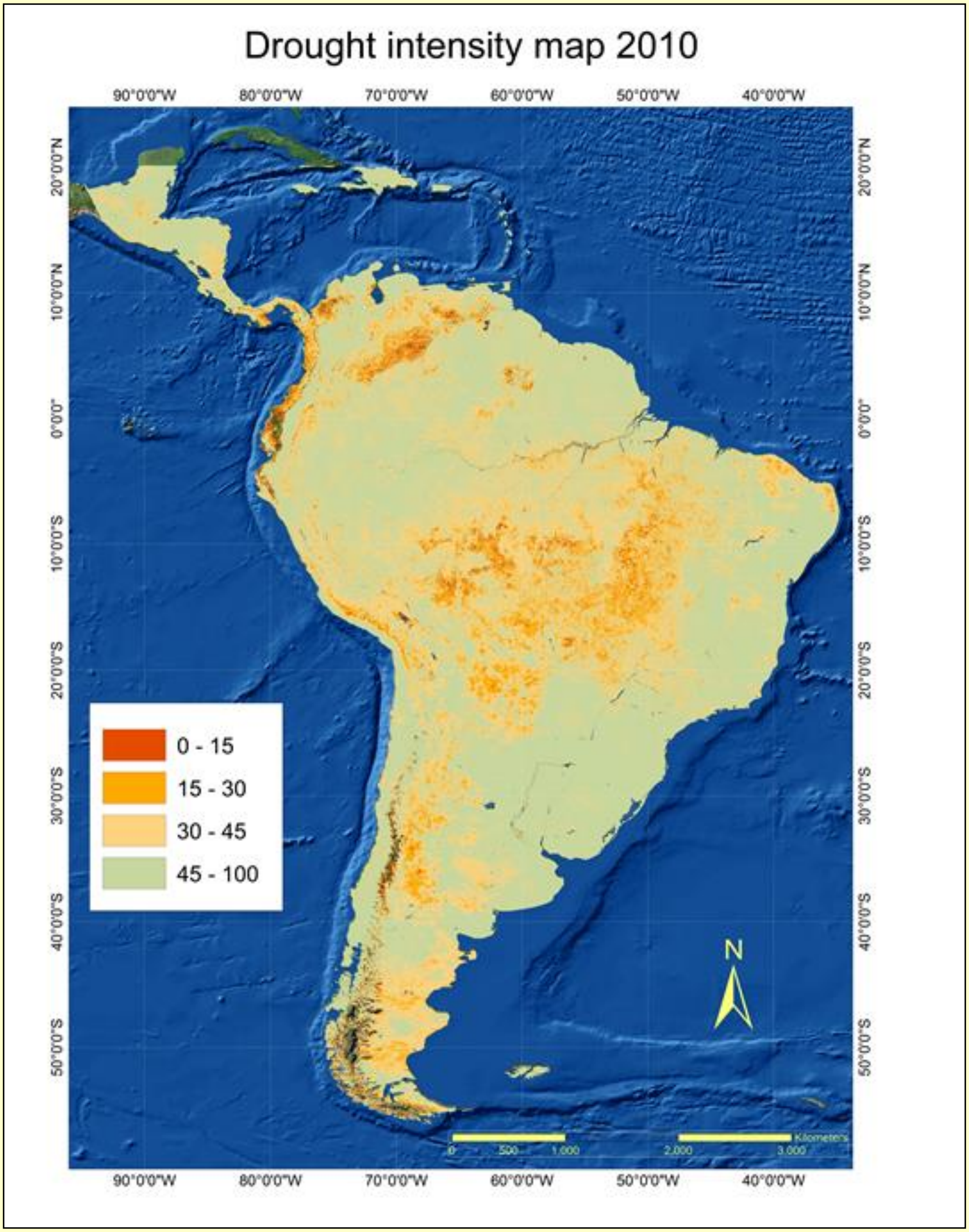


Figure 5.14. Annual Agriculture Drought Intensity in South America Countries - 2010

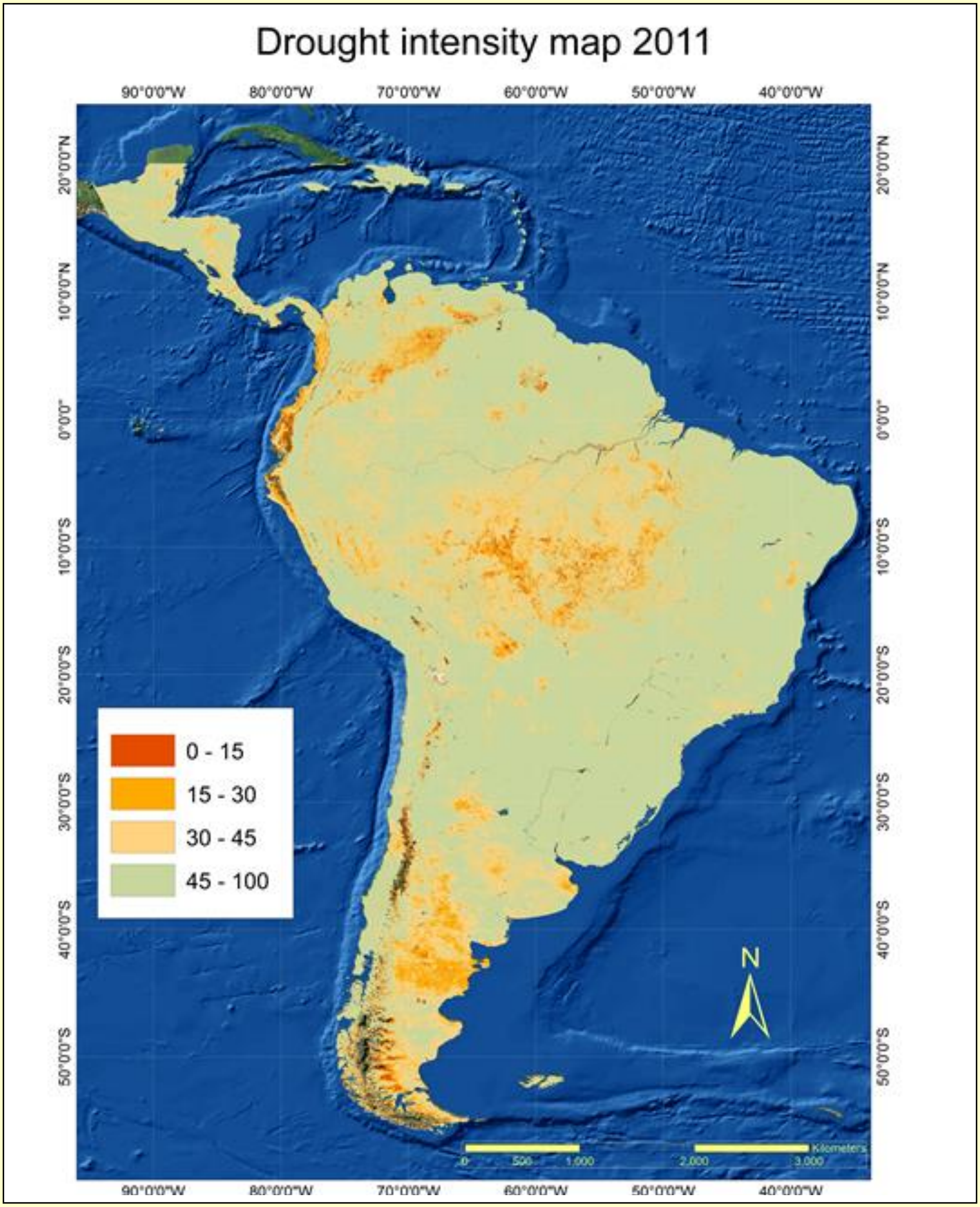


Figure 5.15. Annual Agriculture Drought Intensity in South America Countries - 2011

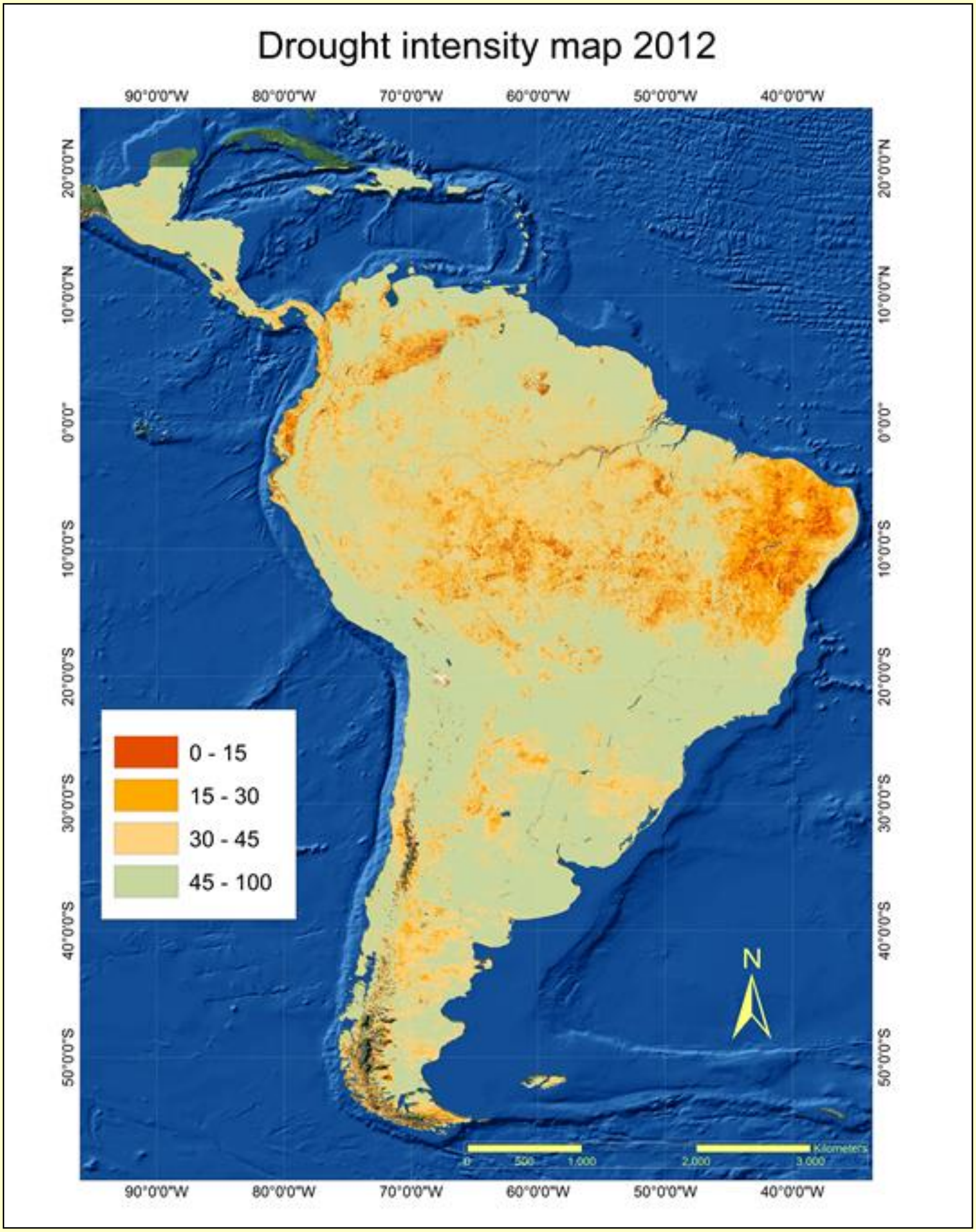


Figure 5.16. Annual Agriculture Drought Intensity in South America Countries - 2012

Table 5.3. Agriculture Drought Intensity in South America Countries as Percentage

Countries	Area in Ha	0-15	15-30	30-45	45-100	Total ADI	Severe ADI
		Severe (1)	Moderate (2)	Slight (3)	No ADI (4)	1+2+3	1+2
Ecuador	28366000	12.11	10.83	27.02	50.04	49.96	22.94
Colombia	1138910	1.53	13.92	24.7	59.85	40.15	15.45
Venezuela	91644500	1.46	6.63	20.44	71.47	28.53	8.09
Peru	128522000	0.65	1.51	19.28	78.56	21.44	2.16
Chile	75695000	2.9	4.02	13.8	79.27	20.72	6.92
Brazil	851487700	0.12	0.92	19.17	79.8	20.21	1.04
Bolivia	109858000	0.31	0.53	12.32	86.84	13.16	0.84
Argentina	276689000	0.78	1.21	8.58	89.43	10.57	1.99
Guyana	21499900	2.32	0.14	4.24	93.29	6.7	2.46
Falkland Islands	1217300	0.57	0.61	3.62	95.2	4.8	1.18
Suriname	16327000	0.14	0.08	0.57	99.21	0.79	0.22
Paraguay	40675000	0.01	0.01	0.7	99.29	0.72	0.02
French Guiana	9100000	0.01	0.02	0.31	99.67	0.34	0.03
Uruguay	17622000	0.04	0.03	0.06	99.87	0.13	0.07
Total	**1537927000**	**0.75**	**2.39**	**16.47**	**80.39**	**19.61**	**3.14**

The study illustrated that south America countries could be ranked due to its ADI total coverage as follows: Ecuador, Colombia, Venezuela, Peru, Chile, Brazil, Bolivia, Argentina, Guyana, Falkland islands (Islas Malvinas), Suriname, Paraguay, French Guiana and Uruguay , and that the main percentage are 49.96, 40.15, 28.53, 21.44, 20.72, 20.21, 13.16, 10.57, 6.7, 4.8, 0.79, 0.72, 0.34 and 0.13 respectively. Slight ADI has low values in most studied countries and

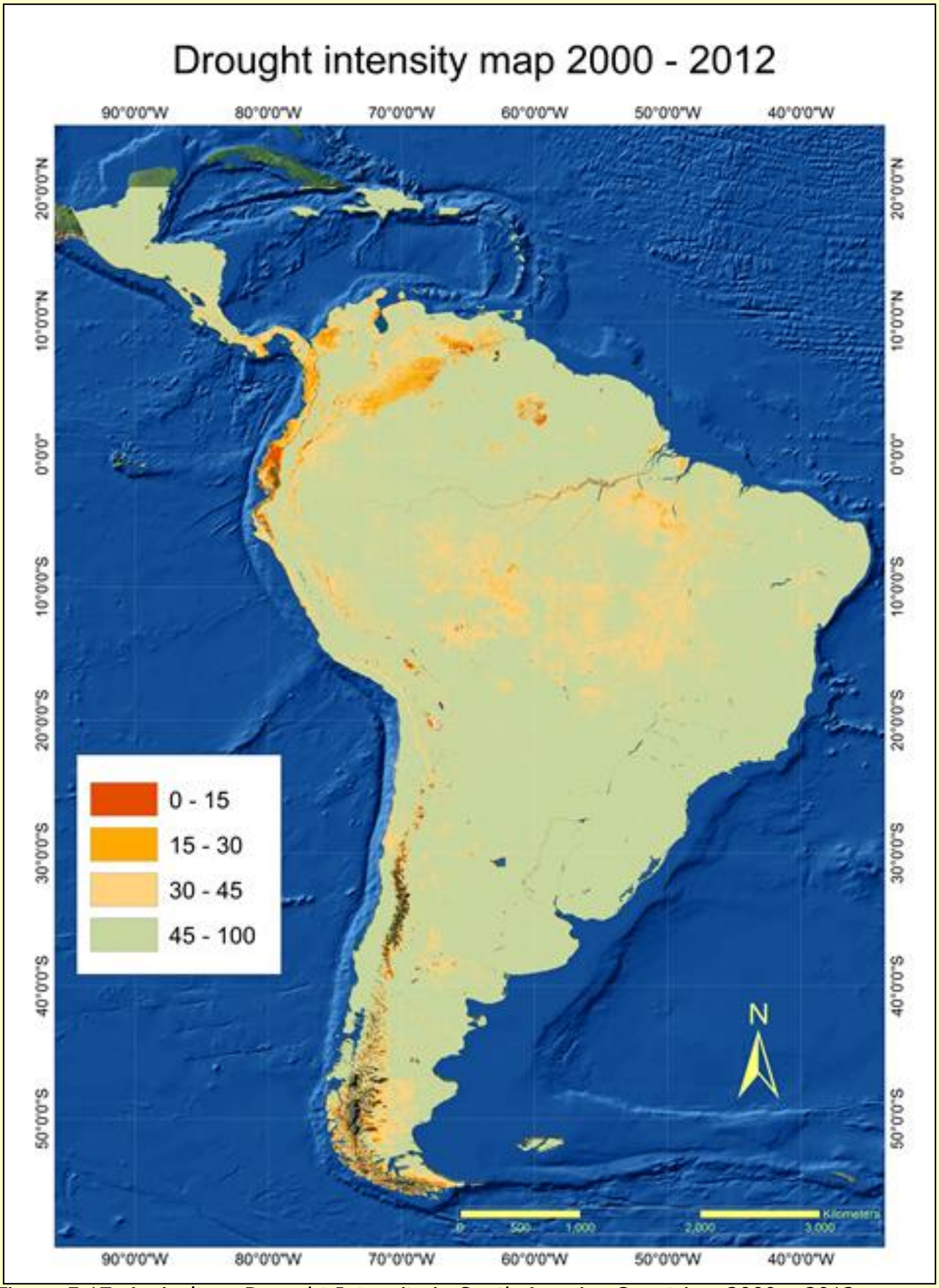


Figure 5.17. Agriculture Drought Intensity in South America Countries, 2000 – 2012

5.4.3. Agriculture Drought Frequency

Agriculture Drought Frequency ADF as presented in in Table (5.4) and figure (5.18) were produced and classified into 4 major groups (each group consists of 3 classes) depending on the number of years that drought occur in each area. The main groups are:

- Group1: that represents the low agriculture drought frequency and covers 44.7% of the total study area and includes (classes 0, 1 and 2).
- Group 2 that represents the moderate agriculture drought frequency and covers 38.75% of the study area and include (classes 3, 4 and 5).
- Group 3 that represents the high agriculture drought frequency and covers 11.14% of the study area and includes (classes 6, 7 and 8)
- Group 4 that represents the severe agriculture drought frequency and covers 3.03% of the study area and includes (classes 9, 10 and 11), and.
- Group 5 that represents the highly severe agriculture drought frequency and covers 2.39% of the study area and includes all classes that are above class 11.

Table 5.4. Agriculture Drought Frequency in South America Countries as Percentage

Countries	Area in Ha	Less than 3 years	3 -5 years	6 -8 years	9 -11 years	More than 11 years
Argentina	276689000	4.72	7.97	1.9	0.24	0.23
Bolivia	109858000	2.39	2.8	0.66	0.08	0
Brazil	851487700	20.19	19.45	5.59	1.06	0.01
Chile	75695000	1.41	1.39	0.45	0.18	0.2
Colombia	1138910	3.42	1.26	0.69	0.67	0.5
Ecuador	28366000	0.64	0.33	0.15	0.17	0.04
Falkland Islands	1217300	0.02	0.01	0	0	0.02
French Guiana	9100000	0.43	0.02	0	0	0
Guyana	21499900	0.99	0.07	0.01	0.01	0.04
Paraguay	40675000	1.08	0.96	0.11	0	0
Peru	128522000	3.93	2.47	0.84	0.22	0.11
Suriname	16327000	0.73	0.02	0	0	0
Uruguay	17622000	0.76	0.18	0	0	0.01
Venezuela	91644500	2.76	1.09	0.54	0.3	0.3
Total	**1537927000**	**44.7**	**38.75**	**11.14**	**3.03**	**2.39**

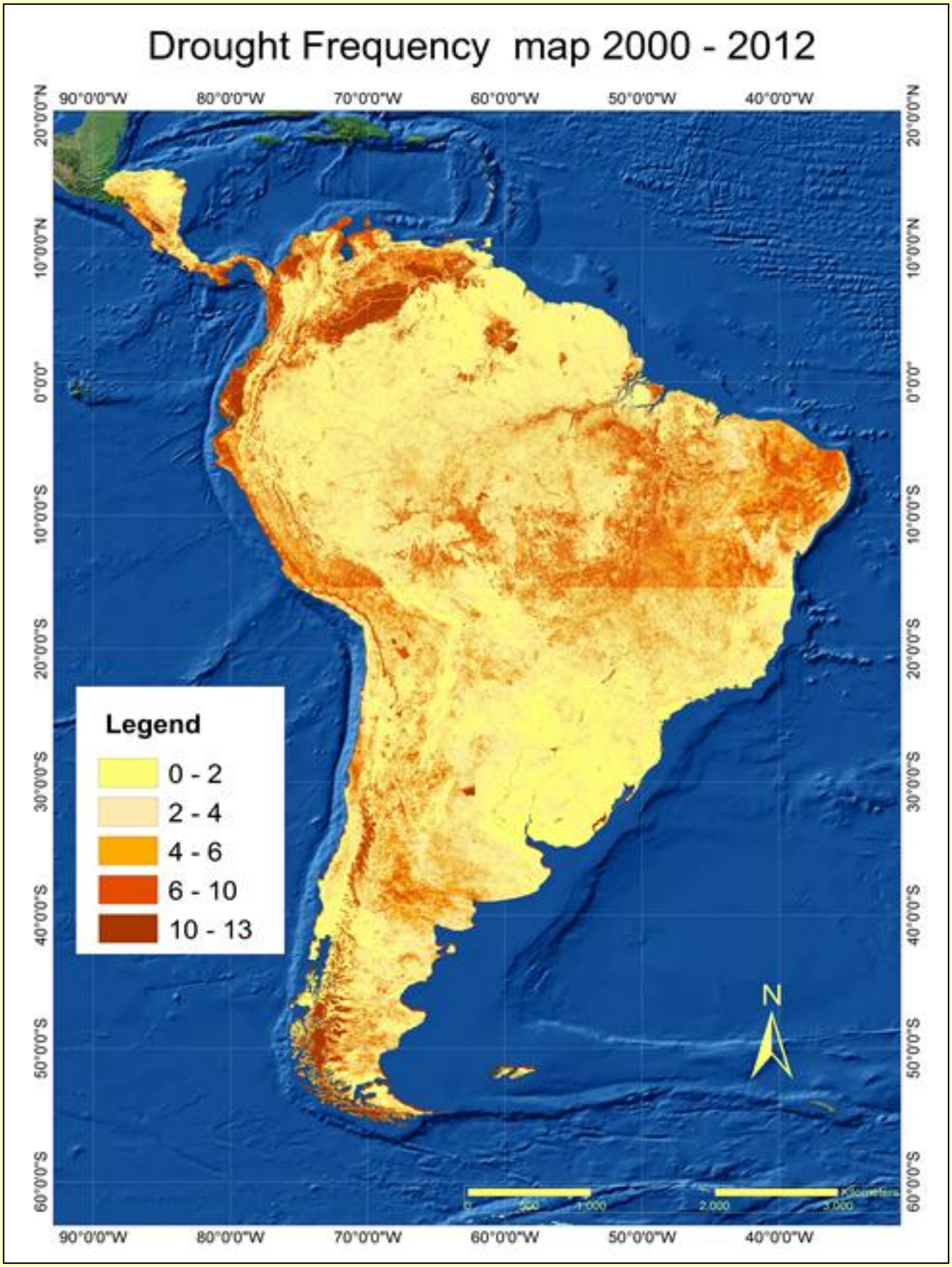


Figure 5.18. Agriculture Drought Frequency in South America Countries, 2000 – 2012

5.4.4. Agriculture Drought Consecutive Duration

Agriculture Drought Consecutive ADC as presented in Table (5.5) and figure (5.19) were produced and classified also into 5 major groups (each group consists of 3 classes) depending on the number of consecutive years that drought occur in each area. The main groups are:

- Group1: that represents the low agriculture drought consecutive and covers 70.88% of the total study area and includes (classes 0, 1 and 2).
- Group 2 that represents the moderate agriculture drought consecutive and covers 22.18% of the study area and include (classes 3, 4 and 5).
- Group 3 that represents the high agriculture drought consecutive and covers 2.43% of the study area and includes (classes 6, 7 and 8)
- Group 4 that represents the severe agriculture drought consecutive and covers 0.44% of the study area and includes (classes 9, 10 and 11), and.
- Group 5 that represents the highly severe agriculture drought consecutive and covers 1.63% of the study area and includes all classes that are above class 11.

Table 5.5. Agriculture Drought Consecutive in South America Countries as Percentage

	Total Area in Ha	Less than 3 Years	3 -5 years	6 -8 years	9 -11 years	More than 11years
Argentina	276689000	10.49	3.96	0.37	0.05	0.19
Bolivia	109858000	4.51	1.33	0.07	0.01	0.01
Brazil	851487700	34.16	11.23	0.86	0.11	0.13
Chile	75695000	2.54	0.74	0.16	0.04	0.44
Colombia	1138910	4.43	1.25	0.43	0.12	0.36
Ecuador	28366000	0.89	0.31	0.13	0.04	0.15
Falkland Islands	1217300	0.03	0	0	0	0.02
French Guiana	9100000	0.44	0.01	0	0	0
Guyana	21499900	1.03	0.05	0.01	0	0.03
Paraguay	40675000	1.85	0.29	0.01	0	0
Peru	128522000	5.54	1.74	0.18	0.03	0.08
Suriname	16327000	0.74	0.02	0	0	0
Uruguay	17622000	0.92	0.03	0	0	0
Venezuela	91644500	3.29	1.22	0.21	0.05	0.22
	1537927000	70.88	22.18	2.43	0.44	1.63

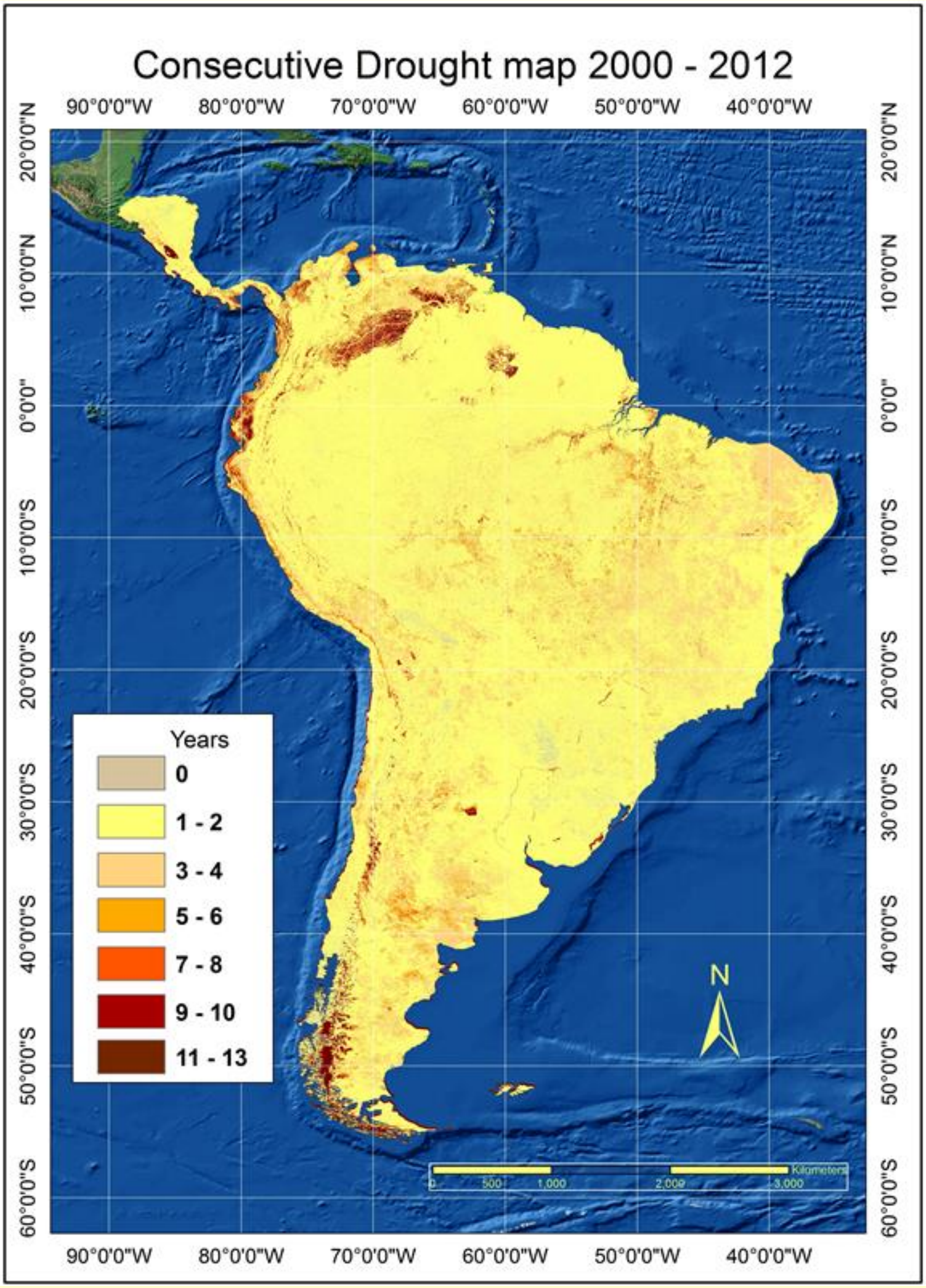


Figure 5.19. Agriculture Drought Consecutive in South America Countries, 2000 - 2012

5.4.5. Agriculture Drought Hazard

Finally, the ADH map was produced from the crossing of the province produced maps (ADI, ADF and ADC), and the result is presented in table (5.6) and figure (5.20), in four major groups , where each group contain 3 classes, beside a special class for areas covered with snow, water, marshy lands, and swamps. The main Groups are:

Group1: No Drought hazard (classes 0,1 and 2), that covers 841.7 million hectors and represents 54.73 % of the study area, Group 2: Slight Drought Hazard (classes 3 and 4), that covers 544.43 million hectares and represent 35.4 % of the study area, Group 3: Moderate Drought Hazard (classes 5,6 and 7), that covers 109.2 million hectares that represent 7.1% of the study area, Group 4: Severe Drought Hazard(classes 8,9 and 10), that covers 34.6 million hectares and represents 2.25% of the study area, and Group (5) : (classes 11 and 12), that represents snow, water, marshy lands, and swamps covers 0.52%,.

Table 5.6. Agriculture Drought Hazard in South America Countries as Percentage

Country	Area in Ha	No	Slight	Moderate	Severe	Total Coverage	Severity	Snow, Water and Swamps
		%	%	%	%	%	%	%
Ecuador	28366000	35.78	31.93	10.67	10.54	53.14	21.21	11.08
Chile	75695000	47.41	33.05	14.58	3.54	51.17	18.12	1.43
Argentina	276689000	49.95	43.53	5.15	1.08	49.76	6.23	0.28
Colombia	1138910	51.06	21.7	12.72	13.12	47.54	25.84	1.39
Brazil	851487700	53.76	38.57	6.73	0.87	46.17	7.6	0.06
Peru	128522000	55.01	35.98	7.28	1.33	44.59	8.61	0.4
Bolivia	109858000	56.65	38.21	4.64	0.47	43.32	5.11	0.03
Venezuela	91644500	58.06	21.8	12.3	6.46	40.56	18.76	1.38
Falkland Islands	1217300	68.82	24.73	4.85	1.04	30.62	5.89	0.55
Paraguay	40675000	72.11	27.6	0.28	0.01	27.89	0.29	0
Guyana	21499900	88.52	6	1.65	1.59	9.24	3.24	2.24
Uruguay	17622000	94.61	4.89	0.42	0.07	5.38	0.49	0.01
Suriname	16327000	97.47	2.17	0.16	0.16	2.49	0.32	0.03
French Guiana	9100000	98.37	1.61	0.01	0.01	1.63	0.02	0
Total	**1537927000**	**54.73**	**35.4**	**7.1**	**2.25**	**44.75**	**9.35**	**0.52**

South America countries were ranked according to the total ADH coverage as follows: Ecuador, Chile, Argentina, Colombia, Brazil, Peru, Bolivia, Venezuela, Falkland Islands, Paraguay, Guyana, Uruguay, Suriname and French Guiana with the following coverage presents, 53.14, 51.17, 49.76, 47.54, 46.17, 44.59, 43.32, 40.56, 30.62, 27.89, 9.24, 5.38, 2.49 and 1.63 respectively

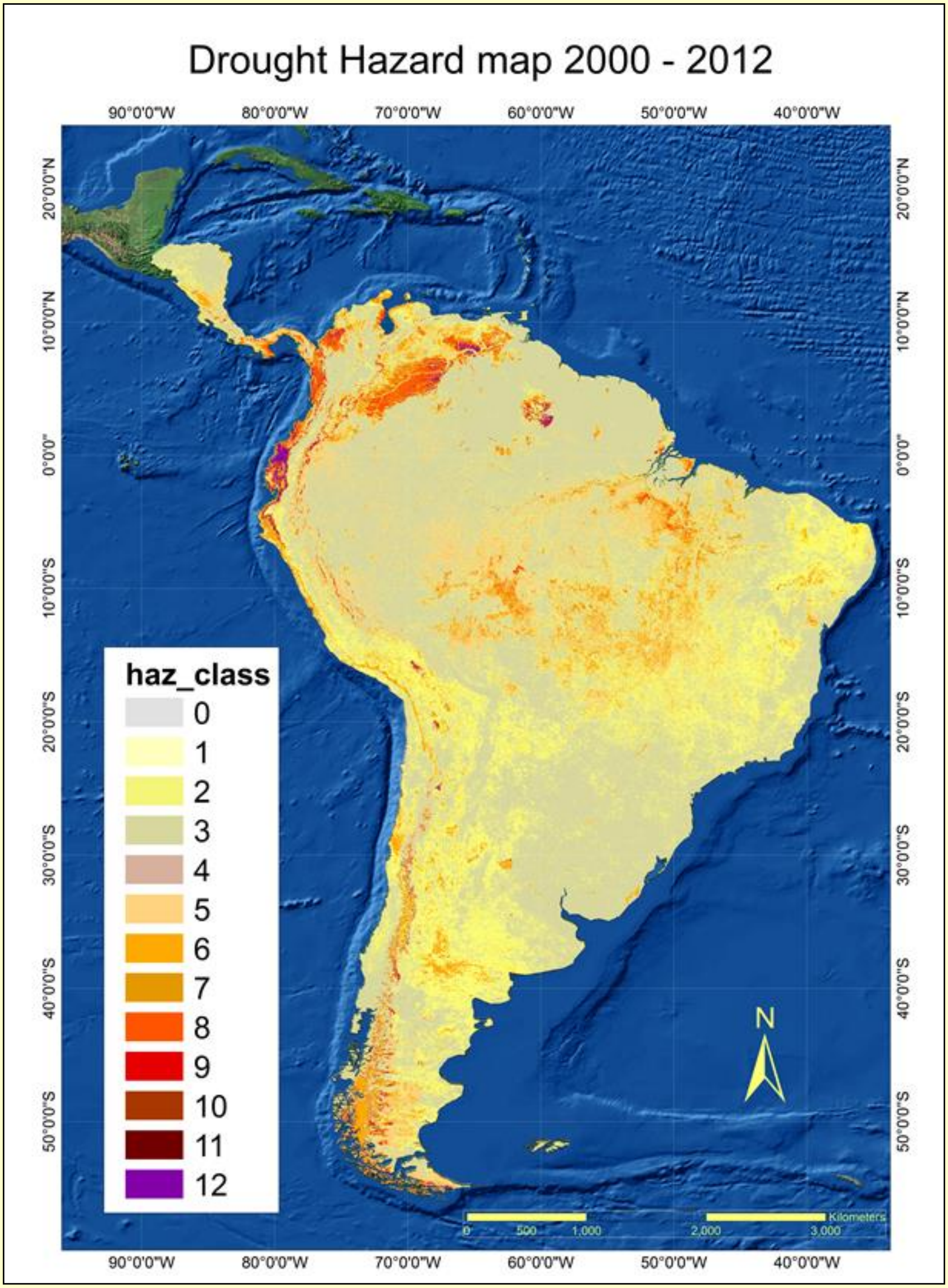


Figure 5.20. Agriculture Drought Hazard in South America

5.4.6. Agriculture Drought Hazard in South America Drylands

Drylands covers 516.9 million hectares of South America, and represent (≈33.6% of the total South America area), out of this 153.6 million hectares and represent (≈10% of the total South America area), these areas are affected by different levels of drought.

Approximately 14.8% of the total area is in semi-arid zone, 12.3% of the total area is in dry sub_ humid zone, 5.19% of the total area is in arid zone, and 1.32% of the total area is in hyper-arid zone. They are affected by drought, 3.11%, 3.22%, 3.26% and 0.4% respectively, (table 5.7).

Table 5.7. Drought in Dryland Classes in South America

Aridity Class	Area in	Very Severe	Severe	Moderate	Slight	No drought	Total
HYPER_ARID	area in %	0.01	0	0.05	0.34	0.92	1.32
ARID	area in %	2.62	0.01	0.05	0.58	1.93	5.19
SEMI_ARID	area in %	0.1	0.01	0.3	2.7	11.69	14.8
DRY SUB_HUMID	area in %	0.26	0.01	0.74	2.21	9.08	12.3
Drylands		2.99	0.03	1.14	5.83	23.62	33.61
OTHERS	area in %	0.39	0.03	2.14	13.13	50.7	66.39
TOTAL	area in %	3.38	0.06	3.28	18.96	74.32	100
	area in M Ha	51.98	0.92	50.44	291.59	1142.99	1537.93

Societies in semi-arid regions in developing countries are typically highly vulnerable to variability of climate and water availability due to low consistency of water availability under average climate conditions. Northeast Brazil is typical of these regions in that it is already regularly affected by severe droughts that have led to major famines in the past. As a result of this natural climate variability, local populations' economic and social well-being has been negatively impacted (Gaiser, Ferreira and Stahr 2003)[42]. More frequent droughts will only make this situation worse. As mean global temperatures rise, semi-arid regions are expected to experience more frequent prolonged droughts and decreased water availability.

Ambrizzi, et al. (2007)[43], wrote that climate projections for Northeast Brazil are indicating a strong likelihood of increased temperatures and decreased precipitation, resulting in a growing aridity of the region If predictions that under climate change there will be more El Niño-like mean conditions are right, Northeast Brazil will become drier since dry years are highly linked to the ENSO phenomenon. Extreme droughts occurred in Northeast Brazil during the strong ENSO years of 1911-1912, 1925-1926, 1982-1983, and 1997-1998 (IPCC TAR). In addition, a recent modeling study (Krol and Bronstert 2007)[44] indicates strong links between changes in

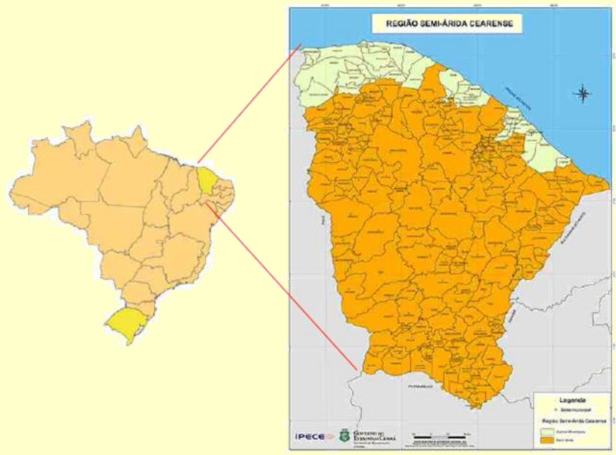
[42] Gaiser, T., Ferreira, L. G. R. and Stahr, K. 2003. 'General View of the WAVES Program', in T. e. a. Gaiser (ed.), Global Change and Regional Impacts: Water Availability and Vulnerability of Ecosystems and Society in the Semiarid Northeast of Brazil, 1-18. Berlin: Springer.

[43] Ambrizzi, T., Rocha, R. M. d., Marengo, J. A., Pisnitchenko, I., Alves, L. M. and Fernandez, J. P. R. 2007. 'Cenários regionalizados de clima no Brasil e América do Sul para o Século XXI: Projeções de clima futuro usando três modelos regionais', São Paulo, Brasil: Ministério do Meio Ambiente, Secretaria de Biodiversidade e Florestas, Diretoria de Conservação da Biodiversidade.

[44] Krol, M. S. and Bronstert, A. 2007. 'Regional integrated modeling of climate change impacts on natural resources and resource usage in semi-arid Northeast Brazil', Environmental Modelling & Software, 22: 259-68.

precipitation and availability of water resources. Under their dry scenario, river runoff decreases by twice the level of precipitation change. Coupled with increased demand, the model predicts increasing water shortages over the next 50 years. Under climate change, drier conditions will have a major impact on agriculture.

In Ceará, these impacts can potentially be devastating since an estimated 96% of the agriculture in the state (around 1, 700 000 ha) is rainfed, figure (5.21), after (SDA 2007). although the economic contribution of agriculture to the overall economy is low (6.6 percent of state GDP), around 40% of the economically active population still depends on it for their livelihoods (SEPLAN, 2000). Moreover, soil moisture levels are expected to decrease, reducing the suitability to cereal production in the region (Fischer, Shah and Velthuizen 2002). In fact, Northeast Brazil is predicted to suffer among the worst yield impacts in the world (Rosenzweig, et al. 1993[45]; Rosenzweig and Hillel 1998)[46].



Source: IPECE, 2007

Figure 5.21. Location Map of Ceará States

Since the region is home to 45 million people and is already prone to droughts and famine, changes in the climate that exacerbate food shortages are expected to have major human consequences (IPCC 2001)[47]. In this context, understanding the underpinnings of adaptive capacity building in the region is paramount.

Historical Response to Drought. In Northeast Brazil, reports about devastating drought episodes trace back to the first Jesuit missionaries who arrived in the region in the late 1500s. From 1877-79, a well-documented period of global drought resulted in a widespread famine that forced 3 million people to migrate and killed an estimated 500,000 (four percent of the Brazilian population at the time) (Villa 2000[48] and ; Davis 2001)[49]. More recently, the El Niño-related 1979-83 drought affected eighteen million people and cost approximately US$1.8 billion in emergency programs (Magalhães, et al.1988)[50]. And while the region's low levels of average rainfall is surely a factor in these disasters, vulnerability to drought among the poor is critically defined by an extreme unequal distribution of power and resources within the region.

---

[45] Rosenzweig, C., Parry, M. L., Fischer, G. and Frohberg, K. 1993. 'Climate Change and World Food Supply', Research Report No. 3, 28. Oxford, United Kingdom: Environmental Change Unit, Oxford University.

[46] Rosenzweig, C. and Hillel, D. 1998. *Climate Change and the Global Harvest: Potential Impacts of the Greenhouse Effect on Agriculture*. Oxford, United Kingdom: Oxford University Press.

[47] IPCC 2001. 'Working group II Climate Change 2001: Impacts, Adaptation and Vulnerability', Geneva: Intergovernmental Panel on Climate Change.

[48] Villa, M. A. 2000. Vida e Morte no Sertão. São Paulo: Editora Atica.

[49] Davis, M. 2001. Late Victorian Holocausts: El Niño Famine and Making of the Third World. New York,NY: Verso

[50] Magalhães, A. R., Filho, H. C., Garagorry, F. L., Gasques, J. G., Molion, L. C. B., Neto, M. D. S. A., Nobre, C. A., Porto, E. R. and Rebouças, O. E. 1988. 'Effects of Climatic Variations on Agriculture in Northeast Brazil', in M. L. Parry, T. R. Carter and N. T. Konijn (eds.), The Impact of Climatic Variations on Agriculture, Dordrecht, Netherlands: Kluwer Academic Publishers.

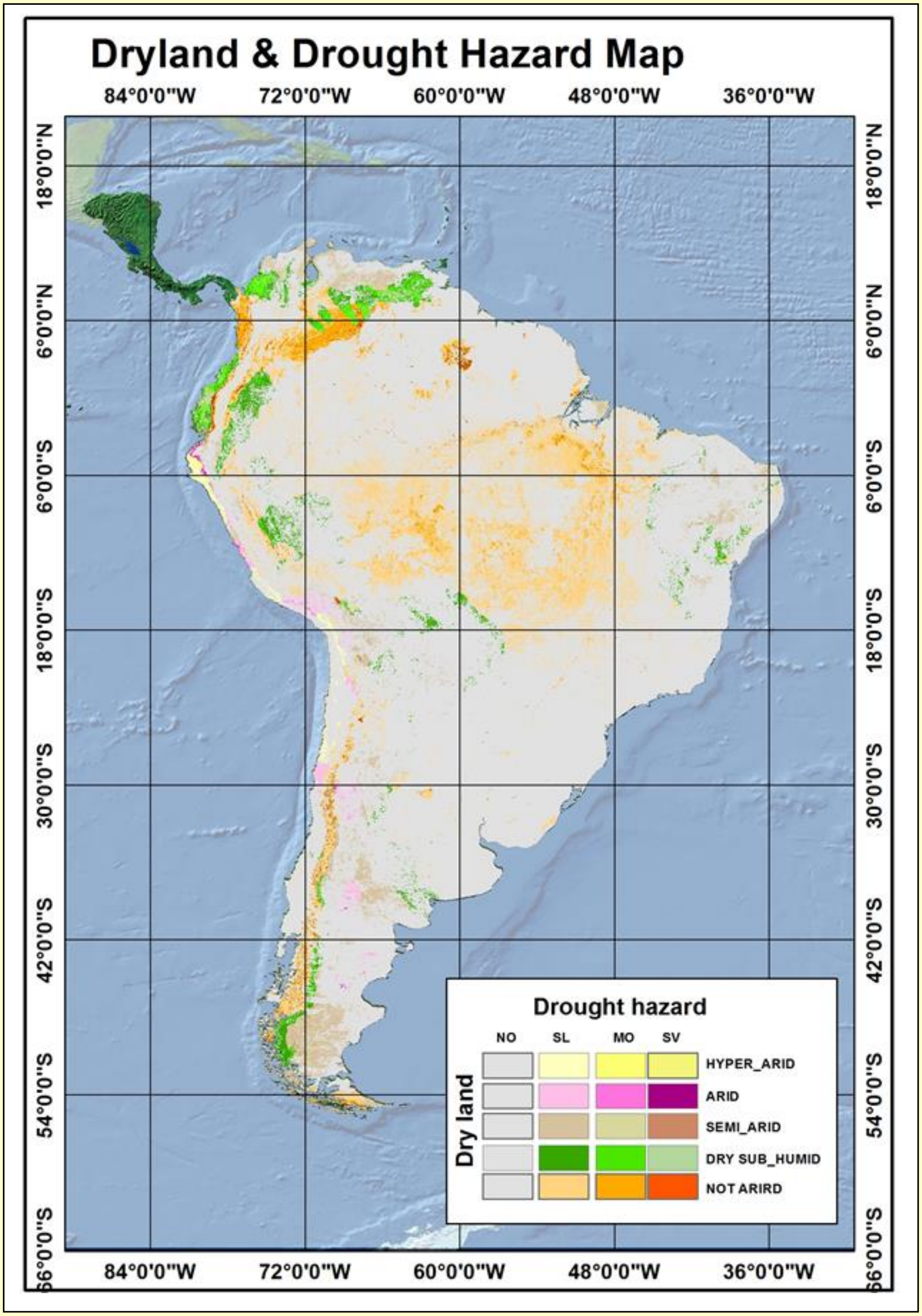


Figure 5.22. Drought in Dryland Classes in South America

5.4.7. Land Degradation and Agriculture Drought Hazard.

The effects of land degradation are often irreversible, and land rehabilitation frequently requires inputs which are costly, labour-demanding or both. Although plant nutrients and soil organic matter may be replaced, degraded pastures can be recovered under improved range management, salinized soils can be restored to productive use.

However, to replace the actual loss of soil material requires thousands of years. In addition, the cost of reclamation or restoration to productive use of degraded soils is invariably higher than the cost of preventing degradation before it occurs. In this regard, lands that are prone to degradation processes should be identified in advance to avoid possible damages. Whilst land degradation is recognized as a major aspect of socio-economic impact affecting the productivity of cropland, rangeland and forest, other aspects such as lowering of the water table and deforestation, are also captured by the concept of land degradation.

Land degradation for the study area was done using the TimeStats software package and the results are shown in table (5.8) and (figure 5.23). The total affected areas by land degradation are of about 498.9 million hectares and represent 32.44% from the total studied area. Out of these area 165.48 million hectares are severe to moderate affected and represent 10.75% from the total studied area. At the meantime areas that developed in South America are of about 331.73 million hectares and represent 21.57% from the total studied area.

Countries could be ranked based on the total land degradation as follows: Brazil, Argentina, Peru, Colombia, Bolivia, Venezuela, Chile, Paraguay, Guyana, Ecuador, Suriname, French Guiana, Uruguay and Falkland Islands (Islas Malvinas) with the following coverage presents: 19.21, 3.86, 3.25, 2.56, 2.35, 1.6, 1.33, 0.96, 0.68, 0.63, 0.42, 0.26, 0.22 and traces respectively

At the mean time Countries could be ranked based on the total land development as follows: Brazil, Venezuela, Argentina, Colombia, Peru, Chile, Bolivia, Ecuador, Guyana, Paraguay, Suriname, French Guiana, Uruguay, and Falkland Islands (Islas Malvinas) with the following coverage presents: 14.38, 2.58, 2.54, 2.39, 2.06,2.06, 1.69, 0.68, 0.52, 0.35, 0.31,0.29,0.08and traces respectively.

While the total percentage reflect more negative trend, but the levels of highly developed areas (12.57%) are higher than highly degraded areas (10.76%). which reflect high dynamics in vegetation cover.

Table 5.8. Land Degradation in South America Countries

Country	Total area	High deg %	Moderate deg %	Slight deg %	Total Land deg %	No Change%	High dev %	Moderate dev %	Slight dev %	Total Land dev %
Argentina	276689000	0.4	0.52	2.54	3.86	9.74	0.66	0.33	0.89	2.54
Bolivia	109858000	0.3	0.37	1.38	2.35	2.74	0.5	0.23	0.46	1.69
Brazil	851487700	2.54	3.09	11.04	19.21	20.01	4.31	2.08	3.68	14.38
Chile	75695000	0.23	0.25	0.62	1.33	1	0.44	0.24	0.94	2.06
Colombia	1138910	0.34	0.4	1.48	2.56	2.6	0.63	0.35	0.78	2.39
Ecuador	28366000	0.09	0.1	0.35	0.63	0.44	0.17	0.1	0.24	0.68
Falkland Islands	1217300	0	0	0	0	0.02	0	0	0	0
French Guiana	9100000	0.05	0.05	0.11	0.26	0.04	0.09	0.05	0.06	0.29
Guyana	21499900	0.1	0.12	0.36	0.68	0.2	0.17	0.08	0.1	0.52
Paraguay	40675000	0.1	0.14	0.62	0.96	1.09	0.13	0.04	0.05	0.35
Peru	128522000	0.4	0.51	1.94	3.25	3.27	0.61	0.27	0.57	2.06
Suriname	16327000	0.05	0.07	0.25	0.42	0.2	0.1	0.05	0.06	0.31
Uruguay	17622000	0.02	0.02	0.16	0.22	0.71	0.02	0.01	0.03	0.08
Venezuela	91644500	0.25	0.27	0.83	1.6	1.59	0.54	0.37	1.13	2.58
Total	1537927000	4.86	5.9	21.68	32.44	43.64	8.37	4.2	9	21.57

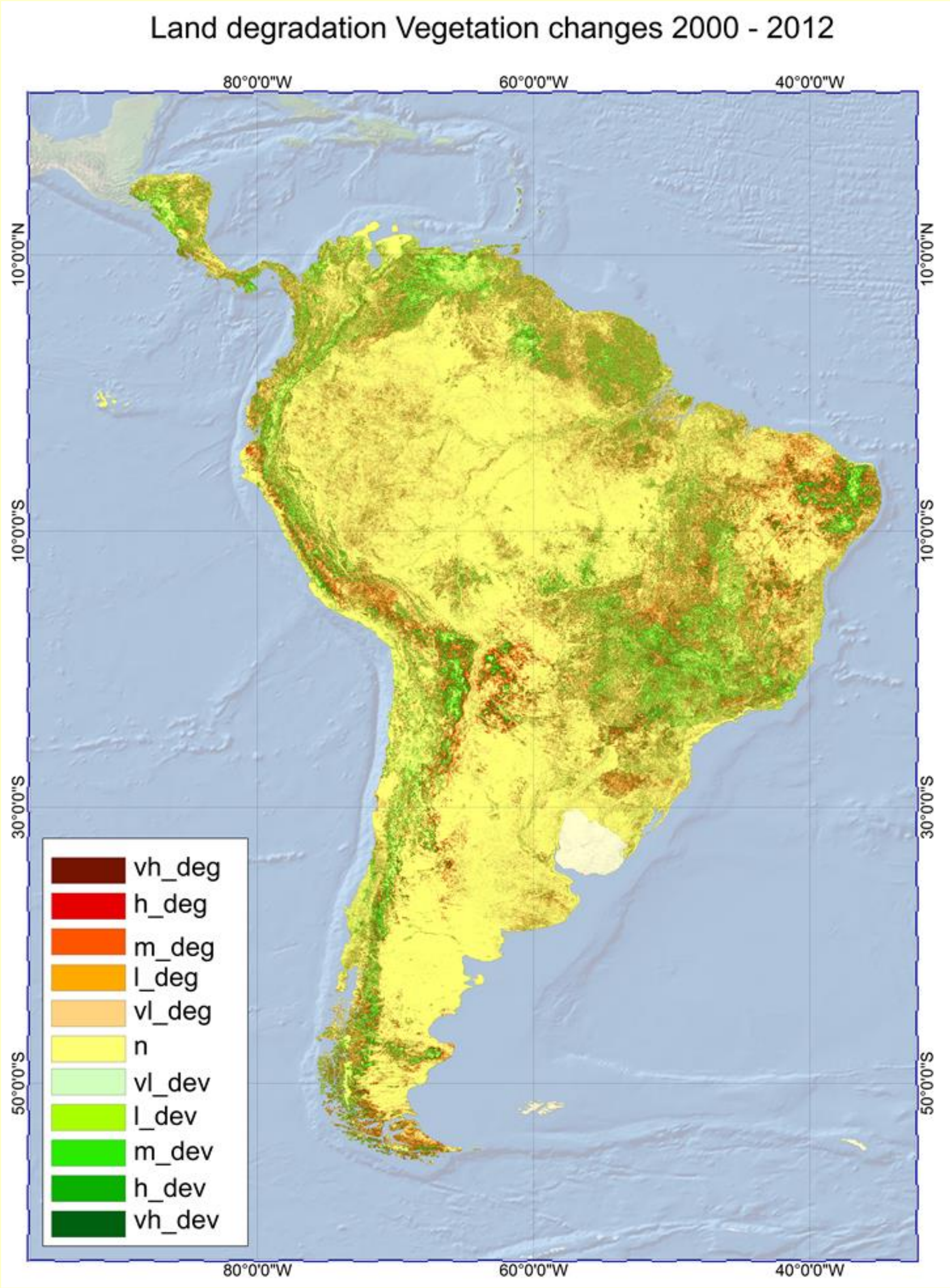


Figure 5.23. Land Degradation Map of Studied area

5.4.8. Land Degradation in South America Drylands

Out of the Drylands 176.24 million hectares are affected by land degradation and represent (≈11.46 % of the total South America area), these areas are affected by different levels of land degradation. Approximately 11.65% of the total area is in semi-arid zone, 11.38% of the total area is in dry sub_ humid zone, 2.1% of the total area is in arid zone, and 0.79% of the total area is in hyper-arid zone. They are affected by drought, 5.88%, 4.72%, 0. 61% and 0.25% respectively, table (5.9) and (figure 5.24).

Table 5.9. Land Degradation in Dryland Classes in South America

Aridity Classes	Area in	H. LD	Mod. LD	Sl. LD	No L D	Total Affected area
Hyper_Arid	%	0.04	0.05	0.16	0.54	0.25
Arid	%	0.1	0.12	0.39	1.49	0.61
Semi_Arid	%	0.86	1.08	3.94	5.76	5.88
Dry Sub_Humid	%	0.63	0.8	3.29	5.66	4.72
Others	%	3.34	3.99	14.43	31.23	21.76
Total	%	**4.97**	**6.04**	**22.21**	**44.68**	**33.22**
	M. Ha	**76.43**	**92.89**	**341.57**	**687.14**	**510.9**

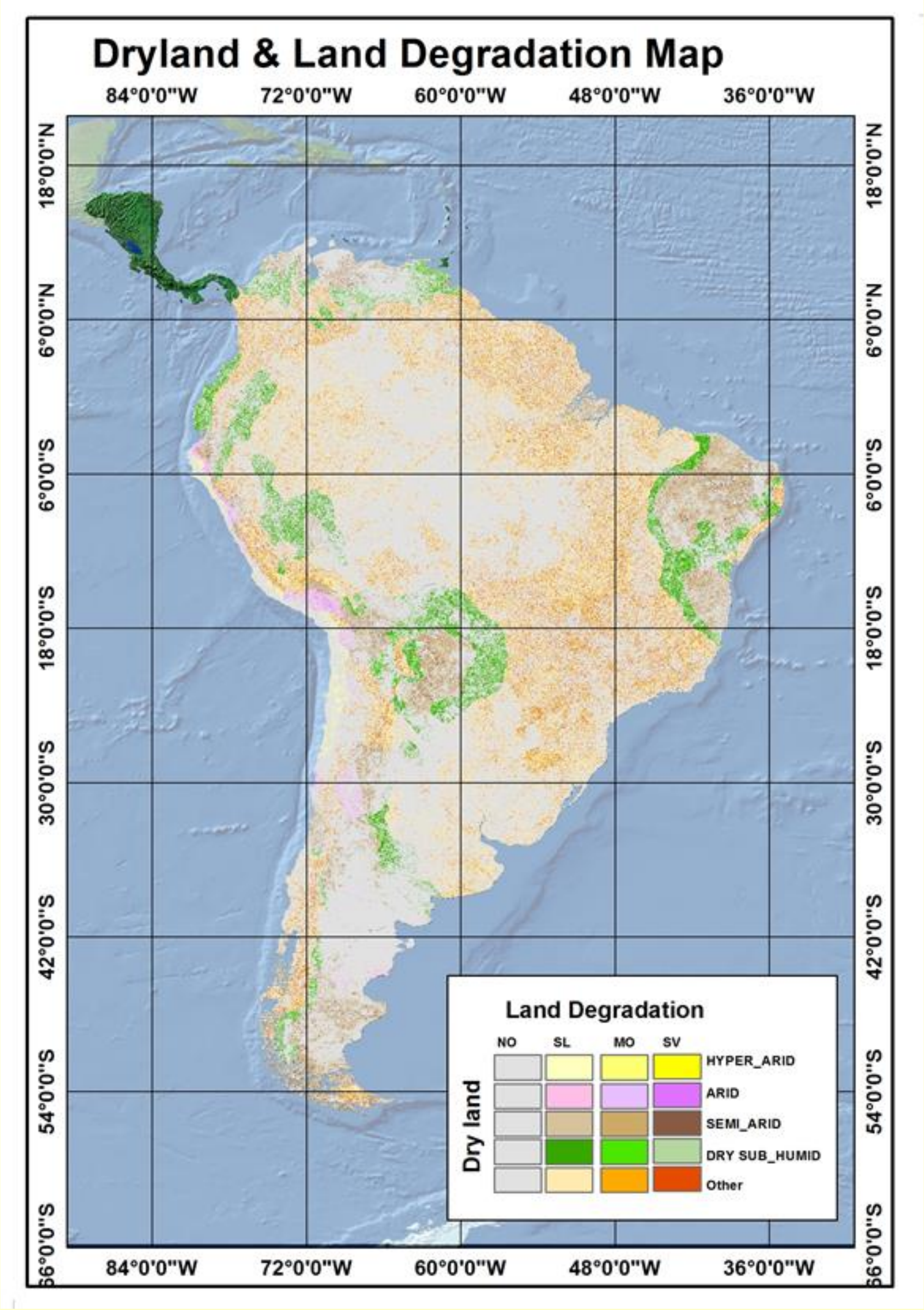


Figure 5.24. Land Degradation within Dryland Classes in South America

5.4.8. Agriculture Drought Hazard and Land Degradation impacts in Drylands

Out of the Drylands 214.57 million hectares are affected by drought and land degradation that represent (≈13.95 % of the total South America area), these areas are affected by different levels of agriculture drought hazard land degradation. Approximately 6.93% of the total area is in semi-arid zone, 5.66% of the total area is in dry sub_ humid zone, 0.9% of the total area is in arid zone, and 0.45% of the total area is in hyper-arid zone. The details of drought and land degradation are shown in table (5.10) and (figure 5.25 – 2.28).

Table 5.10. Agri. Drought Hazards and Land Degradation in South America in Dryland.

Aridity	ADH	Land Degradation				
		Very severe	high	Mod	Slight	No
HYPER_ARID	High	0.001	0	0.001	0.01	0.029
	Moderate	0.001	0	0.002	0.012	0.031
	Slight	0.003	0.001	0.008	0.045	0.105
	NO	0.007	0.001	0.022	0.173	0.341
ARID	High	0.002	0	0.004	0.029	0.066
	Moderate	0.002	0.001	0.004	0.034	0.082
	Slight	0.007	0.002	0.015	0.104	0.258
	NO	0.005	0.001	0.019	0.271	1.193
SEMI_ARID	High	0.009	0.001	0.023	0.161	0.67
	Moderate	0.009	0.001	0.025	0.182	0.867
	Slight	0.02	0.003	0.061	0.56	3.292
	NO	0.018	0.002	0.073	0.954	4.715
DRY SUB_HUMID	High	0.019	0.001	0.051	0.122	0.441
	Moderate	0.022	0.001	0.054	0.141	0.578
	Slight	0.06	0.004	0.137	0.487	2.6
	NO	0.037	0.002	0.111	0.795	4.714
Total Drylands	**Area in %**	**0.22**	**0.02**	**0.61**	**4.08**	**19.98**
	Area in M. Ha	**3.41**	**0.32**	**9.38**	**62.75**	**307.30**
Other	High	0.028	0.002	0.15	0.704	2.452
	Moderate	0.029	0.002	0.161	0.831	2.969
	Slight	0.072	0.005	0.464	2.814	11.074
	NO	0.083	0.005	0.614	5.761	24.77
Total	**Area in %**	**0.42**	**0.03**	**1.97**	**13.95**	**60.74**
	Area in M.Ha	**6.49**	**0.51**	**30.23**	**214.54**	**934.15**

In the Drylands also 113.76 million hectares are improved, this area drought and land improvement that represent (≈7.4 % of the total South America area).

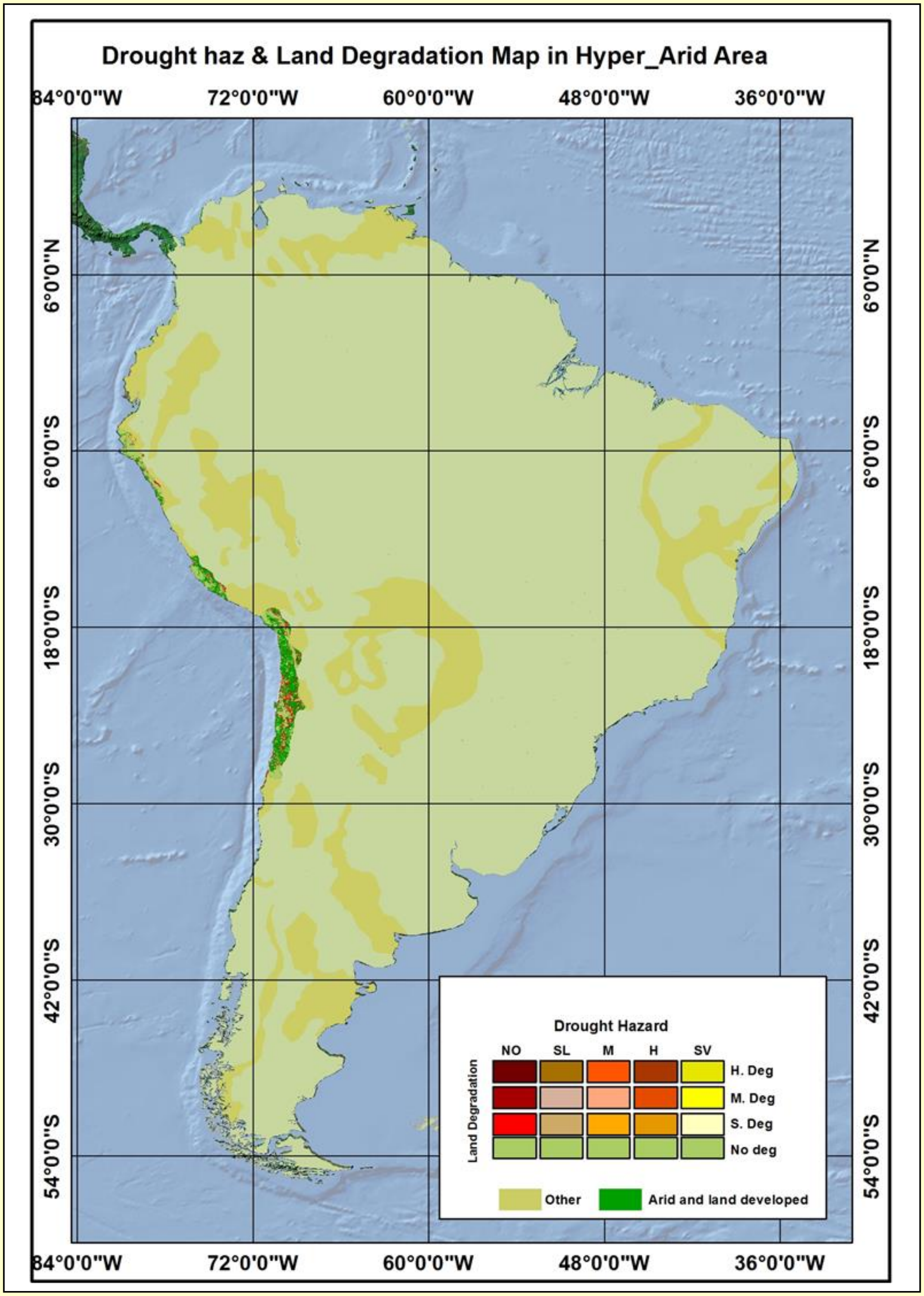


Figure 5.25. ADH and Land Degradation in Hyper-Arid Classes in South America

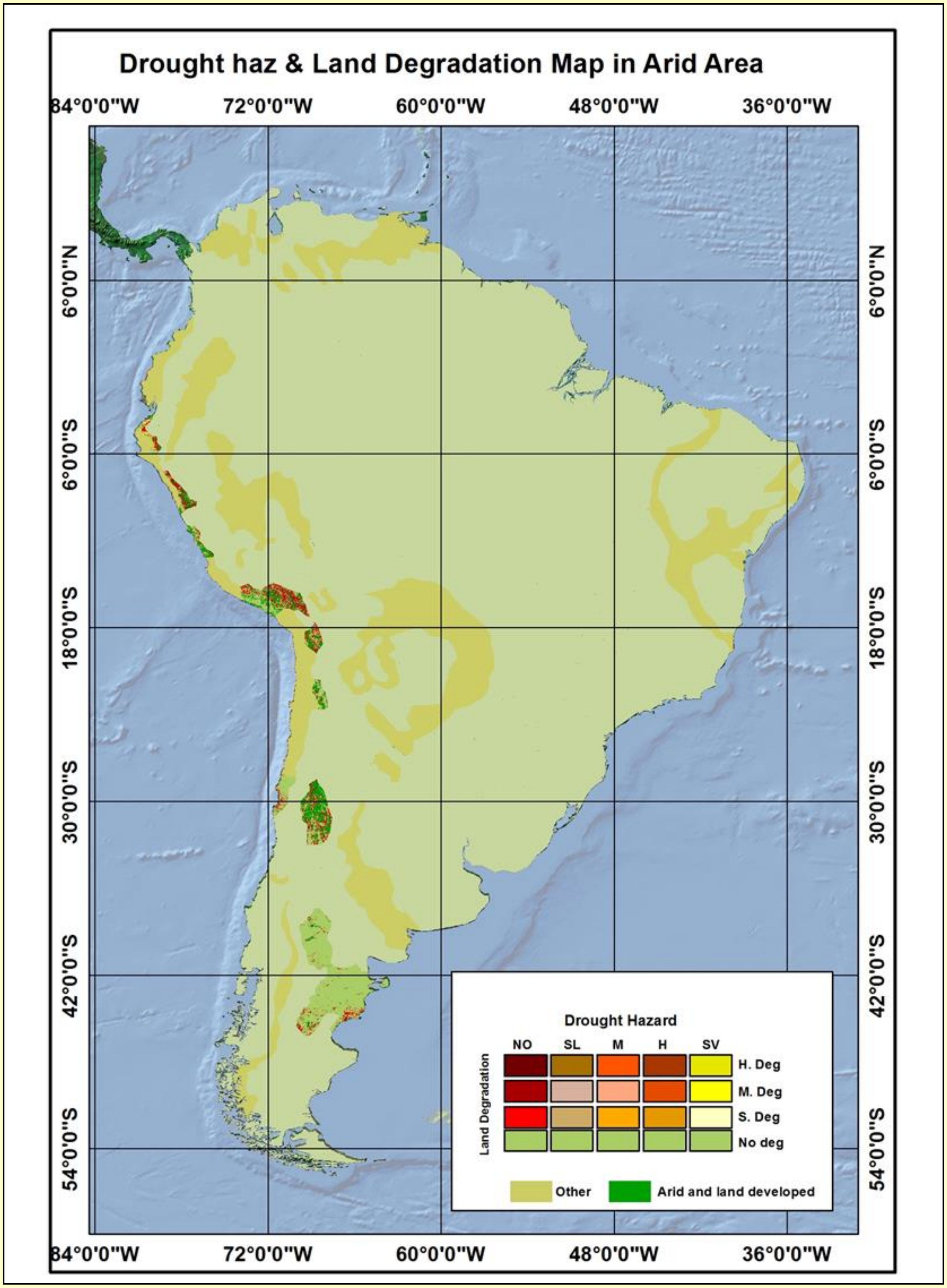


Figure 5.26. ADH and Land Degradation in Arid Classes in South America

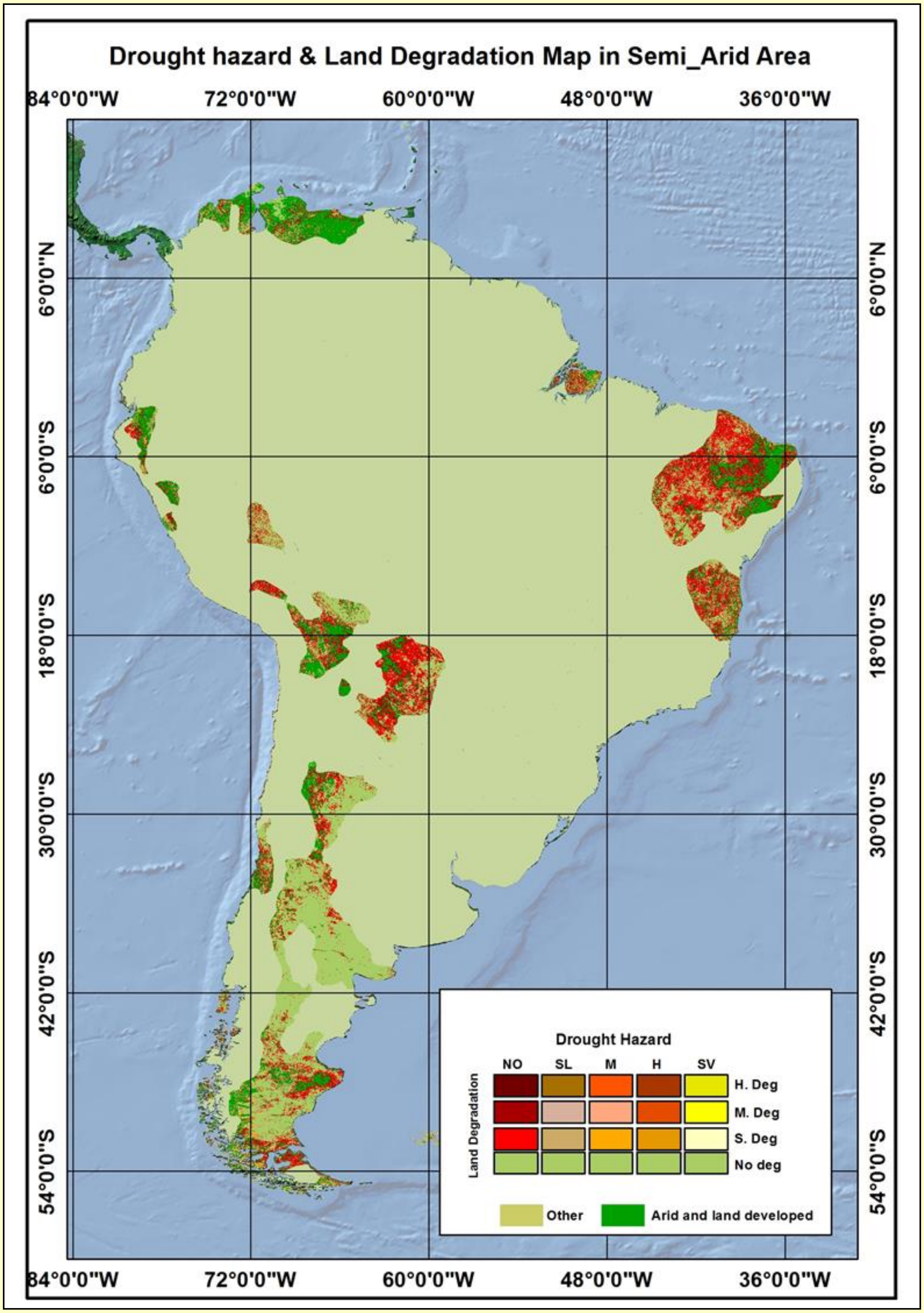


Figure 5.27. ADH and Land Degradation in Semi-Arid Classes in South America

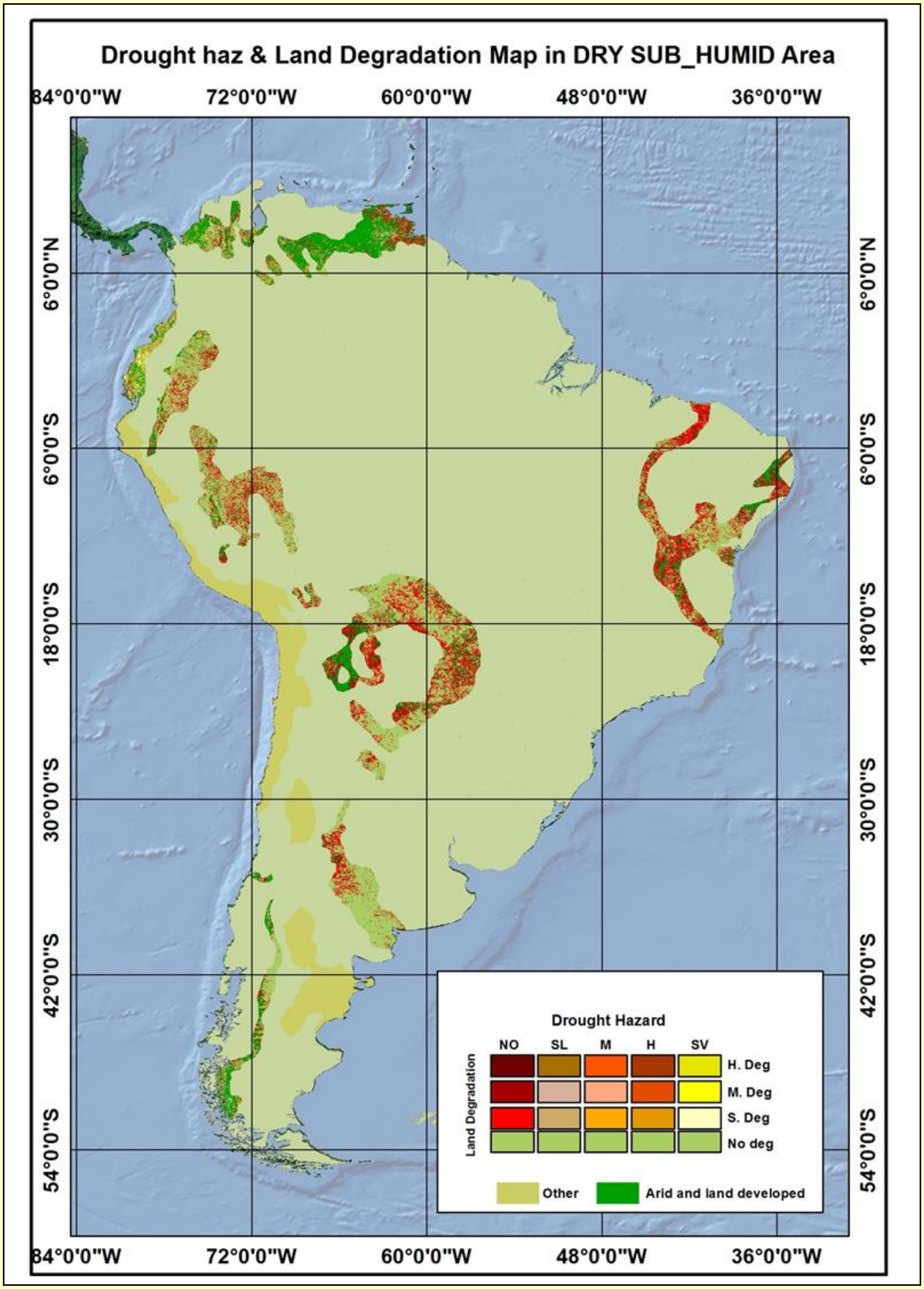


Figure 5.28. ADH and Land Degradation in Dry Sub-Humid Classes in South America

5.5. Conclusion

- Drylandss are arid, semi-arid and dry sub-humid areas , In the context of sustainable development the term generally excludes hyper-arid areas (deserts), as land degradation occurs in the world's drylandss, it often creates desert-like conditions.
- Drylandss cover 41 percent of the earth's terrestrial surface. They are home to a third of all humanity, and have some of the highest levels of poverty, yet in most countries they have long been neglected by investment and sustainable development interventions.
- Drylandss , include desert, grassland and savanna woodland biomes, and considered one of the world's major ecosystems that long-running fear of destruction and rising expectations of a 'tipping point' in climate change.
- Drylandss must be central in strategies to achieve global sustainability, as the six major challenges to global sustainability such as: (1) poverty, inequity and human well-being; (2) globalization; (3) private-public balance in development; (4) environmental damage; (5) conflict and competition for resources; and (6) poor governance, all have their manifestations in the drylands.
- The world as a whole has a stake in the health of drylands systems and that changing drylandss will lead to a changing the world, not only because of their physical extent but on account of our increasing understanding of their interactions with global climatic, economic and geopolitical systems. Such forces are re-integrating drylandss with global futures. Nowhere is this more obvious than in climate change.
- Although drylandss have effects on food prices, but loss of land croplands and in rangeland its impacts are poorly understood.
- Agriculture drought hazard covers 688.23 million hectors that represents 44.75% of the South America, out of this <u>Slight Drought Hazard</u> covers 544.43 million hectares that represent 35.4 % , <u>Moderate Drought Hazard</u> covers 109.2 million hectares that represent 7.1% and <u>Severe Drought Hazard</u> covers 34.6 million hectares that represents 2.25%.
- South America countries were ranked according to the total ADH coverage as follows: Ecuador, Chile, Argentina, Colombia, Brazil, Peru, Bolivia, Venezuela, Falkland Islands, Paraguay, Guyana, Uruguay, Suriname and French Guiana with the following coverage presents, 53.14, 51.17, 49.76, 47.54, 46.17, 44.59, 43.32, 40.56, 30.62, 27.89, 9.24, 5.38, 2.49 and 1.63 respectively
- Approximately 14.8% of Agriculture drought affected areas are in semi-arid zone, 12.3% are in dry sub_ humid zone, 5.19% are in arid zone, and 1.32% are in hyper-arid zone.
- The total affected areas in South America by land degradation are of about 498.9 million hectares and represent 32.44% from the total studied area. Out of these area 165.48 million hectares are severe to moderate affected and represent 10.75% from the total studied area. At the meantime areas that developed in South America are of about 331.73 million hectares and represent 21.57% from the total studied area.

- Countries could be ranked based on the total land degradation as follows: Brazil, Argentina, Peru, Colombia, Bolivia, Venezuela, Chile, Paraguay, Guyana, Ecuador, Suriname, French Guiana, Uruguay and Falkland Islands (Islas Malvinas) with the following coverage presents: 19.21, 3.86, 3.25, 2.56, 2.35, 1.6, 1.33, 0.96, 0.68, 0.63, 0.42, 0.26, 0.22 and traces respectively. While the total percentage reflect more negative trend, but the levels of highly developed areas (12.57%) are higher than highly degraded areas (10.76%). which reflect high dynamics in vegetation cover.
- Areas in South America affected by different levels of land degradation are approximately 11.65% of the total area is in semi-arid zone, 11.38% of the total area is in dry sub_ humid zone, 2.1% of the total area is in arid zone, and 0.79% of the total area is in hyper-arid zone. They are affected by drought, 5.88%, 4.72%, 0. 61% and 0.25% respectively.
- <u>The majority of Drylands areas affected by both Agriculture Drought Hazard and land degradation are in semi-arid and dry sub humid.</u>

Chapter 6: Drought Assessment on Congo and Amazon Basins

6.1. Introduction

Forests are an integral part of the biological carbon cycle. As a part of the biosphere, forests act as an important reservoir for atmospheric carbon. Through the process of photosynthesis, forests absorb atmospheric CO_2, water, and sunlight to form carbohydrates. The carbon becomes locked within the plant's biomass for the life of the plant and then eventually becomes dead organic matter and soil components. 2010 estimates shows there to be more than 650 billion tons of carbon stocks stored within global forests, 44% in biomass (living plant material), 11% in dead and decaying biomass, and 45% in soils (organic carbon in mineral and organic soils) (figure 6.1- after, FAO, 2010).

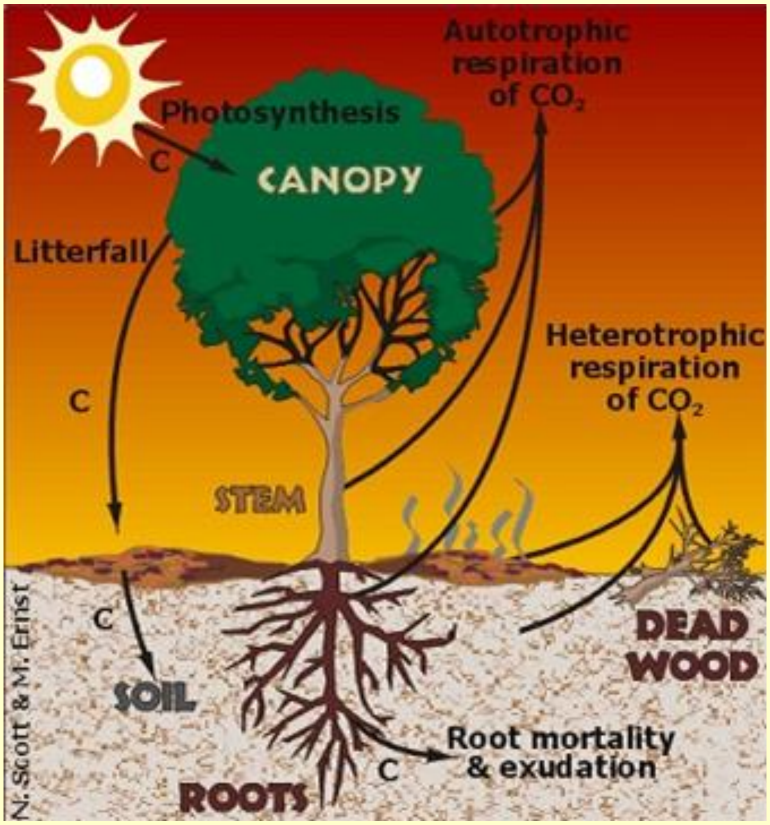


Figure 6.1. Carbon Movement Surrounding Plants, Source: Woods Hole Research Center

Tropical forests are particularly important for forest carbon stocks as they contain the highest levels of biomass per hectare in the world. South America along with Western and Central Africa contain 247.4 and 248.7 tons of biomass per hectare respectively, while the global average for forest is only 149 tons per hectare (FAO, 2010). The Western and Central African forests hold the second highest amount of biomass carbon per hectare at 116.9 tons and the second highest amount of total carbon stocks per hectare globally at 186.2 tons (FAO, 2010). Within the Congo Basin's tropical forest it is the closed evergreen lowland forest that represents more than 60% of stored carbon, while only occupying 35% of the area (OFAC, 2008). This highlights the importance of the tropical forests within Congo Basin in relation to carbon, specifically the immensely valuable role that the closed evergreen lowland forest plays as a regional and global carbon sink, Source: Woods Hole Research Center

Deforestation and forest degradation are causing large amounts of that stored carbon to return to the atmosphere, due to increased biomass decay and fires used to burn the brush and tree refuse left behind once the valuable parts have been harvested. The FAO recent published the 2010 Global Forest Resources Assessment (FRA 2010), in which they estimate that between the years 2000 and 2010 there was global loss of forest of 13 million ha per year (FAO, 2010). However, global afforestation and natural forest expansion during that time period has reduced the total global net loss of forest to 5.2 million ha per year (FAO, 2010). For the world as a whole, the FAO's FRA 2010 calculates that deforestation has resulted in a decrease in forest biomass carbon stocks by 0.5 Gt annually between 2005 and 2010 (FAO, 2010). The UNFCCC estimates of the carbon loss from tropical forests through deforestation in the 1990's is between 0.35 – 0.12 Gt per year (UFCCC, 2006).

Within the Congo Basin, the 2010 State of the Forest report highlights that the annual rate of net deforestation within the Congo Basin was at 0.05% between 1990 and 2000 while it was at 0.09% between 2000 and 2005 (figure 6.2 - OFAC, 2010). Within the individual countries, of most notes is the DRC, which experienced a doubling of their net deforestation percentage between the two time periods from 0.06% to 0.12%. In addition to the immediate loss of forest biomass carbon stock, deforestation and forest degradation are also reducing the global forests' capacity to remove additional atmospheric carbon.

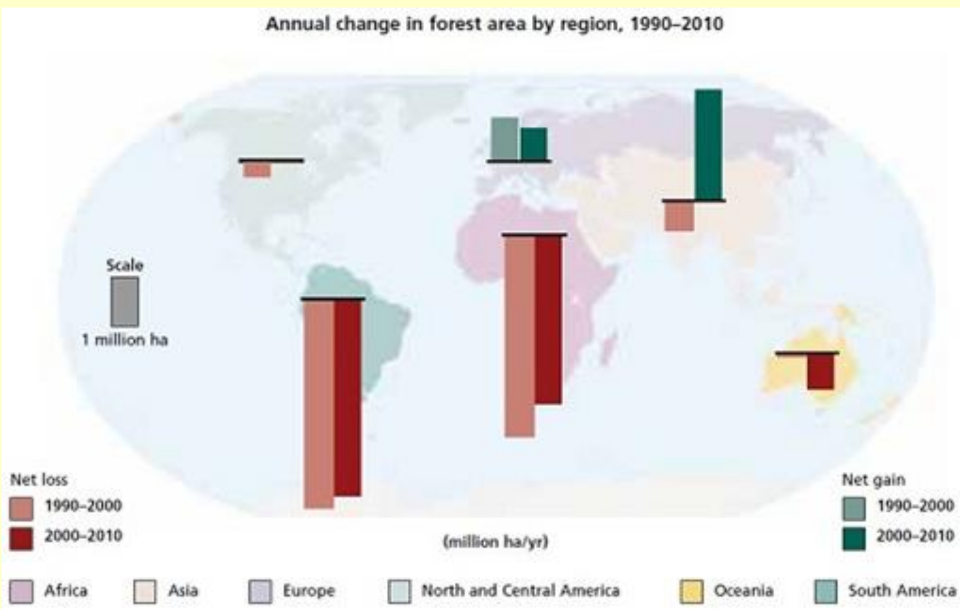


Figure 6.2 Annual changes in Forest Area by Region, 1990-2010, Source: FAO Global Forest Resources Assessment 2010

The tropical forests of the Amazon and Congo Basin contain the bulk of the world’s terrestrial biodiversity. They play a crucial but still not well understood role in regulating our climate. The two basins and the countries they cover are:

- Amazon Basin. Bolivia (Plurinational State of), Brazil, Colombia, Ecuador, French Guiana, Guyana, Peru, Suriname and Venezuela (Bolivarian Republic of).
- Congo Basin. Burundi, Cameroon, Central African Republic, Congo, Democratic Republic of the Congo, Equatorial Guinea, Gabon, and Rwanda.

The two rainforest basins have much in common, but there are also significant differences, both between and within the two sub-regions, table (6.1), after (FAO 2011)[51]

Table 6.1. Basic data on the three rainforest basins

Region	Land area 1000 Ha	Population 2008				GDP 2008	
		Total (1000)	Density (Population/ km2)	Annual growth rate (%)	Rural (% of total)	Per capita (PPP) (US$)	Annual growth rate (%)
Amazon Basin	1 339 294	318 615	24	1.2	18	9 841	5.1
Congo Basin	528 799	129 382	24	2.7	61	1 865	8.3
World	13 009 550	6 750 525	52	1.2	50	10 384	1.7

The population density is low in the Amazon and Congo Basins. More than half of the total population in the Congo Basin lives in rural areas. By contrast, more than 70 percent of the total population in the Amazon Basin lives in urban areas. While decreasing, the annual population growth rate is still high in the Congo Basin (2.7 percent), while close to the global average (1.2 percent) in the Amazon Basin.

The total forest area in the three rainforest basins is over 1.3 billion hectares (Table 6.2), which corresponds to one-third of the total forest area in the world and an average of 2.3 ha of forest per capita. The three most forest-rich countries (Brazil, Democratic Republic of Congo and Indonesia) account for more than half (57 percent) of the total forest area. French Guiana, Suriname and Gabon have the highest percent of their land area covered by forests (98, 95 and 85 percent respectively), while Singapore, Burundi and Rwanda have the lowest, ranging from 3 to 18 percent of their total land area.

Table 6.2. Forest area in the rainforest basins, 2010

Region	Land area 1000 Ha	Rainforest Area	
		Total (1000 Ha)	% of Land Area
Amazon Basin	1 339 294	799 394	60
Congo Basin	528 799	301 807	57
World	13 009 550	4 033 060	27.3

The main countries with the largest forest area could be ranked as follows (area in million hectares are but between brackets) : Brazil (520), Democratic Republic of the Congo (154), Peru (68), Colombia (60), Bolivia (57), and Venezuela (46).

[51] FAO 2011. "The State of Forests in the Amazon Basin, Congo Basin and Southeast". A report prepared by the Food and Agriculture Organization of the United Nations (FAO) or the International Tropical Timber Organization (ITTO) concerning for the Summit of the Three Rainforest Basins, Brazzaville, Republic of Congo.

The rate of deforestation, mainly the conversion of forest to agricultural land, shows signs of decreasing in several countries, but continues at a high rate in others. At the same time, afforestation and natural expansion of forests have reduced the net loss of forest area in some countries. The Amazon Basin suffered the largest net loss of forests, about 3.6 million hectares per year between 2000 and 2010, (0.45 percent per annum) and the Congo Basin also reported a net loss of forests (about 700 000 ha per year) over the period 2000–2010, but its rate of loss (0.23 percent per annum), Table (6.3), and (figures 6.3 and 6.4).

Table 6.3 Trends in forest area in the rainforest basins, 1990–2010

Region	Area (1000 ha)			Annual change (1000 ha)		Annual change rate(%)	
	1990	2000	2010	1990 - 2000	2000 - 2010	1990 - 2000	2000 - 2010
Amazon Basin	874 321	835 847	799 394	-3 847	-3 645	-0.45	-0.44
Congo Basin	316 078	308 864	301 807	-721	-706 -	-0.23	-0.23
World	4 168 399	4 085 063	4 032 905	-8 334	-5 216	-0.20	-0.13

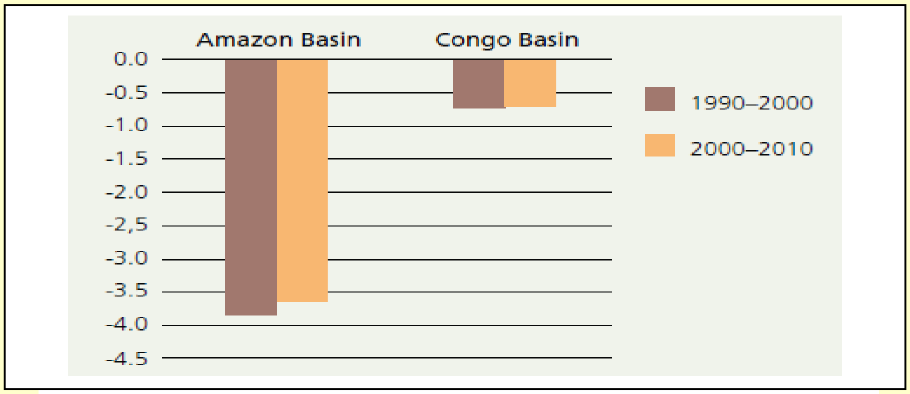


Figure 6.3. Annual change in forest area, 1990–2010 (million ha)

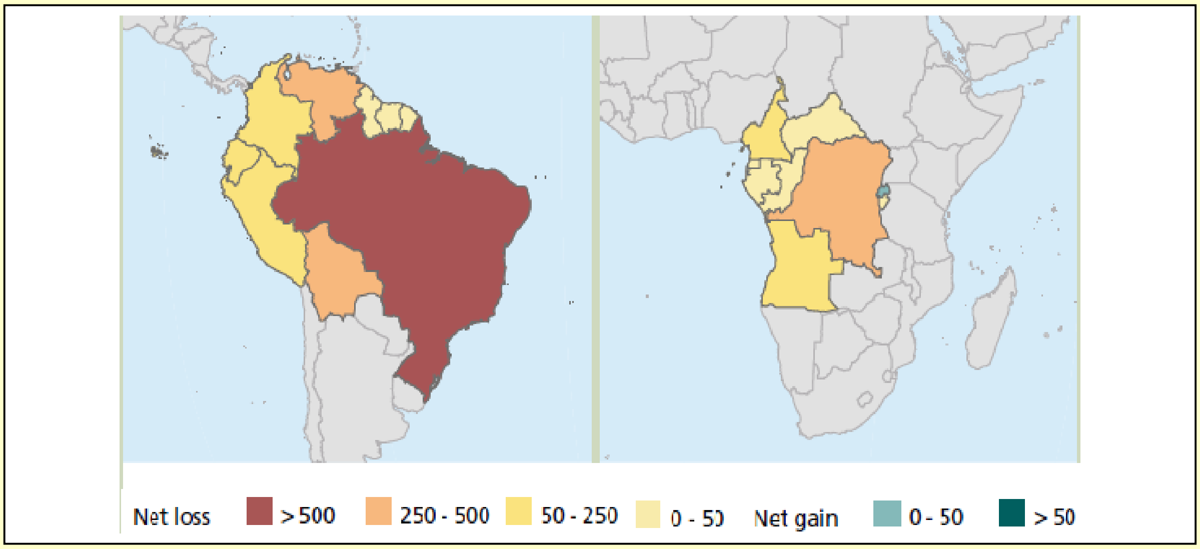


Figure 6.4. Annual change in forest area by country, 2005–2010 (1000 ha/year)

Most of the forests in the studied rainforest basins are classified as dense humid forests, more commonly known as tropical rainforests. They also contain some important areas of flooded forests (including mangroves) and some tropical dry forests. Large areas of the forests are classified as mosaic – a mixture of forest and other vegetation cover, where forests are fragmented and difficult to classify separately. Primary forests and other naturally regenerated forests dominate, constituting 98 percent of all forests. Forest types in the studied rainforest basins are shown in table (6.4) and figures (6.5 and 6.6), Source: Global Land Cover 2000 (GLC2000), Joint Research Centre of the European Commission.

Table 6.4. Composition of forests in the rainforest basins, 2010 (%)

Region	Dense humid forest	Dense dry forest	Flooded forest	Mosaics
Amazon Basin	73	5	4	18
Congo Basin	59	23	4	15
Rainforest Basins	66	9	4	21

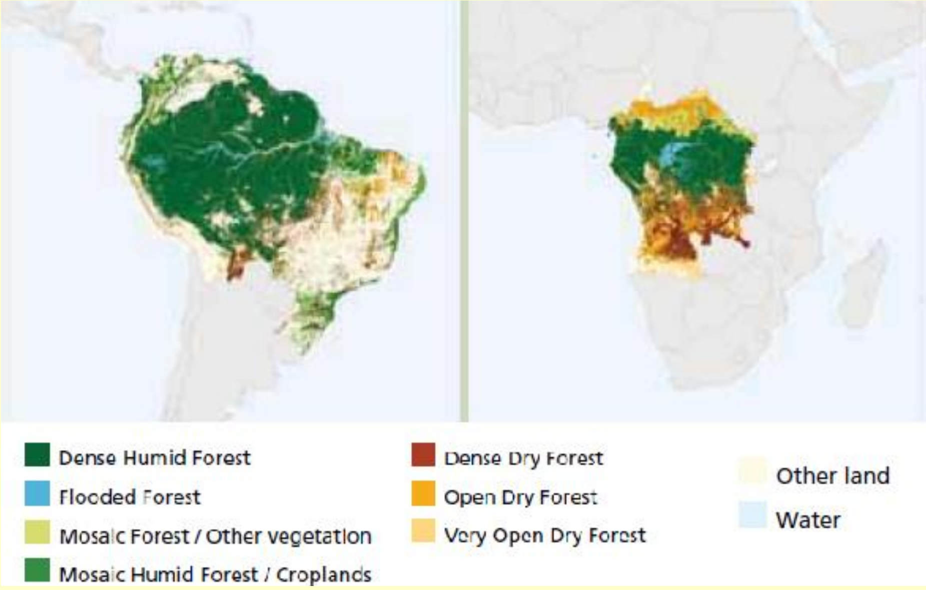


Figure 6.5, Forest types in the rainforest basins.

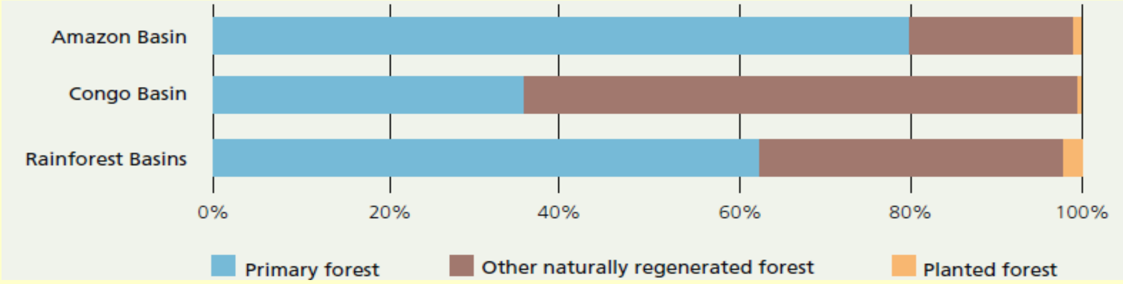


Figure 6.6. Characteristics of the forests in the rainforest basins, 2010

Primary forests consist of native species where there are no clearly visible indications of human activities and the ecological processes have not been significantly disturbed. The primary forests of the basins include the most species-rich, diverse terrestrial ecosystems on Earth. Together, the countries in the rainforest basins account for about half of all primary forests worldwide, over 743,19 million hectares. There is a large variation among the basins, with averages ranging from 35 percent in the Congo Basin to 80 percent in the Amazon Basin. The decrease of primary forest area over the last decade equals 5 % and is largely due to reclassification of primary forest to 'other naturally regenerated forest' because of selective logging and other human interventions. The largest loss in absolute terms is happening in the Amazon Basin, while the largest rate of loss in percentage terms is reported from the Congo Basin.

Table 6.5. Area of primary forest in the three rainforest basins, 2010

Region	Primary forest		Forest area	
	Area (1 000 ha)	% of total forest area	Area (1 000 ha)	% of total forest area
Amazon Basin	636 744	80	53 799	6.7
Congo Basin	106 448	35	645	0.2
Rainforest Basins	743,192	51	54 444	6.9
World	1 462 114	33	329 168	8.2

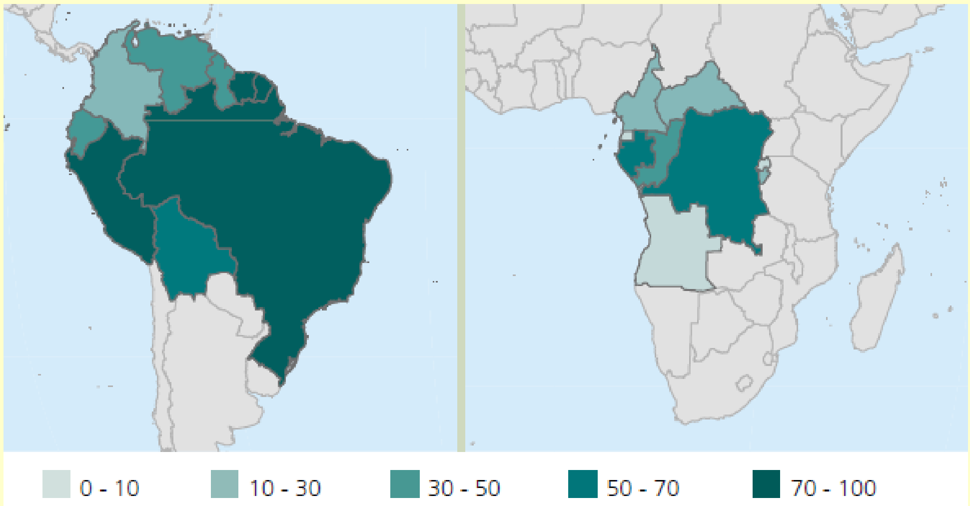


Figure 6.7. Forests Coverage %

Forests and trees are planted for many purposes and make up an estimated 1.5 percent of the total forest area in the rainforest basins, or 10.6 million hectares. The total area of planted forest is smallest in the Congo Basin, where only 0.3 percent of the total forest area is established through planting. Close to 54 million hectares of forest are designated for protective functions, notably the conservation of soil and water resources. These areas increased in the 1990s, but decreased between 2000 and 2010.

Forest degradation due to unsustainable, including illegal, practices is a common phenomenon in most countries, at the meantime the impact of drought phenomena on forests are not yet well defined. In this study we are highlighting both Drought and land degradation influence on forests on both Amazon and Congo Basins.

6.2. Congo Basin

6.2.1. Introduction

The Congo Basin forest is the second largest contiguous moist tropical forest in the world. These forests provide essential ecosystem goods and services to local, regional, and global human populations. These ecosystems goods and services include regional climate and hydrologic cycle regulation, carbon sequestration and storage, support of livelihoods from timber and non-timber forest products, habitat for globally significant biodiversity resources, and cultural values. Some of the non-timber resources that help to support local livelihoods include shelter, bush meat, food, medicines, tourism, and handcrafts. As regards the global climate, the most significant ecosystem service is probably the Congo Basin's carbon sequestration and storage ability. The forestry sector is a renewable raw material and, as such, it guarantees lasting revenues for as long as this resource is adequately managed. It is largely integrated into a rural economy that has limited monetization. It could be considered the main sector for generating direct and indirect employment (table 6.6), and also provides incomes for the local populations and funding for infrastructure in rural areas. In this way, the forestry sector undoubtedly contributes towards the fight against poverty.

Table 6.6: Forestry sector's contribution to national GDPs and direct employment creation in Central Africa

Country	Sources	Forestry sector's contribution to GDP (*)		Number of direct employments (**)	
		Value (%)	Year	Value	Year
Cameroon	the Ministry of Finance and Economic and Financial Audit of the Forestry Sector;	6	2004	13,000	2006
Congo	Poverty Reduction Strategy Paper (PRSP) and MDDEFE;	5.6	2006	7,424	2007
Gabon	Cellule économique; Equatorial	3.5	2009	14,121	2009
E. Guinea	Documento de la seconda Conferencia Economica and Forestry Enterprises.	0.22	2007	2,000	2007
CAR	Institut centrafricain de Statistiques et d'Études économiques et sociales (ICASEES);	13	2009	4,000	2009
DRC	World Bank and Fédération des Industriels du Bois (FIB);	1	2003	15,000	2007
Total				55,545	

(*) Figures given are those available on the OFAC website2009.
(**) It is difficult to ascertain the number of indirect jobs as data in this area is heterogeneous.

For the most part, it fares better than many other forests. Apart from intermittent areas of heavy deforestation, the overall level of deforestation remains relatively low. However, the increasing environment pressure that is being exerted on the forests of the Congo Basin could lead to quite considerable degradation and increased poverty for the very large number of people who are still heavily dependent upon the readily-available resources they provide.

Within the Congo Basin there are a number of drivers of deforestation and forest degradation. Several of the main drivers include; subsistence agriculture, commercial logging, illegal logging, bush meat trade, natural resources acquisitions, urbanization, and fuel wood collection. Subsistence agriculture is common in the Congo Basin and typically consists of farmers and villagers growing just enough food to feed a small number of people or an extended family.

Unfortunately the soils in the area usually are nutrient poor and unable to support the high-yield crops typically used in other areas. This leads to a slash-and-burn technique, whereby once the valuable wood has been harvested from the land, the remaining forest and brush are burned to release nutrients into the soil. The soil is then productive for only a few years before the slash-and-burn practice must be repeated on a new plot of land. The farmers will eventually cycle back to the original plot of land every ten to twenty years and start the cycle all over again, resulting in a large area that never fully recovers to the original forest structure.

Commercial logging is also a threat to the Congo Basin forest. Originally commercial logging was restricted to the coastal areas and areas accessible by the river networks. However, since the introduction of the bulldozer after WWII, the ability to build road networks has become significantly easier and resulted in commercial logging accessing larger inland areas. Most of the harvested wood is exported out of the Congo Basin as logs, sawn wood, veneer, and plywood. Even if the companies are only after a few valuable species, the logging practices used results in large amounts of damage and destruction to the surrounding forest.

Once the commercial logging roads have been constructed, they provide access to the areas for other deforestation and forest degradation activities. The roads provide access for the slash-and-burn subsistence farmers, bush meat hunters, and illegal loggers. The bush meat trade provides additional food for a wide range of communities from the families in the logging camps to the markets in urban centers. With growing need for additional food sources many species are being over hunted and the remaining populations quickly become unsustainable with the current demand.

Burns used to clear land for new fields within shifting cultivation, Photo courtesy of Alice Altstatt, CARPE

The roads also provide access to illegal loggers which have even worse practices than the commercial loggers.

Natural resource acquisition is another major driver of deforestation within the Congo Basin. The Congo Basin is also rich in mineral resources. Many operations will result in the complete removal of forest from the immediate area, plus there is often toxic runoff or spills that results in wider spread forest degradation.

The population in the Congo Basin is rapidly growing and undergoing large amounts of urbanization. This results in large amounts of forest being cleared to create space, produce building materials, farmland, and fuel wood. Large amounts of fuel wood are collected every day for cooking and charcoal production. As urban population centers grow, the regions around the urban areas become increasingly deforested and degraded.

In 1999, the Heads of State of the six Congo Basin forest countries signed the Yaoundé Declaration in Cameroon, thereby confirming their will to collaborate. This was consolidated with the establishment of the Central African Forests Commission (COMIFAC), which drew up a Convergence Plan to monitor all activities under its coordination. The Convergence Plan defines the framework for the elaboration of common objectives for forest conservation and encourages the development of new regional and trans-border conservation efforts.

Central Africa contains the second largest area of contiguous moist tropical forest in the world, covering about 2 million km^2 (Mayaux et al., 1998[52]). The Congo Basin is occupied by vast and still uninterrupted tracts of rainforests from the Gulf of Guinea to the Albertine Rift. Salient features include the presence of the world's largest tropical swamp forest in the central part of the Congo Basin, and two mountainous regions in Cameroon and in eastern Democratic Republic of Congo (DRC).

6.2.2. Forest Cover Change

Local and regional forest cover dynamics impact climate, biodiversity and ecosystems services. National and international decision makers need reliable, objective, verifiable (according to international standards) and up-to-date information to define and monitor forest policies and to report to international conventions. Land cover classes have been reported in (table 6.7.), (Duveiller et al., 2008) [53].

The forest change rates for each country, except for Equatorial Guinea for 2000-2005 due to the lack of cloud free data. The evolution of gross deforestation between 1990-2000 and 2000-2005 is quite significant for DRC, Cameroon and Congo while it becomes stabilized in Gabon and CAR. Net deforestation decreases in Cameroon and Gabon, it remains stable at 0.6 % per year in CAR and increases in Congo and DRC, (table 6.8). At the year 2000 total forest cover was estimated to be 159,529 thousand hectares with gross forest loss from 2000 to 2010 totaling 2.3 % of forest area.

Total forest cover loss (table 6.9) rease occurring within primary tropical forests. Forest cover loss intensity was distributed unevenly and was most correlated with areas of high population density and mining activity. While gross deforestation for all protected areas increased by 64 % between the 2000-2005 and 2005-2010 intervals, (*Ernst et al., 2010*)[54]. The coming years will be critical for forest resources of the Congo Basin. Population growth, immigration, economic development in the region plus increasing demand at the global level will inevitably increase the pressures on natural resources**.**

[52] Mayaux P., Achard F. and Malingreau J.P., 1998. Global tropical forest area measurements derived from coarse resolution satellite imagery: a comparison with other approaches Environmental Conservation, 25, 37-52.

[53] Duveiller G., Defourny P., Desclée B., and Mayaux P., 2008. Deforestation in Central Africa: Estimates at regional,national and landscape levels by advanced processing of systematically distributed Landsat extracts. Remote Sensing of Environment, 112: 1969-1981.

[54] Ernst C., Verhegghen A., Bodart C., Mayaux P., de Wasseige C.,Bararwandika A., Begoto G., Esono Mba F., Ibara M., Kondjo Shoko A., Koy Kondjo H., Makak J.S., Menomo Biang J.D., Musampa C., Ncogo Motogo R., Neba Shu G., Nkoumakali B., Ouissika C.B. and Defourny P., 2010. Congo Basin forest cover change estimate for 1990, 2000 and 2005 by Ling an automated object-based processing chain. The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, XXXVIII-4/C7.

Table 6.7: Area (in hectares) of land cover types for the 8 countries as derived from the Congo Basin land cover map

Land cover class	Cameroon	Congo	CAR	DRC	Gabon	E. Guinea	Burundi	Rwanda
Lowland dense moist forest	18,640,192	17,116,583	6,915,231 (*)	101,822,027	22,324,871	2,063,850	8,412	172
Sub-montane forest	194,638	0	8,364	3,273,671	0	24,262	36,311	39,061
Montane forest	28,396	10	0	930,863	19	6,703	57,212	180,259
Edaphic forest	0	4,150,397	95	8,499,308	16,881	0	0	0
Mangrove forest	227,818	11,190	0	181	163,626	25,245	0	0
Total dense forest	**19,091,044**	**21,278,180**	**6,923,690**	**114,526,051**	**22,505,397**	**2,120,060**	**101,936**	**219,492**
Forest-savanna mosaic	2,537,713	517,068	11,180,042	6,960,040	51,092	0	70,465	54,405
Rural complex and young secondary forest	3,934,142	3,664,609	713,892	21,425,449	1,405,318	507,281	297,748	304,699
Tropical dry forest - Miombo	1,292,106	297,824	3,430,842	23,749,066	31,337 172	172	127	4,344
Woodland	11,901,697	2,659,375	34,381,438	36,994,935	787,231	4,669	297,137	373,999
Shrubland	2,561,163	2,101,556	4,002,258	6,705,478	619,347	1,308	222,700	146,936
Grassland	177,385	1,191,956	62,015	4,372,677	341,688	86	201,875	153,696
Aquatic grassland	20,156	328,254	96,531	75,888	18,857	1,060	0	258
Swamp grassland	128,622	0	0	701,308	0	0	0	2,206
Sparse vegetation	0	95	0	2,129	0	0	0	0
Mosaic of cultivated land and natural vegetation	3,475,766	1,794,050	977,811	12,907,360	304,097	1,098	1,251,030	1,297,014
Agriculture	667,918	60,239	8,994	0	19,535	172	0	50,538
Irrigated agriculture	60,669	0	26,362	181	0	0	0	831
Bare land	0	0	0	41,935	0	0	0	95
Cities and developed area	38,507	2,941	7,199	41,716	18,332	401	0	286
Water	276,637	296,726	35,452	3,944,206	325,017	27,861	20,433	142,591
Total	**46,163,526**	**34,192,873**	**61,846,529**	**232,448,418**	**26,427,250**	**2,664,168**	**2,498,451**	**2,751,390**

(*) For CAR, 3,994,399 ha of the 6,915,231 ha of lowland dense moist forest belong to the Congo-Guinean domain as defined by Boulvert (1986), the rest belonging mainly to the edaphic domain.

Table 6.8: National annual degradation and regeneration rates in the dense forest zones-Congo Basin between 1990 and 2000, and between 2000 and 2005 in **(%)**.

Country	Forest area in 2010 (ha) (*)	1990 - 2000		2000 - 2005	
		Net deforestation	Net degradation	Net deforestation	Net degradation
Cameroon	18,640,192	0.08	0.06	0.03	0.07
Congo	17,116,583	0.03	0.03	0.07	0.03
Gabon	22,324,871	0.05	0.04	0.00	0.01
Equatorial Guinea	2,063,850	0.02	0.03	-	-
CAR	6,915,231	0.06	0.03	0.06	0.03
DRC	101,822,027	0.11	0.06	0. 22	0. 12
Congo Basin	168,882,754	0.09	0.05	0.17	0.09

Source: Ernst et al., 2010 and Verhegghen & Defourny, 2010 – DRC Geodatabases; SIAF Congo; OFAC

(*)The administrative areas are different from the GIS calculated areas. For example, according to the WRI, in February 2011, in DRC, the administrative areas of allocated forests totaled 12,184,130 hectares while a GIS analysis calculated the total area as 14,491,935 hectares.

Table 6.9: Forest cover and loss in DRC (thousands hectares)

Forest type	2000 Forest cover (x 1,000 ha)	2000 - 2005 Forest loss (x 1,000 ha)	Losses in %	2005 - 2010 Forest loss (x 1,000 ha)	Losses in %	Total Losses %
Primary forest	104,455	367	0.35	701	0.67	1.02
Secondary forest	18,293	1,168	6.38	947	5.18	11.56
Woodland	36,781	201	0.55	328	0.89	1.44
Total	159,529	1,736	1.09	1,976	1.24	2.33

Source: OSFAC, 2010

Land degradation in Central Africa has significant environmental, economic and social repercussions. While some areas are more affected than others, all ten COMIFAC member countries have to pay a high price. Overall, the following can be noted: (i) from an environmental perspective, land degradation leads to a decrease in natural vegetation, a fall in crop yields due to the loss of soil fertility, a reduction or even loss of biodiversity, a change in water quality due to various types of chemical pollution; (ii) from an economic perspective, consequences are noticeable in the agricultural sector where loss of production for seven subsistence crops (maize, rice, sorghum/millet, cassava, taro/yam, sweet potato, beans) are estimated at \$ 2.4 billion yearly and \$ 5 billion when this estimate covers both subsistence and cash crops; (iii) from a social perspective, populations in the sub-region suffer from energy and food crises, poverty, health problems and the lack of resources leads to conflicts. In order to mitigate this problem in Central Africa, each country should (i) include matters relating to sustainable land management into policies and poverty reduction programs and give them national priority status; (ii) launch a detailed study on the costs of land degradation; (iii) develop a national land use plan and a national multi-sectorial policy document; (iv) establish monitoring mechanisms to monitor informal sectors of resource exploitation; (v) set up policy, institutional and incentive measures to promote technical and financial partners, farmers and breeders and many other stakeholders, to invest in sustainable land management, (de Wasseige et al 2010)[55].

The evaluation of threats remains a delicate exercise with many uncertainties. Primary direct threats to forest cover (not to biodiversity) **are detailed below:**

Fuel-wood: Fuel-wood is the main energy source for people in developing countries Wood energy in Africa represents over 80 % of total domestic energy consumption across all countries and Africa is the only continent where wood energy should continue to grow in the coming decades (Marien, 2009)[56].

Agriculture: Limited access to improved agricultural technologies has long led farmers to practice shifting cultivation in most tropical African communities. This practice has been part of the ecosystem for many centuries but it becomes a problem when fallow periods are shortened as more land is required for production, leading to a decline in the regeneration of trees, soil fertility and agricultural yield (Boahene, 1998)[57]. This generally occurs along main roads, near villages and on the outskirts of urban centers (Devers & Vande weghe,2007). The threat of deforestation and degradation will increase in the future.

Mining and oil extraction: Africa has extensive mineral resources, constituting approximately one third of global mineral resources. This proportion rises to 89 % for platinum, 81% for chromium, 61% for manganese and 60 % for cobalt. The subsurface strata of the Congo Basin contain very important oil and mineral resources, including iron, copper, manganese, uranium as well as diamonds and gold (Reed & Miranda, 2007)[58]. These resources currently provide significant revenues for the region's countries. According to many experts, this leading position should strengthened by 2015. Much of these resources are exploited in artisanal and small scale operations but even so mining is a significant threat to forest ecosystems. governance must be a priority in order to reduce the adverse effects of mining and oil extraction.

Agro-fuels: Agro-fuels consist of a wide range of fuels which are in some way derived from biomass. Oil palm is a traditional native crop for Central Africa but in recent years, African communities are facing the expansion of large scale oil palm plantations (mostly in DRC and Cameroon). Forest areas in the Congo Basin have been converted to monoculture oil palm aimed at the production of agro-fuels.

Logging: Industrial logging temporally generates inevitable impacts as well as avoidable impacts on the forests, including soil erosion, water pollution and reduction of the regeneration capacity. Logging increases human presence in the forest, from logging camps and providing access through road construction. Logging also removes nutrients and escalates forest

[55] de Wasseige C., Devers D., de Marcken P., Eba'a Atyi R., Nasi R., and Mayaux P. (Eds), 2010. The Forests of the Congo Basin – State of the Forest 2008. Luxembourg: Publications Office of the European Union, ISBN 978-92-79-13210-0,doi: 10.2788/32259, 411 p.

[56] Mockrin M., 2009. Duiker demography and dispersal under hunting in Northern Congo. African Journal of ecology. 48(1): 239-247.

[57] Boahene K., 1998. The Challenge of Deforestation in Tropical Africa: Reflections on its Principal Causes, Consequences and Solutions. Land Degradation and Development, 9, 247-258.

[58] Devers D., Vande weghe J.P. (Eds), 2007. The Forests of the Congo Basin - State of the Forest 2006. CBFP, ISBN 978-90-788-2701-6, 256 p.

fragmentation (Devers & Vande weghe, 2007). The impact of informal or artisanal logging could be more serious than industrial logging as they are not subject to any kind of regulation.

The direct and indirect impacts of forest logging on biodiversity have been widely written about (table 6.10). It is generally considered that selective logging (A maximum disturbance of 20 % of the logged area and a rotation allowing forests to rest for 25 to 30 years.) has a limited direct impact on ecosystems. The main impact that was noted was an indirect one and related to increased hunting by company personnel or non-native hunters, made possible by increased forest accessibility through the opening up of roads.

Table 6.10: Direct and indirect impacts of forest logging

Impacts	Direct	Indirect
Unavoidable	– Decreased biomass – Fragmented habitats – Loss of forest surface area; permanent – (about 10 to 15 %) and temporary (about 20 %) – Noise, various disturbances – Change in the floral composition (trees and vegetation) – Local faunal disturbances – Increased heterogeneity	– Increase in human populations in the forest – Nutrient removal – Change in animal composition (e.g., in favor of herbivores) – To a certain extent, biodiversity diversification (mixed ecosystems)
Avoidable	– Damaged settlements – Soil erosion and pollution – Reduction in the number of seeds – Possible genetic erosion (has yet to be demonstrated)	– Increased access to isolated forests and means of transport – Increasing deforestation for agriculture – Increased hunting – Proliferation of exotic species – Increasing sanitary risks

6.2.3. Assessing Agriculture Drought and Land Degradation In Congo Basin

a) Agriculture Drought Hazard

Agriculture drought hazard for the period from 2000 – 2011, as shown in table (6.11) and Figure (6.8) illustrate the following:

Out of 350 million hectares studied in Congo basin 245 million hectares are affected by drought hazard that represent 70% of the total studied Congo basin area, and that 237.07 million hectares are affected by slight drought, 2.9 million hectares are affected by moderate drought and 0.87 million hectares are affected by severe drought hazard most of it Gabon and Cameroon.

Table 6.11 Agriculture Drought Hazard in Congo Basin

ADH	Area in Ha	Area in %
No Hazard	105127678.6	30.0
Slight Hazard	237067924.23	67.70
Moderate Hazard	2920598.14	0.83
Severe Hazard	865054.64	0.25
Wet and Water Bodies	4168819.17	1.19

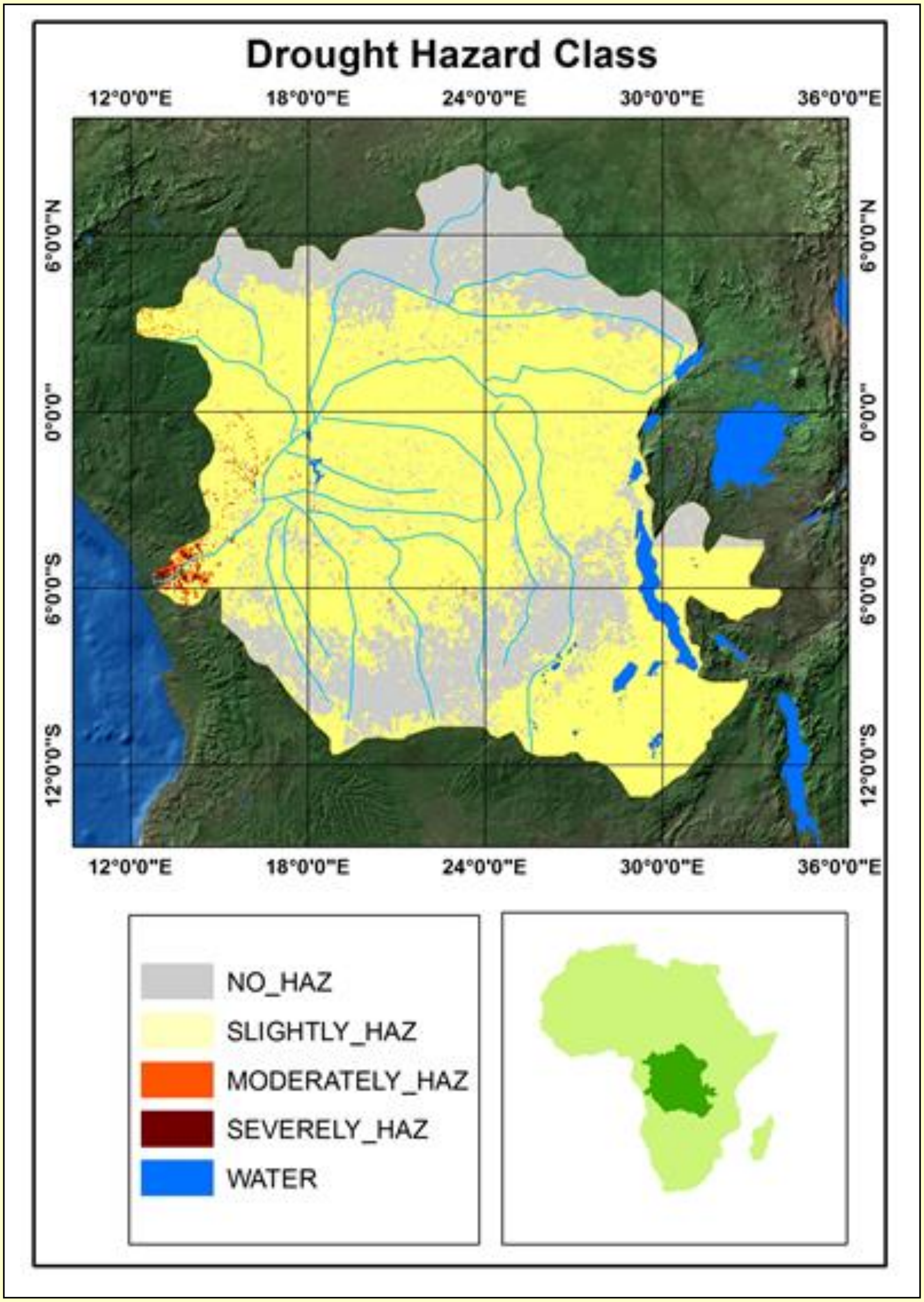


Figure 6.8 Agriculture Drought Hazard in Congo Basin

b) Land Degradation in Congo Basin

Land degradation for the period from 2000 – 2011, as shown in Figure (6.9) illustrates the following: out of 350 million hectares studied in Congo basin

- Approximately 63.3 million hectares are not affected by land degradation (represent 18.09 % of the total studied Congo basin area);
- About 255.07 million hectares are affected by different levels of land degradation (represent 72.87 % of the total studied Congo basin area); where,
  - 48.16 million hectares are very severely affected,
  - 111.54 million hectares are severely affected,
  - 64.19 million hectares are moderately affected and
  - 31.18 million hectares are slightly affected.

On the other hands:

- Approximately 24.53 million hectares are improved (represent 7.01 % of the total studied Congo basin area); where,
  - 1.52 million hectares are highly improved,
  - 1.24 million hectares are moderately improved and
  - 22.53 million hectares are slightly improved

Threats of Forest degradation are recognized but described in much less percentage by by Céline et al (2013), an object-based automatic method combined with a national expert validation to produce regional and national forest cover change statistics over Congo Basin, using High resolution imagery to accurately estimate not only deforestation and reforestation but also degradation and regeneration. The annual rate of net deforestation in Congo Basin is estimated to 0.09% between 1990 and 2000 and of net degradation to 0.05%. Between 2000 and 2005, this unique exercise estimates annual net deforestation to 0.17% and annual net degradation to 0.09%. He added that the direct causes and the drivers of deforestation are Population density, small-scale agriculture; fuel-wood collection and forest's accessibility are closely linked to deforestation, whereas timber extraction has no major impact on the reduction in the canopy cover. The analysis also shows the efficiency of protected areas to reduce deforestation. That reflects that about 12% of the forest cover are highly affected and degraded through the study period.

For better understanding about the impact of vegetation cover degradation more detailed study were undertaken to study Congo basin land cover.

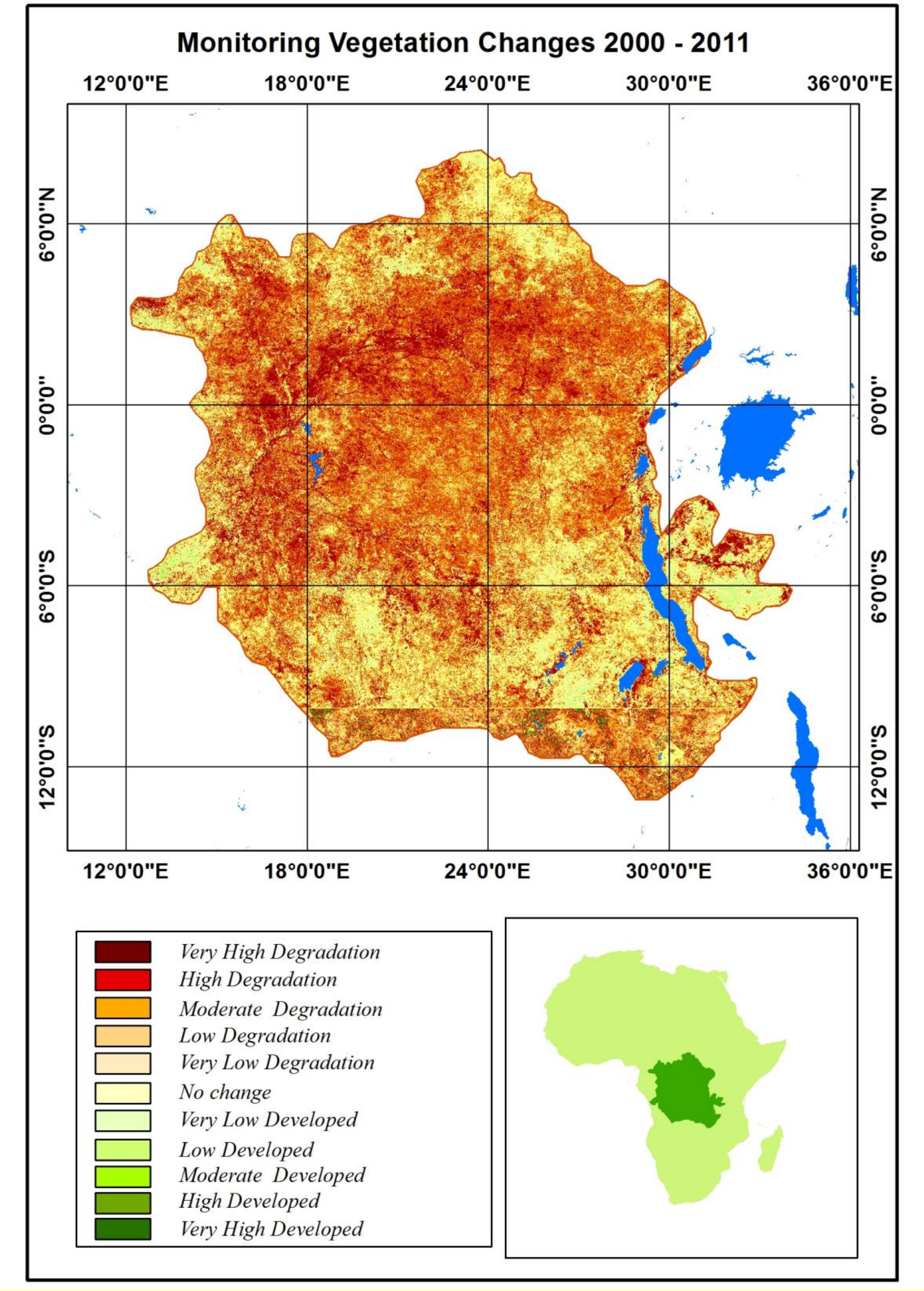


Figure 6.9 Vegetation Cover Degradation in Congo Basin

c) Vegetation Land Cover in Congo Basin

Central Africa has the highest number of plant species per unit area of any region in the world. Reitsma (1988) found over 200 different plant species on a 0.02 ha plot in Gabon and, similarly, Letouzey (1985 and 1986) found 227 species on a 0.01 ha plot in Cameroon.

A study carried out by Wilks (1990) in Gabon has shown that these forests are richer in plant species than those in West Africa. Sources of a very general nature estimate that there are 3,600 known plant species (Stuart et al., 1990; WCMC, 1992), of which 100 are endemic and two species are threatened with extinction.

The "Cuvette centrale" is the main endemic region in the DRC. It has 952 endemic Spermatophyte species, which is 10.7 % of all the known species in this group. Two other endemic areas have been identified. One is in the mountainous region in the east (where the micro thermal orophile species, that include the Lobelia, Philippia and Senecio genera, can be found) and the other is in the region of the Katanga high plains in the south-east of the country.

According to Stuart et al. (1990), and World Conservation Monitoring Centre (WCMC,1992), Cameroon has about 8,260 plant species. More recently, this estimate was lowered to 7,850 plant species, 815 of these are threatened with extinction (Onana & Cheek, 2011).

A check-list of vascular plants in Gabon (Sosef *et al.*, 2006), the most recent estimate is for 4,710 species, 508 of which are thought to be endemic (*Projet Sud Expert Plantes*,2010). This figure is lower than previous estimates of 6,000 to 8,000 plants (Breteler, 1988; Lebrun, 1976) or 7,151 vascular plants (Stuart *etal.*, 1990; WCMC, 1992). In the Republic of Congo , an estimated 6,000 vascular plant species (Hecketsweiler, 1990) was recently revised to about 4,538 species, of which 15 are endemic (Sonke et al., 2010).

According to the Red List workshop that took place in CAR (2009), the threatened species in Congo basin includes, Endemic plants of Cameroon; Species of timber and non-timber forest products used in the sub-region of Central Africa; some taxa of Orchidaceae; some taxa of Rubiaceae; the Begoniaceae; Saprophytes plants; and the Podostemaceae.

The central region is characterized by low deforestation rates resulting from small localized clearings usually associated with shifting agricultural activities (Mayaux et al., 2003[59]; Hansen et al., 2008[60]).

The situation can be explained by the absence of a significant local market for wood products and a poor transportation infrastructure. However, coastal Central Africa has experienced more intensive forest exploitation. Here, population growth and agricultural expansion, as well as emerging marketing opportunities have exerted a strong pressure on forest resources.

[59] Mayaux P., Bartholomé E., Massart M., Vancutsem C., Cabral A., Nonguierma A., Diallo O., Pretorius C., Thompson M., Cherlet M., Pekel J.F., Defourny P., Vasconcelos M., Di Gregorio A., Fritz S., De Grandi G., Elvidge C., Vogt P. and Belward A., 2003. A Land Cover Map of Africa –Carte de l'occupation du Sol de l'Afrique, EUR 20665, EN (European Commission, Luxembourg), 20 pp.

[60] Hansen M.C., Roy D.P., Lindquist E., Adusei B., Justice C.O., Altstatt A., 2008. A method for integrating MODIS and Landsat data for systematic monitoring of forest cover and change in the Congo Basin. Remote Sensing of environment, 112(5), 2495- 2513.

Satellite-based mapping of forest cover in the Congo Basin is challenging due to the persistent cloud cover, the fragmentation and variability of the landscape, while field based inventories are limited by the vast extent and inaccessibility of the territory.

Forest map covering consistently the 8 countries of Congo Basin has been produced (figure 6.10). The production of this new map relied on a semi-automatic method combining statistical classification, expert consultation and manual editing (Verhegghen & Defourny, 2010[61]).

The methodology developed takes advantage of the spatial resolution of MERIS (300 m resolution) and the time-series of 8-years of SPOT –Vegetation (SPOT -VGT), providing a better delineation of the small features and improved discrimination of the vegetation type respectively. This vegetation class discrimination relied on a systematic analysis of the different seasonal spectral profiles in order to split classes showing differences in terms of seasonal dynamic of green biomass.

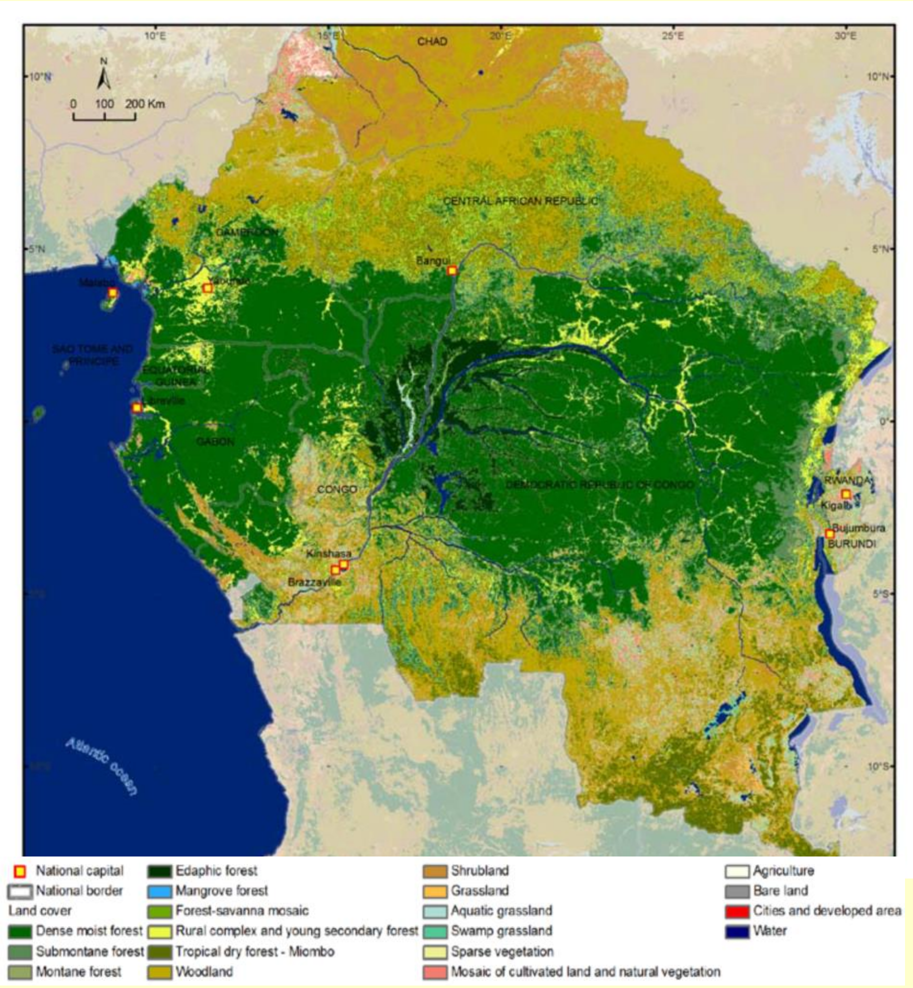


Figure 6.10: Congo Basin land cover map, Source: Verhegghen & Defourny, 2010

[61] Verhegghen A., Defourny P., 2010. A new 300 m vegetation map for Central Africa based on multi-sensor times series. in: Sobrino J.A. (Ed.), Third Recent Advance in Quantitative Remote Sensing. Publicaciones de la Universitat de Valencia,Valencia, Spain.

Efficient assessment of land cover and the ability to monitor change are fundamental to sustainable management of natural resources, environmental protection, food security and successful humanitarian programmes.

FAO and the United Nations Environment Programme (UNEP) have been collaborating in numerous initiatives for improving the reliability and compatibility of land cover data sets, and enabling access to the information for a large user community.

A recent example of such collaboration is the Global Land Cover Network (GLCN), launched in 2004, with the support of the Government of Italy, the Government of the Netherlands and numerous institutes worldwide. The main Land cover of Congo basin are shown in table (2.6), from the Global Land cover (LC) map, after Arino et al (2008[62]) and ESA (2009)[63], figure (2.4) were used in this study, land cover map. Forests represent 263 million hectares (75.13% from the total basin area), closed forests represents 187.4 million hectares of the total area, Other forest areas represents 75.7 million hectares, Mosaic of cultivated land and natural vegetation represents 44.7 million hectares, Cities area represents 40000 hectares, water bodies represents 7 .07 million hectares and bare soils represents 16000 hectares.

This Global Land cover map considered the most detailed maps ever of Earth's land surface have been created with the help of ESA's EnviSat environmental satellite. This global map has a resolution 10 times sharper than any of its predecessors. The global portrait is based on 40 terabytes of imagery – equivalent to the content of 40 million books – acquired by Envisat's Medium Resolution Imaging Spectrometer (MERIS). ESA made a continuous effort to ensure the acquisitions and the production of the MERIS 300 m Full Resolution Full Swath (FRS) products for the period from 1 December 2004 to 30 June 2006.

There are 22 different land cover types shown in the map, including croplands, wetlands, forests, artificial surfaces, water bodies and permanent snow and ice. For maximum user benefit, the map's thematic legend is compatible with the UN Land Cover Classification System (LCCS), (Di Gregorio 2005)[64].

These are the minimum elements required to form a Natural or Semi-Natural Vegetated land cover class, for both Terrestrial and Aquatic or Regularly Flooded Areas. Because Height (in its standard denotation) is automatically linked to the Life Form chosen, the classifiers needed to be determined are actually two: Life Form and Cover. A Life Form is a group of plants having certain morphological features in common (Kuechler and Zonneveld, 1988). According to the quality of the main axis or shoots, a further distinction is made into Woody Life Forms or Herbaceous Life Forms. For further subdivision, the following growth form criteria can be applied: Branching symmetry, subdividing Trees and Shrubs; and Herbaceous plant physiognomy, subdividing Forbs from Graminoids (Strasburger et al., 1983; Kuechler and Zonneveld, 1988) and from Lichens/Mosses Life Forms.

---

[62] Arino O. , P. Bicheron, F. Achard, J. Latham, R. Witt, and J.-Louis Weber 2008 GLOBCOVER The most detailed portrait of EarthEuropean Space Agency | Bulletin 136 |

[63] http://www.esa.int/images/globcover_poster2010_H.jpg

[64] Di Gregorio A. 2005 Land Cover Classification System, Classification concepts and user manual. FAO Environment and Natural Resources Service Series, No. 8 - FAO, Rome

The dominance of a Life Form is based on the "uppermost canopy" level, ranging from Trees to Shrubs to Forbs/Graminoids. This main condition for uppermost canopy has to be considered in conjunction with the sub-condition Cover, ranging from Closed or Open to Sparse. In other words, the uppermost canopy concept is only valid if the dominant Life Form has a cover either Closed, Open or Closed to Open. If the Life Form is Sparse then the dominance goes to another Life Form that has a Closed or Open cover.

Table 6.12. Land Cover in Congo Basin

Land Cover	**Total Area**	
	in M Ha	**%**
Closed broadleaved deciduous forest	38.52	11.00
Closed broadleaved forest permanently flooded (saline-brackish water)	trace	trace
Closed to open broadleaved evergreen or semi-deciduous forest	117.46	33.54
Closed to open broadleaved forest regularly flooded (fresh-brackish water)	31.4	8.97
Open broadleaved deciduous forest	75.6	21.59
Open needleleaved deciduous or evergreen forest	0.12	0.03
Closed to open grassland	2.14	0.61
Closed to open mixed broadleaved and needleleaved forest	trace	trace
Closed to open shrubland	23.64	6.75
Closed to open vegetation regularly flooded	1.09	0.31
Mosaic Croplands/Vegetation	0.64	0.18
Mosaic Forest-Shrubland/Grassland	3.99	1.14
Mosaic Grassland/Forest-Shrubland	4.22	1.21
Mosaic Vegetation/Croplands	43.93	12.55
Rainfed croplands	0.14	0.04
Irrigated croplands	trace	trace
Sparse vegetation	0.01	0.00
Artificial areas	0.04	0.01
Water Bodies	7.07	2.02
Bare soils	0.16	0.05
TOTAL	**350.17**	**100**

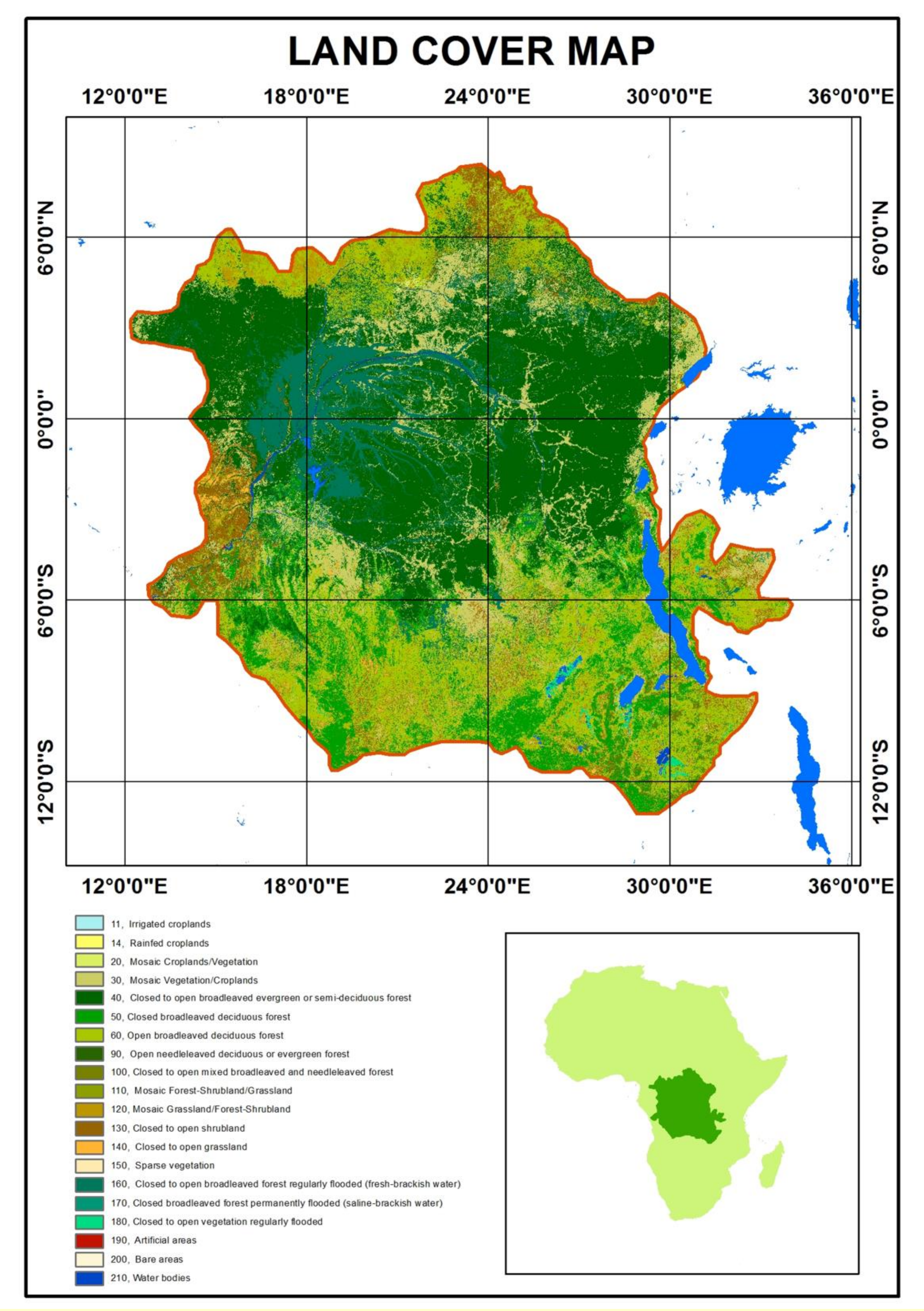


Figure 6.11: Congo Basin land cover map derived from 300 m resolution data
Source: Arino et al (2008) and ESA (2009)

d) Impact of Agriculture Drought Hazard on Vegetation Land Cover in Congo Basin.

Land cover/Land use of the studied basin is likely to be slightly exposed to ADH. The crossing between both ADH map and LC, allowed for better understanding for the type(s) of land use that is more vulnerable to ADH, as shown in (table 6.13). About 52.05% of the vegetation cover is not affected and 45.15% are slightly affected on the Closed to open broadleaved evergreen or semi-deciduous forest where approximately100 million hectares, 27 million hectares of the Closed broadleaved deciduous forest and are affected 26% of the closed to open broadleaved forest regularly flooded (fresh-brackish water).

Table 6.13. Impact of Agriculture Drought Hazard on Vegetation Land Cover

Land Cover	Not affected	Slight	Moderate	Severe
Closed broadleaved deciduous forest	11.43	26.77	0.27	0.04
Closed to open broadleaved evergreen or semi-deciduous forest	17.32	99.72	0.34	0.08
Closed to open broadleaved forest regularly flooded (fresh-brackish water)	5.05	26.25	0.07	0.02
Closed to open grassland	0.69	1.36	0.08	0.02
Closed to open mixed broadleaved and needleleaved forest	0.00	0.00	0.00	0.00
Closed to open shrubland	21.49	1.41	0.68	0.21
Closed to open vegetation regularly flooded	1.05	0.02	0.01	0.00
Mosaic Croplands/Vegetation	0.62	0.01	0.01	0.00
Mosaic Forest-Shrubland/Grassland	3.66	0.22	0.10	0.03
Mosaic Grassland/Forest-Shrubland	4.11	0.07	0.04	0.01
Mosaic Vegetation/Croplands	41.97	1.47	0.41	0.10
Open broadleaved deciduous forest	74.61	0.79	0.15	0.04
Open needleleaved deciduous or evergreen forest	0.12	0.00	0.00	0.00
Rainfed croplands	0.12	0.01	0.01	0.00
Sparse vegetation	0.01	0.00	0.00	0.00
TOTAL in Ha	182.25	158.09	2.16	0.57
TOTAL in %	52.05	45.15	0.62	0.16

e) Impact of Land Degradation on Vegetation Land Cover in Congo Basin

Land cover/Land use of the studied basin is likely exposed to LD. The crossing between LD map and Land degradation, allowed for better understanding for the type (s) of land use that is more vulnerable to LD, as shown in (table 6.14).

The most affected land cover type is the Closed to open broadleaved evergreen or semi-deciduous forest that covers 99.36 million hectares that represents 28.37% of the total basin area, Open broadleaved deciduous forest that covers 43.03 million hectares that represents 12.3% of the total basin area, Closed to open broadleaved forest regularly flooded (fresh-brackish water) that covers 27 million hectares that represents 7.71% of the total basin area, and Closed broadleaved deciduous forest that covers 8 million hectares that represents 2.3% of the total basin area. The total affected forest area is covering 177.4 million hectares that represents 75.1% of the total forest basin area (263 million hectares). Other land cover types are also affected, e.g. shrubs and grass that covers 53.23 million hectares that represents 15.2% of the total basin area.

Table 6.14. Impact of Land Degradation on Vegetation Land Cover in Congo Basin

Land Cover	Degradation				No Change	improved
	V H	H.	Mod.	Slight		
Closed broadleaved deciduous forest	0.39	0	7.63	0	8.74	21.76
Closed broadleaved forest permanently flooded (saline-brackish water)	0	0	0	0	0	0.01
Closed to open broadleaved evergreen or semi-deciduous forest	16.71	51.9	23.9	6.81	13.5	4.6
Closed to open broadleaved forest regularly flooded (fresh-brackish water)	8.28	12.22	5.01	1.48	1.48	2.93
Open needleleaved deciduous or evergreen forest	0.02	0.03	0.02	0.01	0.03	0.01
Open broadleaved deciduous forest	6.87	15.82	13.9	6.48	20.91	11.66
Closed to open grassland	0.31	0.45	0.32	0.15	0.54	0.37
Closed to open shrubland	2.83	4.8	3.99	1.86	6.23	3.93
Closed to open vegetation regularly flooded	0.18	0.15	0.13	0.08	0.33	0.22
Sparse vegetation	0	0	0	0	0	0.01
Mosaic Forest-Shrubland/Grassland	0.38	0.85	0.69	0.3	1.12	0.65
Mosaic Grassland/Forest-Shrubland	0.36	1.15	0.86	0.33	1.07	0.45
Mosaic Croplands/Vegetation	0.06	0.12	0.09	0.04	0.18	0.15
Mosaic Vegetation/Croplands	7.6	14.8	7.63	2.63	7.42	3.85
Rainfed croplands	0.03	0.03	0.02	0.01	0.03	0.02
TOTAL in Ha	44.02	102.3	64.2	20.18	61.58	57.89
TOTAL in %	12.57	29.22	18.3	5.76	17.59	16.53

6.3. AMAZON BASIN

6.3.1. The Amazon River

The Amazon River, according to many accounts, was named by Spanish explorer Fransisco de Orellana in 1541. The name was in honor of the female warriors he encountered on his voyage through the territory previously called Maranon.

The Amazon rain forest occupies 40 percent of Brazil's total geographical area. It is the drainage basin for the Amazon River and its many tributaries and covers 5,500,000 km2.

The Amazon River basin is covering about 6,915,000 km2 in area (almost 2 times the size of India), The Amazon river is over 6600 km long including its 15,000 tributaries and sub-tributaries. It is the largest river basin in the world, figure (6.12 and 6.13), after (Castello 2012) [65].

The source of the Amazon is the lake, Lauricocha, in the Peruvian Andes. The river is still known as the Maranon in its upper course, in the Andes. The length of the Amazon is measured from the source of the Ucayali river, which joins with the Maranon to eventually form the Amazon.

Much of northern Brazil is drained by the Rio Negro, which joins the Amazon to give it full strength before flowing into the Atlantic.

The powerful discharge at the mouth of the Amazon measures about eight trillion gallons a day, 60 times that of the Nile and eleven times that of the Mississippi. The annual average discharge is 17.981 cubic meter per second ("cusecs") into the Atlantic, rising to over 19,821 cusecs during a flood. The mouth of the Amazon is more than 155 km wide. In the Amazon Basin, flooding often occurs between June and October.

Figure 6.12. Amazon Basin Location

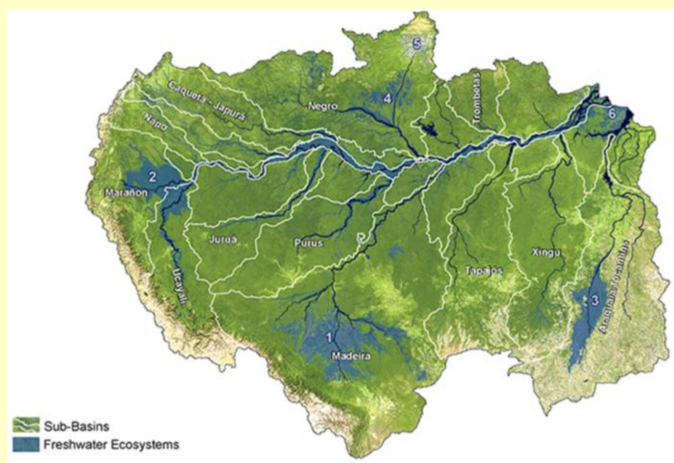


Figure 6.13 The Amazon Basin, main river sub-basins

The vast Amazon rainforest is on the brink of being turned into desert, with catastrophic consequences for the world's climate. And the process, which would be irreversible, could begin as early. The cause comes from the permanence of the El Nino climate from the Pacific that is altering the precipitation in Amazonia.

---

[65] Castello, L., McGrath, D.G., Hess, L.L., Coe, M.T., Lefebvre, P.A., Petry, P., Macedo, M.N., Reno, V., Arantes, C.C. 2012. The vulnerability of Amazon freshwater ecosystems.Conservation Letters DOI: 10.1111/conl.12008

The principal threat to most Amazon freshwater ecosystems is large-scale alteration of the basin’s natural hydrology. A total of 154 hydroelectric dams in operation, 21 in construction, and plans to construct 277 additional dams in the future. There are also thousands of small dams located in small streams to provide water for cattle These infrastructure projects, together with deforestation-induced changes to regional rainfall, could fundamentally change the hydrology of Amazon freshwater systems and could disrupt fish migrations and associated fishery yields, threatening riverine livelihoods and food security, (Castello et al 2012).

Ecological science has shown how large-scale forest clearings cause declines in biodiversity and the availability of forest products. Yet some important changes in the rainforests, and in the ecosystem services they provide, have been underappreciated until recently. Land use in the Amazon goes far beyond clearing large areas of forest; selective logging and other canopy damage is much more pervasive than once believed. Deforestation causes collateral damage to the surrounding forests – through enhanced drying of the forest floor, increased frequency of fires, and lowered productivity. The loss of healthy forests can degrade key ecosystem services, such as carbon storage in biomass and soils, the regulation of water balance and river flow, the modulation of regional climate patterns, and the amelioration of infectious diseases, (Foley et al 2007[66])

6.3.2. Sources of Changes in Amazon Basin

Little attention has been paid to freshwater ecosystems, which through the hydrological cycle are interconnected to other ecosystems at local and distant locations, being highly sensitive to a broad array of human impacts, figure (6.14), after (Castello et al 2012)[67] .

The Amazon Basin is one of the world's most important bioregions, harboring a rich array of plant and animal species and offering a wealth of goods and services to society. Science and policy in the Amazon have focused largely on forests and their associated biodiversity and carbon stocks. Three decades of effort have generated an understanding of some key biophysical transitions in the basin and enabled the establishment of a network of protected areas, largely designed to preserve forests and their biodiversity.

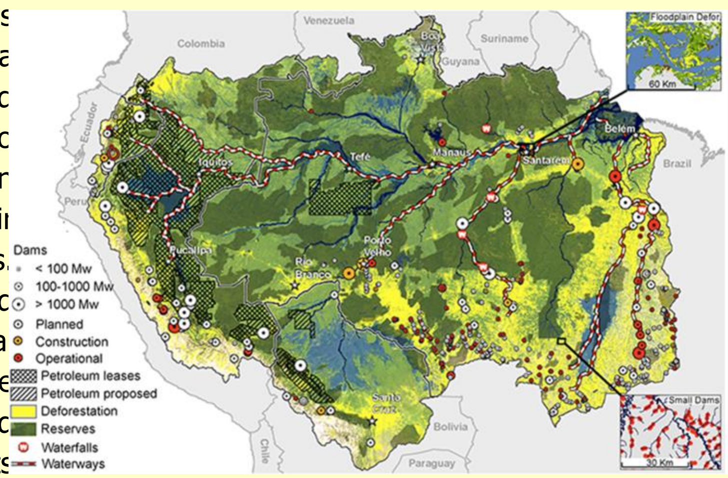


Figure 6.14 The Amazon Basin, Major sources of changes

a) Trees distribution on the basin

Several studies were carried out to survey the tree species, “More than 900 flood-tolerant tree species were recorded, which indicates that Amazonian várzea forests are the most species-rich

[66] Foley, J. A., G. P. Asner, M. H. Costa, M. T. Coe, R. DeFries, H. K. Gibbs, E. A. Howard, S. Olson, J. Patz, N. Ramankutty, and P. Snyder. 2007. Amazonian revealed: forest degradation and loss of ecosystem goods and services in the Amazon Basin. Frontiers in Ecology and Environment 5(1):25–32.

[67] Castello, L., McGrath, D.G., Hess, L.L., Coe, M.T., Lefebvre, P.A., Petry, P., Macedo, M.N., Reno, V., Arantes, C.C. 2012. The vulnerability of Amazon freshwater ecosystems.Conservation Letters DOI: 10.1111/conl.12008

floodplain forests worldwide. The most important plant families recorded also dominate most Neotropical upland forests, and 31% of the tree species occur in the uplands. Species distribution and diversity varied: 1) on the flood-level gradient, with a distinct separation between low-várzea forests and high-várzea forests, 2) in relation to natural forest succession, with species-poor forests in early stages of succession and species-rich forests in later stages, and 3) as a function of geographical distance between sites, indicating an increasing α diversity from eastern to western Amazonia, and simultaneously from the southern part of western Amazonia to equatorial western Amazonia. The east-to-west gradient of increasing species diversity in várzea forests reflects the diversity patterns also described for Amazonian terra firme. Despite the fine-scale geomorphological heterogeneity of the floodplains, and despite high disturbance of the different forest types by sedimentation and erosion, várzea forests are dominated by a high proportion of generalistic, widely distributed tree species. In contrast to high-várzea forests, where floristic dissimilarity increases significantly with increasing distance between the sites, low-várzea forests can exhibit high floristic similarity over large geographical distances. The high várzea may be an important transitional zone for lateral immigration of terra firme species to the floodplains, thus contributing to comparatively high species richness. However, long-distance dispersal of many low-várzea trees contributes to comparatively low species richness in highly flooded low várzea", (Wittmann et al 2006)[68].

b) Deforestation and Climate Change

A changing climate leads to variation in the frequency, intensity, spatial extent, duration, and timing changes has been the major cause of long-term increases in economic losses from climate-related disasters. Furthermore, assessments have indicated that in many regions of the world, socio-economic factors will be among the main drivers of future increases in related losses. Many countries in South America face severe challenges in coping with climate-related disasters (IPCC 2012[69], IPCC 2007[70], 2014[71]). Flash floods and landslides due to intense rainfall have affected the entire region, and have been costly both in terms of money and human life. Seasonal floods and droughts have also affected regions such as Amazonia, the Andean Valleys, the La Plata Basin and Northeast Brazil, and regions of Central America, with huge impacts on the national and regional economies (Magrin et al 2014[72], IPCC 2012).

---

[68] Wittmann F, J Schöngart, J Carlos Montero, T Motzer, W J. Junk, M T. F. Piedade, H L. Queiroz and M Worbes, 2006. "Tree species composition and diversity gradients in white-water forests across the Amazon Basin", Journal of Biogeography, Volume 33, Issue 8, pages 1334–1347,

[69] IPCC SREX. 2012. Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation. In: A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change. [Field C.B, Barros V, Stocker T.F, Qin D, Dokken D.J, Ebi K.L (eds.)]. Cambridge University Press, Cambridge, UK, and New York, NY, USA, pp. 582.

[70] IPCC. 2007. Summary for Policymakers. 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, Qin D, Mamming M, Chen Z, Marquis M, Averyt K.B, Tignor M, Miller H.L (eds.)].Cambridge University Press, Cambridge, United Kingdom and New York, NY,USA.

[71] IPCC. 2014. Summary for Policymakers. In: Climate Change 2014: Impacts, Vulnerability and Adaptation. Part A: Global and Sectiral Aspects. Contribution of Working Group 2 to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Field C, Barros V.R, Dokken D.J, Mach K.J, Mastrandrea M.D, Bilir T.E, Chatterjhee M, Ebi K.L, Estrada Y.O, Genova R.C, Girma B, Kissel E.S, Levy A.N, MacCracken S, Mastrandrea P.R, and White L.L (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA. pp. 1-32.

[72] Magrin G, Marengo J, Boulanger JP, Buckeridge M.S, Castellanos E, Poveda G, Scarano FR, Vicuña S. 2014. Central and South America. In: Climate Change 2014: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. In Press, Cambridge University Press, Cambridge, UK.

The observed trends in temperature and rainfall in the world are summarized after (IPCC 2013)[73], and presented in Figure (6.15, a and b), some of the South America region, from 1901 to 2012, temperatures have increased between 0.5 to 3°C, with the more significant increases in tropical SA. On rainfall, the most consistent signals are a gradual rainfall increase in South American Monsoon System (SESA), and northern South America, as well over Northeast Brazil and the Northwest Coast of Peru and Ecuador. Reductions have been detected over northern and southern Chile, Northern and Argentina. Since, around 1950. The West coast of South America experienced a prominent but localized coastal cooling of about 1°C during the past 30-50 years extending from central Peru down to central Chile. This occurs in connection with an increased upwelling of coastal waters favored by the more intense trade winds (Falvey and Garreaud, 2009[74]; Gutiérrez et al, 2011a[75]; Gutiérrez et al, 2011b[76]; Kosaka and Xie, 2013[77]; Narayan et al, 2010[78]; Schulz et al, 2012[79]).

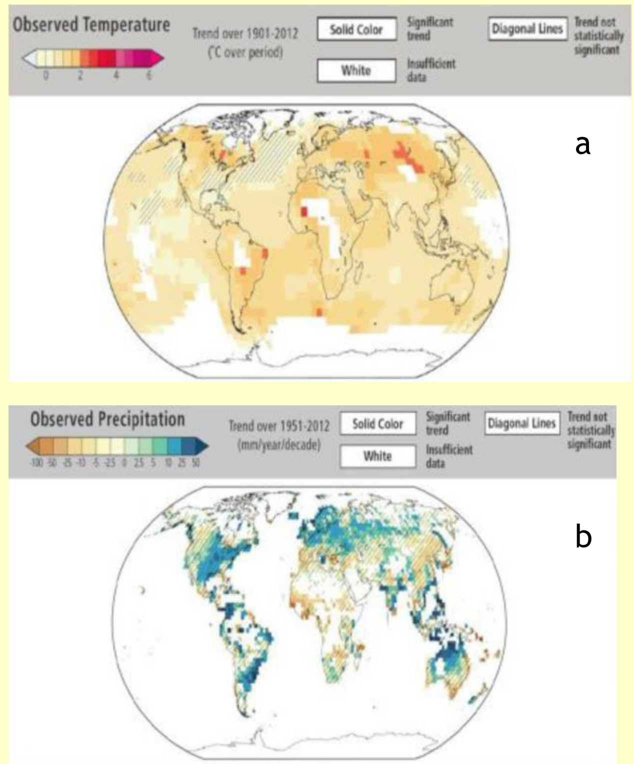


Figure 6.15 .Observed worldwide (a) annual temperature (1901-2013) and (b) rainfall trends (1951-2012).(IPCC 2013)

Recent observational studies show increases in warm days and decreases in cold days, as well asincreases on warm nights and decreases in cold nights in South America, Northeast Brazil, South-eastern South America and the west coast of South America. It is detected that while in some regions there is a tendency for warmer conditions; in others the signal is unclear. While signals for rainfall and dryness are inconsistent in some places, due to lack of good data

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

[74] Falvey M. and Garreaud RD. 2009. Regional cooling in a warming world: Recent temperature trends in the southeast Pacific and along the west coast of subtropical South America (1979–2006). Journal of Geophysical Research, 114, D04102.

[75] Gutiérrez D, Bertrand A, Wosnitza-mendo C, Dewitte B, Purca S, Peña C, Chaigneau A, Tam J, Graco M, Grados C, Fréon P, and Guevara-carrasco R. 2011a. Sensibilidad del sistema de afloramiento costero del Perú al cambio climático e implicancias ecológicas [Climate change sensitivity of the Peruvian upwelling system and ecological implications]. Revista Peruana Geoatmosférica. 3: 1-24.

[76] Gutiérrez D, Bouloubassi I, Sifeddine A, Purca S, Goubanova K, Graco M, Field D, Mejanelle L,Velazco F, Lorre A, Salvatteci R, Quispe D, Vargas G, Dewitte B, and Ortlieb L. 2011b. Coastal cooling and increased productivity in the main upwelling zone off Peru since the mid-twentieth century. Geophysical Research Letters, 38, L07603.

[77] Kosaka Y, and Xie S. 2013. Recent global-warming hiatus tied to equatorial Pacific surface cooling.Nature, (published online 28 August 2013).

[78] Narayan N, Paul A, Mulitza S, and Schulz M. 2010. Trends in coastal upwelling intensity during the late 20th century. Ocean Science, 6:3, 815-823.

[79] Schulz N, Boisier J.P, and Aceituno P. 2012. Climate change along the arid coast of northern Chile. International Journal of Climatology, 32:12, 1803-1814.

coverage, the tendency is for increases in rainfall extremes and drought since 1950. With regard to dry spells (Consecutive dry days CDD), there is an increase in the frequency of dry spells in south-eastern SA and in the northern coast of Peru and Ecuador, suggesting that in those regions a concentration of rainfall extremes is observed over the span of a few days, with longer dry spells in between. This situation favours the possibility of floods and landslides triggered by intense rainfall extremes, as already observed in South and Central America. With longer warm and dry spells, there is a significant impact on human health and agriculture, since these episodes are characterized by dry air and high maximum temperatures and low soil moisture, responsible for drought, increased risk of fires and biomass burning, and higher risk of allergies and respiratory diseases due to smoke, (Donat et al 2013[80]). Extreme events have the greatest impacts on sectors that are closely linked with or dependent on the climate, for example water, agriculture and food security, forestry, health, and tourism. There is high confidence that changes in the climate could seriously affect water management systems, as well as food and energy security in SA.

The deforestation is the conversion of forested areas in the field of agriculture (mostly soy). More than one fifth of the Amazon rainforest has already been destroyed, and the remaining one is threatened. In the space of just ten years, the area of forest lost in the Amazon reached between 415 000 and 587 000 km 2 which most used to produce food for livestock (CIFOR 2004)[81]. In Brazil, the Instituto Nacional de Pesquisas Espaciais (National Institute for Space Research) produces yearly figures on deforestation. Their estimate is based on 100 to 220 images taken during the dry season satellite Landsat , and considers only the loss of the Amazon rainforest biome - not the loss of natural areas or savanna in the forest. According to INPE, the biome of the Amazon rainforest, originally of 4.1 million km in Brazil was reduced to 3,403,000 km^2 in 2005, representing a loss of 17.1% , as explained by the National Institute for Space Research (INPE) (2005).

According to a scenario accepted by the World Bank (2010)[82] , current climate conditions, due to accessibility of trees to deep soil water. Scenario Analysis of the influence of deep roots (a rooting depth of 8 m, with a soil profi le of 50 cm of soil in the upper, and 750 cm in the lower layer was assumed. It was also assumed that evergreen trees have deeper roots with only 55 percent of their roots in the upper and 45 percent in the lower layer. Raingreen trees were assumed to have 85 percent of their roots in the upper and only 15 percent of the roots in the lower layer) and shallow roots (the soil is differentiated in two layers: the upper layer contains 50 cm of soil and the lower layer 150 cm. 85 percent of the roots of evergreen PFTs are located in the upper and 15 percent in the lower soil layer. Raingreen trees are assumed to have 60

[80] Donat MG., Alexander LV, Yang H, Durre I, Vose R, Dunn RJH, Willett KM, Aguilar E, Brunet M,Caesar J, Hewitson B, Jack C, Klein Tank AMG, Kruger AC, Marengo JA, Peterson TC, Renom M,Oria Rojas C, Rusticucci M, Salinger J, Sanhouri Elrayah A, Sekele SS, Srivastava AK, Trewin B,Villarroel C, Vincent LA, Zhai P, Zhang X, and Kitching S. 2013. Updated analyses of temperature and precipitation extreme indices since the beginning of the twentieth century: The HadEX2 dataset. Journal of Geophysical Research: Atmospheres, 118:5, 2098-2118.

[81] Centre for International Forestry Research (CIFOR) (2004) Beef exports fuel loss of Amazonian Forest. [archive] CIFOR News Online , Number 36.

[82] World Bank, 2010. Assessment of the Risk of Amazon Dieback, Environmentally and Socially Sustainable Development Department Latin America and Caribbean Region, Main Report, p 50 .

percent of their roots in the upper and 40 percent in the lower soil layer) under climate and CO2 effects are shown in table (6.15) and (figure 6.16).

Table 6.15. Percentage of Forest Cover of the Classified Vegetation Types in the Amazon Basin under HadCM3-A2 Scenario

Forest cover (%)						
1991–2000						
Scenario	**Tropical**	**Deciduous**	**Open forest**	**Woodland**	**Shrubland**	**Savanna**
S1	45.5	46.5 0	0.6	1.5	0.2	5.8
S2	75.3	16.8	0.3	1.5	0.2	5.8
S3	45.5	46.5 0	0.6	1.5	0.2	5.8
S4	75.3	16.8	0.3	1.5	0.2	5.8
2041 - 2050						
Scenario	**Tropical**	**Deciduous**	**Open forest**	**Woodland**	**Shrubland**	**Savanna**
S1	32.0	60.8	0.2	1.2	0.1	5.8
S2	69.4	23.1	0.2	1.5	0.1	5.8
S3	25.3	27.8	20.	5.0	15.9	5.8
S4	45.5	20.1	13.7	13.7	11.4	5.8
2091 - 2100						
Scenario	**Tropical**	**Deciduous**	**Open forest**	**Woodland**	**Shrubland**	**Savanna**
S1	15.2	55.7	2.7	8.2	10.3	7.7
S2	36.9	38.9	2.9	9.0	5.9	6.4
S3	0.5	5.8	6.9	1.9	67.6	17.3
S4	0.8	2.5	2.8	3.1	74.7	16.1

Source: Table generated for the report by Rammig et al. 2009[83]. Note: Results for the factorial experiments, in which the effects of climate and CO2 and the effects of shallow and deep rooting trees were tested.

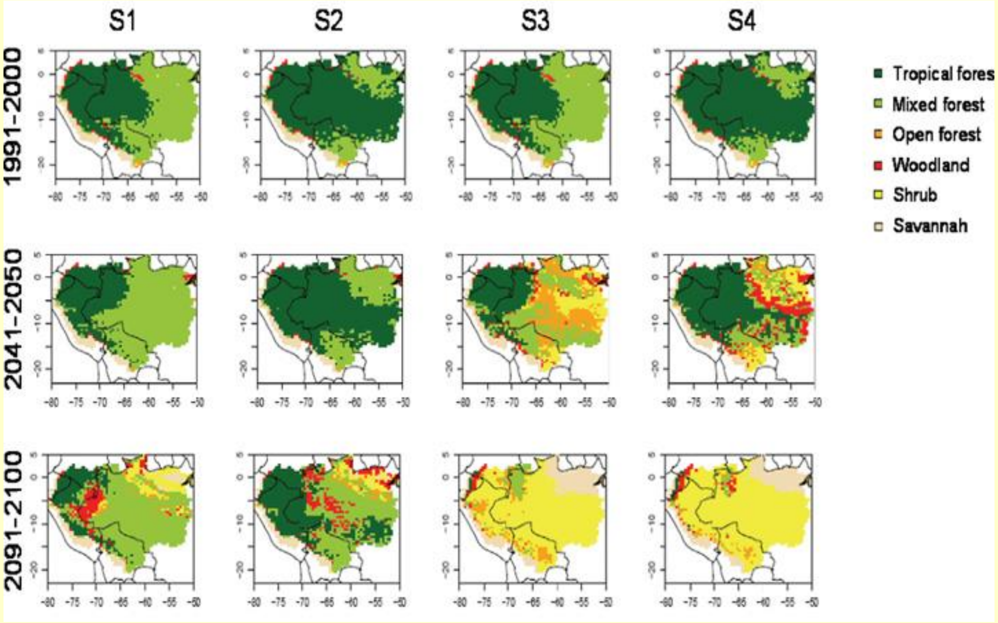


Figure 6.16. Scenario Analysis of the Influence of Deep and Shallow Roots under Climate and CO_2 Effects and Climate-Only Effects, Source: (Rammig et al. 2009)[84].

[83] Rammig, A., W. Cramer, W. Lucht, K. Thonicke, and U. Heyder. 2009. "Brazil: Risk analysis for Amazon dieback, 2009." Report produced by the Potsdam Institute for Climate Impact Research (PIK) for the World Bank as a background for this report.

Expansion of the cattle and soy industries in the Amazon basin has increased deforestation rates and will soon push all-weather highways into the region's core. In the face of this growing pressure, a comprehensive conservation strategy for the Amazon basin should protect its watersheds, the full range of species and ecosystem diversity, and the stability of regional climates. Protected areas in the Amazon basin—the central feature of prevailing conservation approaches are an important but insufficient component of this strategy, based on policy-sensitive simulations of future deforestation. By 2050, current trends in agricultural expansion will eliminate a total of 40% of Amazon forests, including at least two-thirds of the forest cover of six major watersheds and 12 ecoregions, releasing 32 ± 8 Pg of carbon to the atmosphere. One-quarter of the 382 mammalian species examined will lose more than 40% of the forest within their Amazon ranges. Although an expanded and enforced network of protected areas could avoid as much as one-third of this projected forest loss, conservation on private lands is also essential. Expanding market pressures for sound land management and prevention of forest clearing on lands unsuitable for agriculture are critical ingredients of a strategy for comprehensive conservation, (Filho et al 2005)[85]

The annual deforestation and forest degradation estimates for the 10-year study period are presented for each Amazonian state and for the region as a whole in Figure (6.17), for the interval between 2000 and 2010, (Souza et al 2013)[86]. He estimated the annual forest degradation rates did not vary as much or have any noticeable trend, with a peak of 8,396 km2/yr in 2008 and a minimum annual rate of 3,731 km2/yr in 2010, degradation rates corresponded to a low percentage of 17% of deforestation rates in 2003 and a high of 68% in both 2008 and 2010.

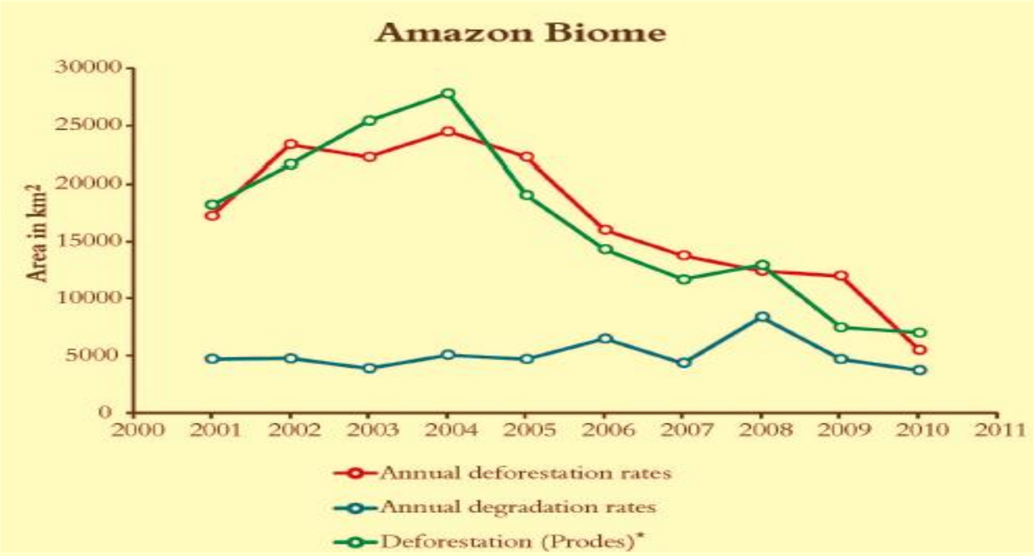


Figure 3.17. Deforestation, Degradation in Amazon Basin

[84] Rammig, A., W. Cramer, W. Lucht, K. Thonicke, and U. Heyder. 2009. "Brazil: Risk analysis for Amazon dieback, 2009." Report produced by the Potsdam Institute for Climate Impact Research (PIK) for the World Bank as a background for this report.

[85] Soares-Filho B S, D C Nepstad, L M. Curran, G C Cerqueira1, R A Garcia, C A Ramos, E Voll, A McDonald, P Lefebvre and & P Schlesinger2005 Modelling conservation in the Amazon basin, Nature 440, 520-523

[86] Souza C M., Jr , J V. Siqueira 1, M H. Sales, A V. Fonseca, J G. Ribeiro, I Numata, M A. Cochrane, Cr P. Barber, Dar A. Roberts and J Barlow 2013. "Ten-Year Landsat Classification of Deforestation and Forest Degradation in the Brazilian Amazon", Remote Sens, 5, 5493-5513

For Amazonia as a whole, the remaining tropical forest area relative to its original extension is progressively reduced as climate change impacts, deforestation and fi re effects are combined. Substantial impacts are already projected by 2025 and the situation worsens by 2050. The effect of climate change alone would contribute to reduce the extent of the rainforest biome by one third by the end of the century, Major impacts are projected in Eastern Amazonia. The combined effects of climate and deforestation result in a severe decrease of the rainforest biome, in relation to its original extension of forest area. The remaining forest biome, by 2075, accounting for 50 percent deforestation and/or the effects of fi res, is about 2 percent. This is the largest relative decrease in the entire basin. (World Bank 2010)[87].

c) Drought in Amazon Basin

Several global circulation models (GCMs), project an increase in the frequency and severity of drought events affecting the Amazon region as a consequence of anthropogenic greenhouse gas emissions. Such droughts may lead to a loss of some Amazon forests, which would accelerate climate change). During this decade, the Amazon region has suffered two severe droughts in the short span of five years – 2005 and 2010. Studies on the 2005 drought present a complex, and sometimes contradictory, picture of how these forests have responded to the drought. In 2005 a major Atlantic SST–associated drought occurred, identified as a 1-in-100-year event In the second drought in 2010, when Atlantic SSTs were again high, dry-season rainfall was low across Amazonia, with apparent similarities to the major 2005 drought. Standardized anomalies of dry-season rainfall showed that 57% of Amazonia had low rainfall in 2010 as compared with 37% in 2005 after (Lewis et al 2011).

Now, on the heels of the 2005 drought comes an even stronger drought in 2010, as indicated by record low river levels in the 109 years of bookkeeping. severe and persistent declines in vegetation greenness, a proxy for photosynthetic carbon fixation, in the Amazon region during the 2010 drought based on analysis of satellite measurements, (Xu 2011)[88]. He added that the 2010 drought, as measured by rainfall deficit, affected an area 1.65 times larger than the 2005 drought – nearly 5 million km2 of vegetated area in Amazonia. The decline in greenness during the 2010 drought spanned an area that was four times greater (2.4 million km2) and more severe than in 2005. Notably, 51% of all drought-stricken forests showed greenness declines in 2010 (1.68 million km2) compared to only 14% in 2005 (0.32 million km2). These declines in 2010 persisted following the end of the dry season drought and return of rainfall to normal levels, unlike in 2005. Overall, the widespread loss of photosynthetic capacity of Amazonian vegetation due to the 2010 drought may represent a significant perturbation to the global carbon cycle. The Normalized Difference Vegetation Index (NDVI) and Enhanced Vegetation Index (EVI) data, which are proxies for photosynthetic carbon fixation [Myneni et al., 1995; Huete et al., 2006; Yang et al., 2007; Brando et al., 2010], show wide spread declines, especially south of the Equator, during the 2010 drought, in contrast to the 2005 drought (figure 6.18). About 49.1% of the vegetated area that was subject to drought shows greenness index declines (July to September NDVI standardized). the impacts of 2010

[87] World Bank, 2010. Assessment of the Risk of Amazon Dieback, Environmentally and Socially Sustainable Development Department Latin America and Caribbean Region, Main Report, p 50 .

[88] Xu L, Samanta A, Costa M H, Ganguly S, Nemani R R and Myneni R B 2011 Widespread decline in greenness of Amazonian vegetation due to the 2010 drought Geophys. Res. Lett. 38 L07402

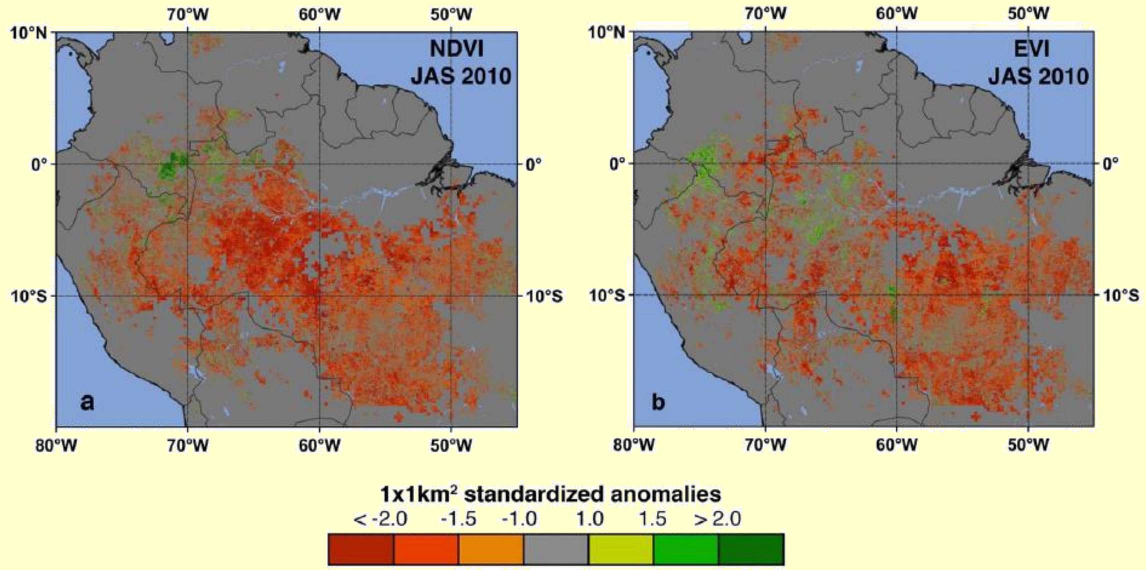


Figure 6.18. Spatial patterns of July to September (JAS) 2010 standardized anomalies of normalized difference vegetation index (NDVI) and enhanced vegetation index (EVI) in vegetated areas of drought (precipitation anomalies less than −1 standard deviation).

An analysis of the climate situation indicates that the drought of 2010 was unique, and that changes in circulation regimes leading to the drought were associated with the warming of the tropical North Atlantic, which was even warmer than in the previous drought of 2005. The warming in the tropical North Atlantic during 2010 was the strongest of the whole 1903–2010 period, (Marengo 2011)[89]. He added that changes in the dry season and hydrology of the Amazon Basin are related to sea surface temperature (SST) warming in the tropical North Atlantic. The changes observed in the length and intensity of the dry season have influence over the very low river water levels and discharge at the end of the dry season. Decadal variations in the intensity and extension of the dry season, associated with changes in the dry season drought frequency and intensity, will have profound environmental and social impacts in the region.

By using relationships between drying and forest biomass responses measured for 2005, we predict the impact of the 2010 drought as 2.2 × 1015 grams of carbon, largely longer-term committed emissions from drought-induced tree deaths, compared with 1.6 ×1015 grams of carbon (CIs 0.8 and 2.6) for the 2005 event, as shown in figure (3.19), after (Lewis et al 2011).

The two recent Amazon droughts demonstrate a mechanism by which remaining intact tropical forests of South America can shift from buffering the increase in atmospheric carbon dioxide to accelerating it. Indeed, two major droughts in a decade may largely offset the net gains of ~0.4 PgCyear−1 in intact Amazon forest aboveground biomass in non-drought years. Thus, repeated droughts may have important decadal-scale impacts on the global carbon cycle.

[89] Marengo, J. A., J. Tomasella, L. M. Alves, W. R. Soares, and D. A. Rodriguez (2011), The drought of 2010 in the context of historical droughts in the Amazon region, Geophys. Res. Lett., 38, L12703, doi:10.1029/2011GL047436.

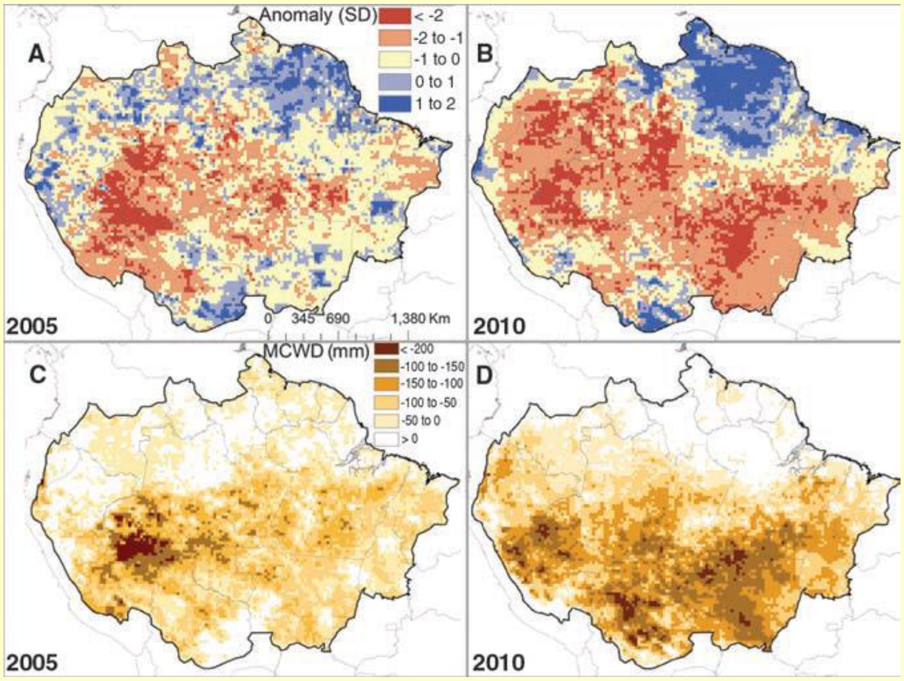


Figure. 6.19. (A and B) Satellite-derived standardized anomalies for dry-season rainfall for the two most extensive droughts of the 21st century in Amazonia. (C and D) The difference in the 12-month (October to September), maximum climatological water deficit (MCWD) from the decadal mean (excluding 2005 and 2010), a measure of drought intensity that correlates with tree mortality. (A) and (C) show the 2005 drought; (B) and (D) show the 2010 drought.

Droughts co-occur with peaks of fire activity (Aragão et al 2007)[90]. Such interactions among climatic changes, human actions, and forest responses represent potential positive feedbacks that could lead to widespread Amazon forest degradation or loss. The significance of these processes will depend on the growth response of tropical trees to increases in atmospheric carbon dioxide concentration, fire management, and deforestation trends. Nevertheless, any shift to drier conditions would favor drought adapted species, and drier forests store less carbon. If drought events continue, the era of intact Amazon forests buffering the increase in atmospheric carbon dioxide may have passed. it is envisaged that at the current rate 40% of the Amazon will be gone in 2050, but elevated CO_2 concentrations reduce the negative effects of drought on plant growth (Gerten et al. 2005)[91] which increase plant productivity.

Fires are rare events under undisturbed conditions in tropical forest ecosystems. They have been observed historically either as part of small-scale slash-and-burn activity (Kauffman and Uhl 1990)[92], or due to lightning-caused ignitions in occasional drought years (Cochrane and

[90] Aragão, L.E.O.C., Malhi, Y., Roman-Cuesta, R.M., Saatchi, S., Anderson, L.O., and Shimabukuro, Y.E. 2007. Spatial patterns and fire response of recent Amazonian droughts. Geophysical Research Letters, 34.

[91] Gerten, D., W. Lucht, S. Schaphoff , W. Cramer, T. Hickler, and W. Wagner. 2005 "Hydrologic resilience of the terrestrial biosphere." Geophysical Research Leİ ers 32: L21408.

[92] Kauff man, J.B., and C. Uhl. 1990. "Interactions of anthropogenic activities, fi re, and rain forests in the Amazon basin." In Fire in the Tropical Biota: Ecosystem Processes and Global Challenges. Goldammer JG. Berlin, Springer Verlag: 117-134.

Laurance 2008)[93]. Thus, besides physiology-driven growth and mortality responses, another important indicator for the eff ects of climate change on the Amazon rainforest could be changes in the occurrence of actual fi res or fi re danger, (World Bank 2010) .

According to Rammig et al. (2009)[94], using the HadCM3-A2 Scenario for simulated climatic fire danger is still low under current climate conditions, but already higher than under the MRI CGCM. Changed climatic conditions by the end of the 21st century could lead to an increased fire danger, with very high danger levels in Northeastern Amazonia in the HadCM3-A2 Scenario. In the wet scenario (MRI CGCM 2.3.2a), climatic fire danger increases from very low to low fire danger levels, mainly in the southeast of the basin. The elevated fi re danger index is not automatically leading to increased fi re frequency. Fires can start after lightning events only if sufficient fuel load is available. Thus, after a significant increase of flammable grasses, e.g., as a result from drought-induced forest degradation figure (6.20), increases in climatic fire danger in the Northeastern Amazon lead to an increase in burned area, thus the fi re-related carbon emission in the HadCM3-A2 scenario. Low climatic fi re danger levels do not allow the development of sufficient surface energy which could sustain burning. Therefore, no carbon emissions are simulated under the wet MRI-CGCM 2.3.2a climate scenario.

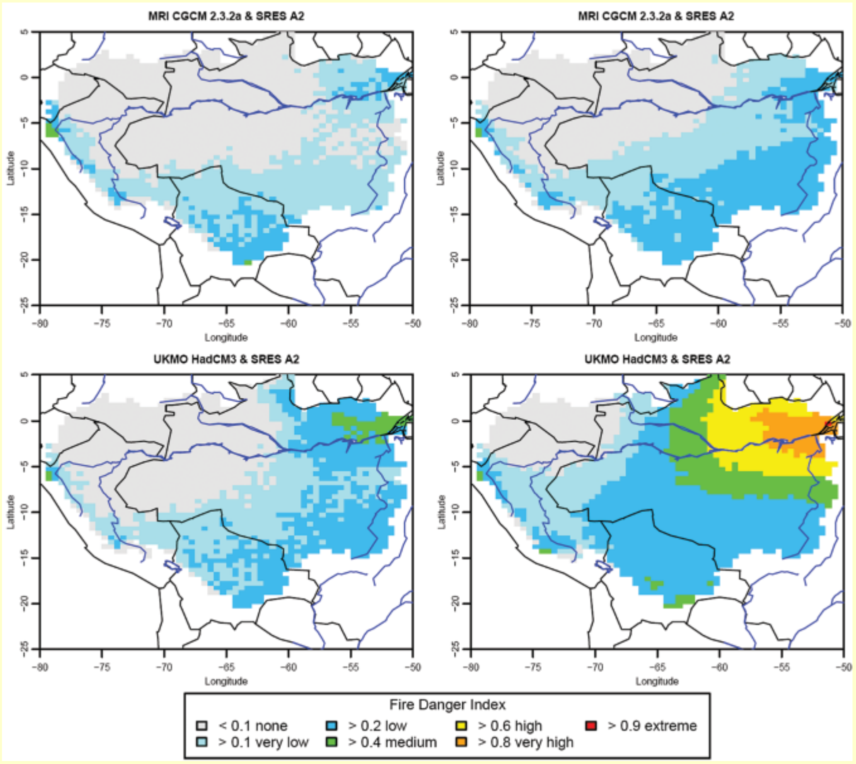


Figure 6.20. Simulated Climatic Fire Danger under the MRI CGCM 2.3.2a (Top) and the HadCM3 (Bottom) Climate Scenario Using the SRES A2 Emission Scenario

[93] Cochrane M.A., and W.F. Laurance. 2008. "Synergisms among fi re, land use, and climate change in the Amazon." Ambio 37: 522-527.

[94] Rammig, A., W. Cramer, W. Lucht, K. Thonicke, and U. Heyder. 2009. "Brazil: Risk analysis for Amazon dieback, 2009." Report produced by the Potsdam Institute for Climate Impact Research (PIK) for the World Bank as a background for this report.

6.3.3 Agriculture Drought and Land Degradation in Amazon Basin

a) Agriculture Drought Hazard

Agriculture drought hazard for the period from 2000 – 2011, as shown in table (6.16) and Figure (6.21) illustrate the following:

Out of 619 million hectares studied in Amazon basin 241 million hectares are affected by drought hazard that represent 38.79 % of the total studied Amazon basin area, and that 193.47 million hectares are affected by slight drought, 39.3 million hectares are affected by moderate drought and 8.10 million hectares are affected by severe drought hazard.

Table 6.16 Agriculture Drought Hazard in Amazon Basin

ADH	Area in Ha	Area in %
No Hazard	378495012.59	60.95
Slight Hazard	193477255.62	31.16
Moderate Hazard	39264724.84	6.32
Severe Hazard	8100507.66	1.30
Wet and Water Bodies	1628351.58	0.26
TOTAL	619337500.70	100.00

b) Land Degradation in Amazon Basin

Land degradation for the period from 2000 – 2012, as shown in Figure (6.22) illustrates the following: out of 621 million hectares studied in Amazon Basin

- Approximately 371.7 million hectares are not affected by land degradation (represent 59.8 % of the total studied Amazon basin area);
- About 79.00 million hectares are affected by different levels of land degradation (represent 40 % of the total studied Amazon basin area); where,
  - 12.08 million hectares are very severely affected,
  - 8.78 million hectares are severely affected,
  - 27.02 million hectares are moderately affected and
  - 123.02 million hectares are slightly affected.

On the other hands:

- Approximately 79.00 million hectares are improved (represent 12.71 % of the total studied Amazon basin area); where,
  - 34.06 million hectares are highly improved,
  - 16.32 million hectares are moderately improved and
  - 28.62 million hectares are slightly improved

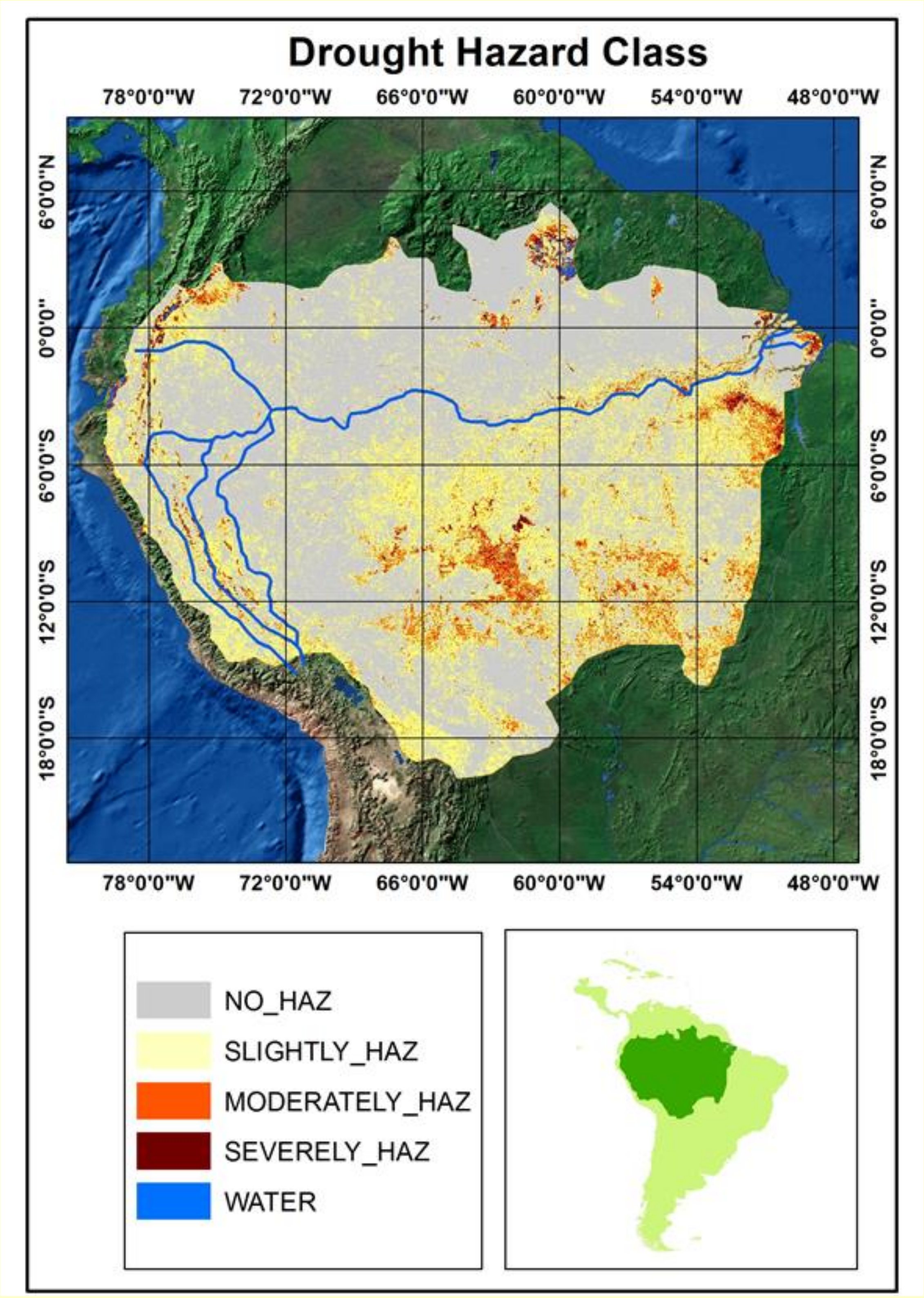


Figure 6.21. Agriculture Drought Hazards

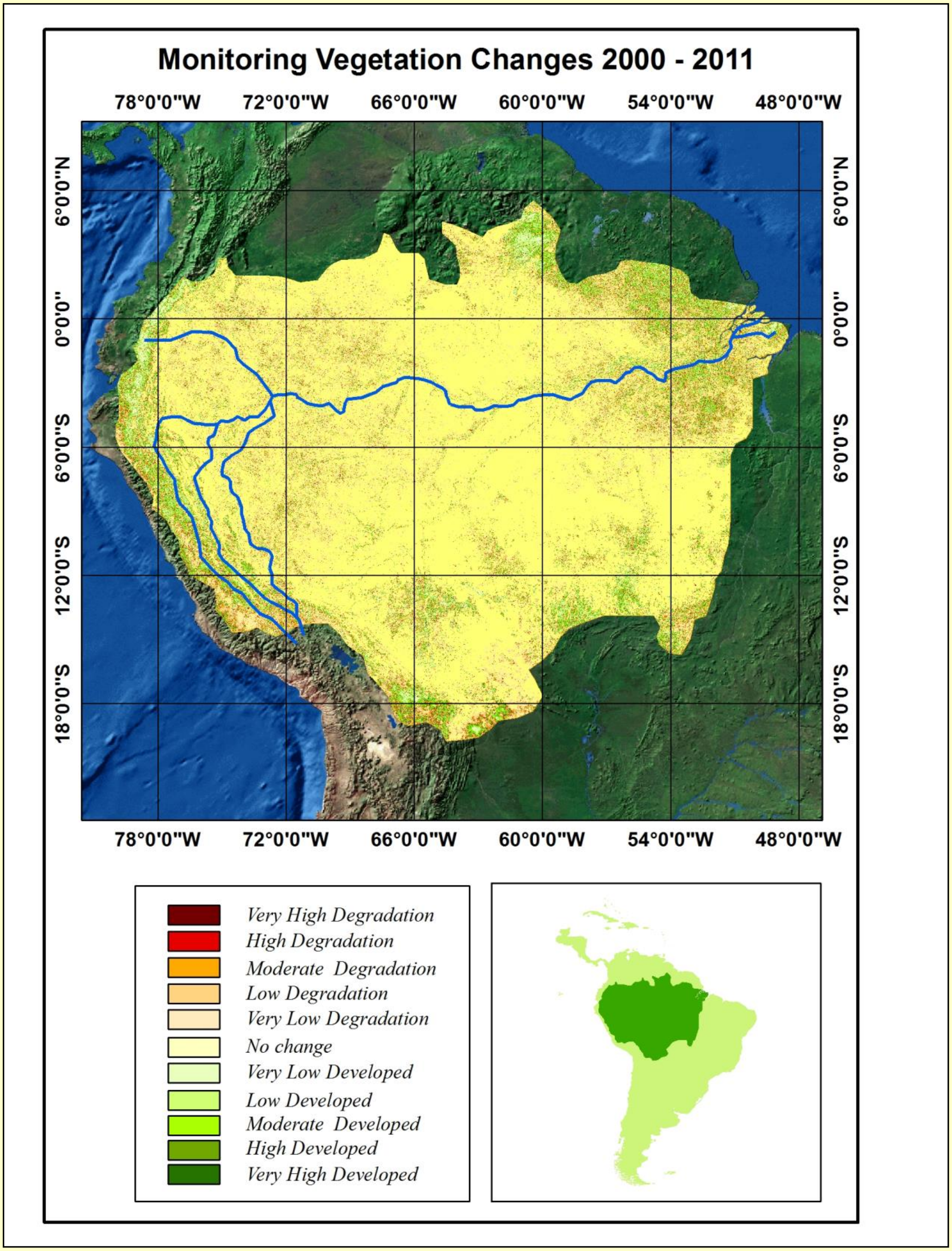


Figure 6.22. Land degradation in Amazon Basin

c) Vegetation Land Cover in Amazon Basin

For better understanding about the impact of vegetation cover degradation more detailed study were undertaken to study Amazon basin land cover, as in table (6.17) and (Figure 6.23)..

Table 6.17. Land Cover main classes in Amazon Basin.

Land Cover Classes	Area in	
	Hectares	%
Closed (>40%) broadleaved deciduous forest (>5m)	4139445.4	0.67
Closed (>40%) broadleaved forest or shrubland permanently flooded - Saline or brackish water	5496.9	0.00
Closed to open (>15%) (broadleaved or needleleaved, evergreen or deciduous) shrubland (<5m)	28902117.1	4.65
Closed to open (>15%) broadleaved evergreen or semi-deciduous forest (>5m))	494029716.8	79.47
Closed to open (>15%) broadleaved forest regularly flooded (semi-permanently or temporarily) - Fresh or brackish water	21077360.7	3.39
Closed to open (>15%) grassland or woody vegetation on regularly flooded or waterlogged soil - Fresh, brackish or saline waterr	10283761.4	1.65
Closed to open (>15%) herbaceous vegetation (grassland, savannas or lichens/mosses)	8523615.9	1.37
Mosaic cropland (50-70%) / vegetation (grassland/shrubland/forest) (20-50%)	24488764.5	3.94
Mosaic forest or shrubland (50-70%) / grassland (20-50%))	2680793.2	0.43
Mosaic grassland (50-70%) / forest or shrubland (20-50%)	773225.5	0.12
Mosaic vegetation (grassland/shrubland/forest) (50-70%) / cropland (20-50%)	8989463.0	1.45
Open (15-40%) broadleaved deciduous forest/woodland (>5m)	31616.7	0.01
Permanent snow and ice	342801.5	0.06
Rainfed croplands	6554407.8	1.05
Sparse (<15%) vegetation	1523768.2	0.25
Water bodies	8392735.5	1.35
Artificial surfaces and associated areas (Urban areas >50%)	81565.6	0.01
Bare areas	864352.2	0.14
TOTAL	621685007.8	100.00

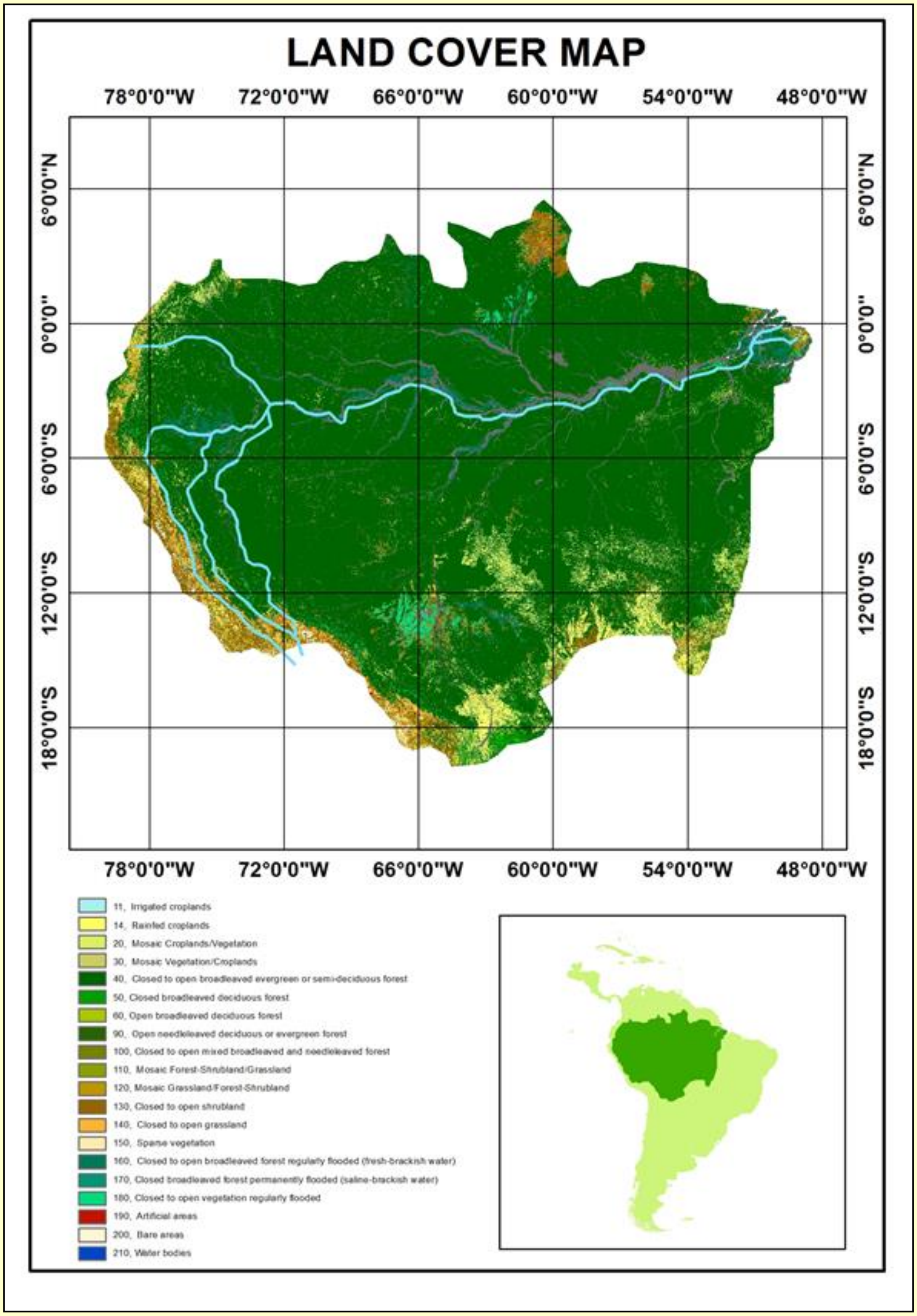


Figure 6.23 Vegetation Cover Degradation in Congo Basin

d) Impact of Agriculture Drought Hazard on Vegetation Cover in Amazon Basin.

Land cover/Land use of the studied basin is likely to be slightly exposed to ADH. The crossing between both ADH map and LC, allowed for better understanding for the type(s) of land use that is more vulnerable to ADH, as shown in (table 6.18). About 61.68% of the vegetation cover is not affected and 30.62% are slightly affected on the Closed to open (>15%) broadleaved evergreen or semi-deciduous forest (>5m), approximately142 million hectares.

e) Impact of Land Degradation on Vegetation Land Cover in Amazon Basin

Land cover/Land use of the studied basin is likely exposed to LD. The crossing between LD map and Land degradation, allowed for better understanding for the type (s) of land use that is more vulnerable to LD, as shown in (table 6.19).

Land degradation impacted 213 million hectares that represent the Closed to open (>15%) broadleaved evergreen or semi-deciduous forest (>5m), impacted 25.37 million hectares that represent the Closed to open (>15%) (broadleaved or needleleaved, evergreen or deciduous) shrubland (<5m), impacted 12 million hectares that represent Mosaic cropland (50-70%) / vegetation (grassland/shrubland/forest) (20-50%), and impacted 10 million hectares that represent Closed to open (>15%) broadleaved forest regularly flooded (semi-permanently or temporarily) - Fresh or brackish water.

Table 6.18. Impact of Agriculture Drought Hazards on Vegetation Land Cover

LCNAME	Sever ADH		Moderate ADH		Slight ADH		Not Affected	
	In Ha	%	In Ha	%	In Ha	%	In Ha	%
Artificial surfaces and associated areas (Urban areas >50%)r	9060.55	0.00	17306.12	0.00	32631.50	0.01	1357.48	0.00
Open (15-40%) broadleaved deciduous forest/woodland (>5m)			1506.85	0.00	17592.29	0.00	9001027.67	1.45
Closed (>40%) broadleaved deciduous forest (>5m)	26621.42	0.00	376059.78	0.06	1556703.70	0.25	2177549.98	0.35
Closed (>40%) broadleaved forest or shrubland permanently flooded - Saline or brackish water					769.04	0.00	3767.01	0.00
Closed to open (>15%) (broadleaved or needleleaved, evergreen or deciduous) shrubland (<5m)	1119351.75	0.18	3259860.33	0.52	13519420.83	2.17	10426002.83	1.68
Closed to open (>15%) broadleaved evergreen or semi-deciduous forest (>5m))	4656671.07	0.75	23864448.99	3.84	142067648.54	22.85	322757644.51	51.92
Closed to open (>15%) broadleaved forest regularly flooded (semi-permanently or temporarily) - Fresh or brackish water	165088.83	0.03	896274.97	0.14	5161407.70	0.83	14835700.76	2.39
Closed to open (>15%) grassland or woody vegetation on regularly flooded or waterlogged soil - Fresh, brackish or saline waterr	284208.81	0.05	1589845.50	0.26	3988625.76	0.64	4369334.86	0.70
Closed to open (>15%) herbaceous vegetation (grassland, savannas or lichens/mosses)	139439.99	0.02	672802.46	0.11	3945900.58	0.63	3721533.32	0.60
Mosaic cropland (50-70%) / vegetation (grassland/shrubland/forest) (20-50%)	990236.52	0.16	4922371.34	0.79	10084813.37	1.62	8411192.18	1.35
Mosaic forest or shrubland (50-70%) / grassland (20-50%))	86591.00	0.01	267307.22	0.04	1219602.00	0.20	1085287.36	0.17
Mosaic grassland (50-70%) / forest or shrubland (20-50%)	6972.57	0.00	52686.73	0.01	484674.67	0.08	215830.44	0.03
Mosaic vegetation (grassland/shrubland/forest) (50-70%) / cropland (20-50%)	280530.46	0.05	1344278.56	0.22	3686748.23	0.59	3631078.05	0.58
Bare areas	10366.82	0.00	79835.37	0.01	505576.47	0.08	264382.92	0.04
Rainfed croplands	112171.21	0.02	1158564.28	0.19	3155250.51	0.51	2104856.26	0.34
Sparse (<15%) vegetation	11030.30	0.00	105909.98	0.02	963575.28	0.15	438168.51	0.07

Table 6.19. Impact of Land Degradation on Vegetation Land Cover in Amazon Basin

Land Cover Classes	Land Improvement	No Change	Land Degradation			
			Slight	Moderate	High	Very High
Closed (>40%) broadleaved deciduous forest (>5m)	0.16	0.21	0.19	0.06	0.02	0.03
Closed (>40%) broadleaved forest or shrubland permanently flooded - Saline or brackish water	0.00	0.00	0.00	0.00	0.00	0.00
Closed to open (>15%) (broadleaved or needleleaved, evergreen or deciduous) shrubland (<5m)	0.76	0.94	1.13	0.43	0.16	1.25
Closed to open (>15%) broadleaved evergreen or semi-deciduous forest (>5m))	8.60	51.70	15.23	2.94	0.93	0.06
Closed to open (>15%) broadleaved forest regularly flooded (semi-permanently or temporarily) - Fresh or brackish water	0.37	2.12	0.69	0.13	0.04	0.04
Closed to open (>15%) grassland or woody vegetation on regularly flooded or waterlogged soil - Fresh, brackish or saline waterr	0.30	0.83	0.34	0.09	0.03	0.07
Closed to open (>15%) herbaceous vegetation (grassland, savannas or lichens/mosses)	0.53	0.22	0.33	0.13	0.05	0.11
Mosaic cropland (50-70%) / vegetation (grassland/shrubland/forest) (20-50%)	0.92	1.89	0.80	0.23	0.08	0.02
Mosaic forest or shrubland (50-70%) / grassland (20-50%))	0.18	0.10	0.09	0.03	0.01	0.01
Mosaic grassland (50-70%) / forest or shrubland (20-50%)	0.01	0.01	0.04	0.02	0.01	0.05
Mosaic vegetation (grassland/shrubland/forest) (50-70%) / cropland (20-50%)	0.42	0.59	0.32	0.09	0.03	0.00
Open (15-40%) broadleaved deciduous forest/woodland (>5m)	0.00	0.00	0.00	0.00	0.00	0.00
Rainfed croplands	0.36	0.35	0.23	0.07	0.03	0.02
Sparse (<15%) vegetation	0.09	0.02	0.07	0.03	0.01	0.02
Total in Hectares	**88133190**	**366673215**	**121075409**	**26549444**	**8634641.3**	**10619109**
Total in %	**14.18**	**58.98**	**19.48**	**4.27**	**1.39**	**1.71**

6.4. Conclusion

The most alarming trends that has been highlighted by FAO and ITTO report in 2011, and could impacts the aspirations for sustainable forest management and for progress towards the four Global objectives on forests and the Non legally binding instrument on all types of forests, adopted by the United Nations General Assembly in December 2007are:

- Deforestation continues at alarming rates in most of the countries in the rainforest basins. Together, the 30 countries reported a net loss of forest area of 3.6 million hectares per year in the last decade, or 0.45 percent annually. As a result, the total carbon stock in forests decreased by an estimated 1.2 Gt annually during the period 2000–2010.
- The area of primary forest is decreasing by about 3.7 million hectares a year. This is partly due to deforestation and partly due to other human activities that leave visible signs of human impact and thus transform the forest into 'other naturally regenerated forest' in the Global Forest Resources Assessment (FRA), 2010 classification system.
- Less than 15 percent of the total forest area is covered by a forest management plan, and only 3.5 percent of the total forest area is considered to be under sustainable forest management. Just over 1 percent has undergone certification.
- The rate of loss of forests is showing signs of steady losses in the studied basins. When comparing the average annual loss of the 1990s (4.5 million ha/year) with that of 2000–2010 (4.3 million ha/year), it fell by 4.4 percent.
- Elevated CO_2 concentrations reduce the negative effects of drought on plant growth which increase plant productivity.
- Out of 350 million hectares studied in Congo basin 245 million hectares are affected by drought hazard that represent 70% of the total studied Congo basin area, and that 237.07 million hectares are affected by slight drought, 2.9 million hectares are affected by moderate drought and 0.87 million hectares are affected by severe drought hazard most of it Gabon and Cameroon. About 255.07 million hectares are affected by different levels of land degradation (represent 72.87 % of the total studied Congo basin area). The most affected land cover type is the Closed to open broadleaved evergreen or semi-deciduous forest that covers 99.36 million hectares that represents 28.37% of the total basin area, Open broadleaved deciduous forest that covers 43.03 million hectares that represents 12.3% of the total basin area, Closed to open broadleaved forest regularly flooded (fresh-brackish water) that covers 27 million hectares that represents 7.71% of the total basin area, and Closed broadleaved deciduous forest that covers 8 million hectares that represents 2.3% of the total basin area.
- Out of the 619 million hectares studied in Amazon basin 241 million hectares are affected by drought hazard that represent 38.79 % of the total studied Amazon basin area, and that 193.47 million hectares are affected by slight drought, 39.3 million hectares are affected by moderate drought and 8.10 million hectares are affected by severe drought hazard About 79.00 million hectares are affected by different levels of land degradation (represent 40 % of the total studied Amazon basin area)Land degradation impacted 213 million hectares that represent the Closed to open (>15%)

broadleaved evergreen or semi-deciduous forest (>5m), impacted 25.37 million hectares that represent the Closed to open (>15%) (broadleaved or needleleaved, evergreen or deciduous) shrubland (<5m), impacted 12 million hectares that represent Mosaic cropland (50-70%) / vegetation (grassland/shrubland/forest) (20-50%), and impacted 10 million hectares that represent Closed to open (>15%) broadleaved forest regularly flooded (semi-permanently or temporarily) - Fresh or brackish water.

REFERENCES

Abou-Hadid, A.F., (2006). Assessment of impacts, adaptation and vulnerability to climate change in North Africa: food production and water resources.Assessments of Impacts and Adaptations to Climate Change, Washington, DC

Abou hadid, A F. ()2009 Impact of Climate Change: Vulnerability and Adaptation Food Production pp(63-74) Arab Forum for Environment and Development (AFED) Published with Technical Publications and Environment & Development magazine,

Abou Kheir. R. and W. Erian, (2009). Land Degradation In the Arab Region, chapter one the Guideline Monitoring and Assessing Land Degradation Processes, prepared by A3AD and GIZ.

Abramovitz. 1996. Imperiled Waters, Impoverished Future: The Decline of Freshwater Ecosystems. World Watch Paper, 128, marzo, Washington, D.C.

ACSAD, (2009). Desertification Bulletin , second issue, published in cooperation with GTZ.

ACSAD, (2010). Livelihood Development Response to Alleviate Rural Poverty and Drought Conditions in the North East of Syria, project document presentation, A3AD, MAAR, AECID and ACF.

Adeel, Z., Safriel, U., Niemeijer, D. and White, R. 2005. Ecosystems and human well-being: Desertification synthesis. Millennium Ecosystem Assessment. World Resources Institute, Washington, DC.

Akhtar-Schuster, M., (1995): Degradations prozesse und Desertification in semi arid en randtropischen Gebiet der Butana/Rep. Sudan. Goettinger Beitraege zur Land- und For stwirstschaft in den Tropen und Subtropen, Vol. 105, Universität Goettingen, 166 pp.

Alcamo, J., Moreno, J.M., Nováky, B., Bindi, M., Corobov, R., Devoy, R.J.N., Giannakopoulos,C., Martin, E., Olesen, J.E., Shvidenko, A., 2007. Europe. Climate change (2007): impacts, adaptation and vulnerability. In: Parry, M.L., Canziani, O.F., Palutikof, J.P., van der Linden, P.J.,Hanson, C.E. (Eds.), Contribution ofWorking Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC). Cambridge University Press, Cambridge, UK, pp. 541–580

Ambrizzi, T., Rocha, R. M. d., Marengo, J. A., Pisnitchenko, I., Alves, L. M. and Fernandez, J. P. R. 2007. 'Cenários regionalizados de clima no Brasil e América do Sul para o Século XXI: Projeções de clima futuro usando três modelos regionais', São Paulo, Brasil: Ministério do Meio Ambiente, Secretaria de Biodiversidade e Florestas, Diretoria de Conservação da Biodiversidade.

Aragão, L.E.O.C., Malhi, Y., Roman-Cuesta, R.M., Saatchi, S., Anderson, L.O., and Shimabukuro, Y.E. 2007. Spatial patterns and fire response of recent Amazonian droughts. Geophysical Research Letters, 34.

Arino O. , P. Bicheron, F. Achard, J. Latham, R. Witt, and J.-Louis Weber (2008). GLOBCOVER The most detailed portrait of Earth European Space Agency | Bulletin 136 | Cullen, H. M., A. Kaplan, P. A. Arkin, and P. B. de Menocal. (2002). ―Impact of the NAO on Middle Eastern Climate and Streamflow.‖ Climate Change 55: 315–38.Barnett, J. and Adger, W.N. (2007). Climate change, human security and violent conflict. *Political Geography* 26 (6): 639–655.

Beg, N., J.C. Morlot, O. Davidson, Y. Afrane-Okesse, L. Tyani, F. Denton, Y. Sokona, J.P. Thomas, E.L. La Rovere, J.K. Parikh, K. Parikh, and A.A. Rahman,(2002): Linkages between climate change and sustainable development. Climate Policy, 2, 129-144Beniston, M., et al., (2007): Future extreme events in European climate: an exploration of regional climate model projections. Climatic Change, 81, 71-95

Beloqui, C., and A. Kaplan. 1998. Los suelos del área rural de Montevideo. Un Desarrollo de los Recursos Hídricos y Promoción del Riego en el Area Rural de Montevideo. Serie Investigaciones Nº 126. CIEDUR-IMM. Montevideo (Uruguay). 25-45 pp.

Benites, J., D., Saintraint, and K. Morimoto. 2003. Degradación de suelos y producción agrícola en Argentina, Bolivia, Brasil, Chile, y Paraguay.

Boahene K., 1998. The Challenge of Deforestation in Tropical Africa: Reflections on its Principal Causes, Consequences and Solutions. Land Degradation and Development, 9, 247-258.

Bresch, and S.I. Seneviratne, (2009): Simulating past droughts and associated building damages in France. Hydrology and Earth System Sciences, 13, 1739-1747

Brown, O., Hammill, A. and McLeman, R. 2007. Climate change as the 'new' security threat: implications for Africa. International Affairs 83(6): 1141-1154.

Burke, E.J., and S.J. Brown, (2008): Evaluating uncertainties in the projection of future drought. Journal of Hydrometeorology, 9(2),292-299

Byers, 1990;White and Maldonado, 1991. Erosion processes in tropical watersheds: A preliminary assessment of measurement methods, action strategies, and information availability in the Dominican Republic, Ecuador, and Honduras. Development Strategies for Fragile Lands. Agency for International Development, Washington, D.C.

Casas, R. 2001. La Conservación de los Suelos y la Sustentabilidad de los Sistemas Agricolas en la Republica de Argentina

Castello, L., McGrath, D.G., Hess, L.L., Coe, M.T., Lefebvre, P.A., Petry, P., Macedo, M.N., Reno, V., Arantes, C.C. 2012. The vulnerability of Amazon freshwater ecosystems.Conservation Letters DOI: 10.1111/conl.12008

Centre for International Forestry Research (CIFOR) (2004) Beef exports fuel loss of Amazonian Forest. [archive] CIFOR News Online , Number 36.

Challinor, A.J., T.R. Wheeler, P.Q. Craufurd, C.A.T.Ferro and D.B. Stephenson, (2007). Adaptation of crops to climate change through genotypic responses to mean and extreme temperatures'. *Agriculture,Ecosystems and Environment,* 119:190-204.

Cochrane M.A., and W.F. Laurance. 2008. "Synergisms among fi re, land use, and climate change in the Amazon." Ambio 37: 522-527.

Corti, T., V. Muccione, P. Köllner-Heck, D.Bresch, and S.I. Seneviratne, (2009): Simulating past droughts and associated building damages in France. Hydrology and Earth System Sciences, 13, 1739-1747

Cook, B.I., G.B. Bonan, and S. Levis, 2006: Soil moisture feedbacks to precipitation in southern Africa. Journal of Climate, 19(17), 4198-4206

Dai, A., (2011): Drought under global warming: a review. Wiley Interdisciplinary Reviews: Climate Change, (in press, doi: 10.1002/wcc.81)

Dall'Olmo, G., Karnieli, A., (2002). Monitoring phenological cycles of desert ecosystems using NDVI and LST data derived fromNOAA-AVHRRimagery. Int. J.RemoteSens.23, 4055–4071.

Davis, M. 2001. Late Victorian Holocausts: El Niño Famine and Making of the Third World. New York,NY: Verso

de Châtel F. (2014). "The Role of Drought and Climate Change in the Syrian Uprising: Untangling the Triggers of the Revolution" Middle Eastern Studies, Publication details, including instructions for authors and subscription information: http://www.tandfonline.com/loi/fmes20

de la Fuente, A. and Dercon, S. (2008). *Disasters, growth and poverty in Africa: Revisiting the microeconomic evidence*. Background paper prepared for the 2009 Global Assessment Report on Disaster Risk Reduction. Geneva, Switzerland: UNISDR.

deMenocal, P.B., (2001). Cultural responses to climate change during the Late Holocene. Science 292, 667–673.

De Noni, G. and Trujillo, G. 1986. La erosión actual y potencial en Ecuador: Localización, manifestaciones y causas. En CEDIG: La erosión en el Ecuador. Documentos de Investigación N° 6. Quito-Ecuador. 1-14 pp.

Deo, R.C., J.I. Syktus, C.A. McAlpine, P.J. Lawrence, H.A. McGowan, and S.R. Phinn, (2009): Impact of historical land cover change on daily indices of climate extremes including droughts in eastern Australia. Geophysical Research Letters, 36(L08705)

Devers D., Vande weghe J.P. (Eds), 2007. The Forests of the Congo Basin - State of the Forest 2006. CBFP, ISBN 978-90-788-2701-6, 256 p.

de Wasseige C., Devers D., de Marcken P., Eba'a Atyi R., Nasi R., and Mayaux P. (Eds), 2010. The Forests of the Congo Basin – State of the Forest 2008. Luxembourg: Publications Office of the European Union, ISBN 978-92-79-13210-0,doi: 10.2788/32259, 411 p.

Di Gregorio A. 2005 Land Cover Classification System, Classification concepts and user manual. FAO Environment and Natural Resources Service Series, No. 8 - FAO, Rome

Diouf, A., Lambin, E.F.,(2001). Monitoring land-cover changes in semi-arid regions: remote sensing data and field observations in the Ferlo, Senegal. J. Arid Environ. 48, 129–148Dirmeyer, P.A., R.D. Koster, and Z. Guo, (2006): Do Global Models Properly Represent the Feedback between Land and Atmosphere? Journal of Hydrometeorology, 7, 1177-1198.

Donat MG., Alexander LV, Yang H, Durre I, Vose R, Dunn RJH, Willett KM, Aguilar E, Brunet M,Caesar J, Hewitson B, Jack C, Klein Tank AMG, Kruger AC, Marengo JA, Peterson TC, Renom M,Oria Rojas C, Rusticucci M, Salinger J, Sanhouri Elrayah A, Sekele SS, Srivastava AK, Trewin B,Villarroel C, Vincent LA, Zhai P, Zhang X, and Kitching S. 2013. Updated analyses of temperature and precipitation extreme indices since the beginning of the twentieth century: The HadEX2 dataset. Journal of Geophysical Research: Atmospheres, 118:5, 2098-2118.

Duveiller G., Defourny P., Desclée B., and Mayaux P., 2008. Deforestation in Central Africa: Estimates at regional,national and landscape levels by advanced processing of systematically distributed Landsat extracts. Remote Sensing of Environment, 112: 1969-1981.

Eagleson, P., (2002). Ecohydrology. In: Darwinian Expression of Vegetation Form and Function. Cambridge University Press, Cambridge.

Faye, A., Fall, A., Mortimore, M., Tiffen, M. and Nelson, J. 2001. Région de Diourbel: Synthesis. Drylands Research Working Paper 23e. Drylands Research, Crewkerne, UK.

EEA, 2004. Impact of climate change, EEA Report No 2/2004. Available at http://reports.eea.eu.int/climate_report_2_2004/en

El-Quosy, D. (2009). Impact of Climate Change: Vulnerability and Adaptation, Fresh Water. p (75-86), Arab Forum for Environment and Development (AFED) Published with Technical Publications and Environment & Development magazine,

ENDF. 2001. Proyecto FAO GCP/PER/035/NET "Apoyo a la Estrategia Nacional para el Desarrollo Forestal."

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 A3AD.

Erian, W., Katlan, B. and Babah, O. (2010). Drought vulnerability in the Arab region: Special case study: Syria. Background paper prepared for the 2011Global Assessment Report on Disaster Risk Reduction. Geneva, Switzerland: UNISDRFAO (2011). Food security in Syria under Climate Change; WB, MAAR and A3AD Workshop on: Reducing Vulnerability to climate change in Agricultural Systems in Syria, March 23-24, El-Hassakeh governorate, Syria.

Erian, W., Katlan, B. and Babah, O. (2010). *Drought vulnerability in the Arab region: Special case study: Syria*. Background paper prepared for the 2011Global Assessment Report on Disaster Risk Reduction. Geneva, Switzerland: UNISDR.

Erian (2011). Living with Drought:- Challenges and Solutions, Conference Disaster Risk: Integrating Science & Practice, organized by the Integrated Research on Disaster Risk (IRDR) in Beijing, China. 31 October to 2 November

Erian, W., Katlan, B. and Babah, O., (2011). Drought Vulnerability in the Arab Region, Case Study- Drought in Syria Ten Years of Scarce Water (2000 – 2010), A3AD and UNISDR publication Giorgi, F., 2006: Climate change hot-spots. Geophysical Research Letters, 33(L08707)

Erian W., B Katlan, B. oul.dbedy, H. Awad, E. Zaghtity and S Ibrahim, (2012). "Agriculture Drought in Africa Mediterranean and Middle East, Background paper prepared for the 2013 Global Assessment Report on Disaster Risk Reduction. Geneva, Switzerland: UNISDR.

Erian W, B Katlan, A. Khalil, Y Hanfi N Assad and. S Ibrahim 2014. "Studying the long term metrological drought in Africa, Mediterranean and Middle East Regions, using SPEI", Background paper prepared for the 2015 Global Assessment Report on Disaster Risk Reduction. Geneva, Switzerland: UNISDR (draft).

Ernst C., Verhegghen A., Bodart C., Mayaux P., de Wasseige C.,Bararwandika A., Begoto G., Esono Mba F., Ibara M., Kondjo Shoko A., Koy Kondjo H., Makak J.S., Menomo Biang J.D., Musampa C., Ncogo Motogo R., Neba Shu G., Nkoumakali B., Ouissika C.B. and Defourny P., 2010. Congo Basin forest cover change estimate for 1990, 2000 and 2005 by Ling an automated object-based processing chain. The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, XXXVIII-4/C7.

Evans, J.P., Geerken, R., (2004). Discrimination between climate and human-induced dryland degradation. J. Arid Environ. 57, 535–554.Findell, K.L., and E.A.B. Eltahir, (2003a): Atmospheric controls on soil moisture-boundary layer interactions. Part I: Framework development. Journal of Hydrometeorology, 4(3), 552-569

Evans, (2008); http://web.maths.unsw.edu.au/~jasone/eplots/pi3/evans_4_1_lg.png

Falvey M. and Garreaud RD. 2009. Regional cooling in a warming world: Recent temperature trends in the southeast Pacific and along the west coast of subtropical South America (1979–2006). Journal of Geophysical Research, 114, D04102.

FAO 2011. "The State of Forests in the Amazon Basin, Congo Basin and Southeast". A report prepared by the Food and Agriculture Organization of the United Nations (FAO) or the International Tropical Timber Organization (ITTO) concerning for the Summit of the Three Rainforest Basins, Brazzaville, Republic of Congo.

FAO (2014). "Executive Brief Syria Crisis", http://www.fao.org/fileadmin/user_upload/emergencies/do3/Syria-Crisis-Executive-Brief-03-04-14.pdf

Findell, K.L., and E.A.B. Eltahir, (2003b): Atmospheric controls on soil moisture-boundary layer interactions. Part II: Feedbacks within the continental United States. Journal of Hydrometeorology, 4(3), 570-583

Foley, J. A., G. P. Asner, M. H. Costa, M. T. Coe, R. DeFries, H. K. Gibbs, E. A. Howard, S. Olson, J. Patz, N. Ramankutty, and P. Snyder. 2007. Amazonian revealed: forest degradation and loss of ecosystem goods and services in the Amazon Basin. Frontiers in Ecology and Environment 5(1):25–32.

Freiwan, M., Kadioglu, M., (2008). Climate variability in Jordan. Int. J. Climatol. 28,69–89.

Funk, C., M.D. Dettinger, J.C. Michaelsen, J.P. Verdin, M.E. Brown, M. Barlow, and A. Hoell, (2008): Warming of the Indian Ocean threatens eastern and southern African food security but could be mitigated by agricultural development. Proceedings of the National Academy of Sciences of the United States of America, 105(32), 11081-11086

European Commission 2013 http://eeas.europa.eu/delegations/ecuador/documents/echo_ayuda_humanitaria/20131009_monthlyreport_09_2013_es.pdf

IPCC, (2001), IPCC Third Assessment Report. Synthesis Report, Cambridge University Press, Cambridge, UK.

IPCC. 2007. Summary for Policymakers. 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, Qin D, Mamming M, Chen Z, Marquis M, Averyt K.B, Tignor M, Miller H.L (eds.)].Cambridge University Press, Cambridge, United Kingdom and New York, NY,USA.

IPCC, (2012), Managing the Risks of Extreme Events and Disasters to Advance Climate Climate Change Adaptation. A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change [Field, C.B., V. Barros, T.F. Stocker, D. Qin, D.J. Dokken, K.L. Ebi, M.D. Mastrandrea, K.J. Mach, G.-K. Plattner, S.K. Allen, M. Tignor, and P.M. Midgley (eds.)].

Cambridge University Press, Cambridge, UK, and New York, NY, USA, 582 pp.ESCWA (2005). “Regional Cooperation Between Countries in the Management of Shared Water Resources: Case Studies of Some Countries in the ESCWA Region.” E/ESCWA/SDPD/2005/15.

IPCC. 2014. Summary for Policymakers. In: Climate Change 2014: Impacts, Vulnerability and Adaptation. Part A: Global and Sectiral Aspects. Contribution of Working Group 2 to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Field C, Barros V.R, Dokken D.J, Mach K.J, Mastrandrea M.D, Bilir T.E, Chatterjhee M, Ebi K.L, Estrada Y.O, Genova R.C, Girma B, Kissel E.S, Levy A.N, MacCracken S, Mastrandrea P.R, and White L.L (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA. pp. 1-32.

Gaiser, T., Ferreira, L. G. R. and Stahr, K. 2003. 'General View of the WAVES Program', in T. e. a. Gaiser (ed.), Global Change and Regional Impacts: Water Availability and Vulnerability of Ecosystems and Society in the Semiarid Northeast of Brazil, 1-18. Berlin: Springer.

Gerten, D., W. Lucht, S. Schaphoff , W. Cramer, T. Hickler, and W. Wagner. 2005 “Hydrologic resilience of the terrestrial biosphere.” Geophysical Research LeĴ ers 32: L21408.

Giannakopoulos, C., P. Le Sager, M. Bindi, M. Moriondo, E. Kostopoulou, and C.M. Goodess, (2009): Climatic changes and associated impacts in the Mediterranean resulting from a 2°C global warming. Global and Planetary Change, 68(3), 209-224

Giorgi, F.,(2006): Climate change hot-spots. Geophysical Research Letters, 33(L08707).

Gitay, H., Brown, S., Easterling, W., Jallow, B., (2001). Ecosystems and their goods and services. In: McCarthy, J.J., Canziani, O.F., Leary, N.A., Dokken, D.J., White, K.S. (Eds.), Climate Change 2001: Impacts, Adaptation and Vulnerability, pp. 735–800.

Göbel, W and De Pauw, E, (2010). Climate and Drought Atlas for parts of the Near East A baseline dataset for lanning adaptation strategies to climate change”. .International Center for Agricultural Research in the Dry Areas, ICARDA

Gutiérrez D, Bertrand A, Wosnitza-mendo C, Dewitte B, Purca S, Peña C, Chaigneau A, Tam J, Graco M, Grados C, Fréon P, and Guevara-carrasco R. 2011a. Sensibilidad del sistema de afloramiento costero del Perú al cambio climático e implicancias ecológicas [Climate change sensitivity of the Peruvian upwelling system and ecological implications]. Revista Peruana Geoatmosférica. 3: 1-24.

Gutiérrez D, Bouloubassi I, Sifeddine A, Purca S, Goubanova K, Graco M, Field D, Mejanelle L,Velazco F, Lorre A, Salvatteci R, Quispe D, Vargas G, Dewitte B, and Ortlieb L. 2011b. Coastal cooling and increased productivity in the main upwelling zone off Peru since the mid-twentieth century. Geophysical Research Letters, 38, L07603.

Hahn, L., T. Mader, D. Spiers, J. Gaughan, J.Nienaber, R. Eigenberg, T. Brown, Brandl, Q. Hu and Co-authors, (2001). Heat wave impacts on feedlot cattle: considerations for improved environmental management.Proc. 6th International Livestock Environment Symposium, R.R. Stowell, R. Bucklin and R.W. Bottcher, Eds.,American Society of Agricultural Engineering, St. Joseph, Michigan, 129-130.

Hamouda, G, (2011). Drought Early warning system in Syria; WB, MAAR and A3AD Workshop on: Reducing Vulnerability to climate change in Agricultural Systems in Syria, March 23-24, El-Hassakeh governorate, Syria.

Hansen M.C., Roy D.P., Lindquist E., Adusei B., Justice C.O., Altstatt A., 2008. A method for integrating MODIS and Landsat data for systematic monitoring of forest cover and change in the Congo Basin. Remote Sensing of environment, 112(5), 2495- 2513.

Heim Jr, R.R., (2002): A Review of Twentieth-Century Drought Indices Used in the United States. Bulletin of the American Meteorological Society, 83, 1149-1165

Hohenegger, C., P. Brockhaus, C.S. Bretherton, and C. Schar, (2009): The Soil Moisture-precipitation Feedback in Simulations with Explicit and Parameterized Convection. Journal of Climate, 22(19), 5003-5020

Hole, F., (1994). Environmental instabilities and urban origins. In: Chiefdoms and Early States in the Near East: the Organizational Dynami3 of Complexity. Prehistory Press, pp. 121–151.

Homer-Dixon T F., (1999). "Environment, Scarcities and Violence", (Princeton, Nj: Princeton University Press, 13.

Hugo G 2008.Trends in Land Degradation in South America, Direccion, Meteorologica de Chile, Santiago, Chile

Kattana, H. , (2011). Agriculture Production Indicators In North Eastern Part of Syria. WB, MAAR and A3AD Workshop on: Reducing Vulnerability to climate change in Agricultural Systems in Syria, March 23-24, El-Hassakeh governorate, Syria.

Kauff man, J.B., and C. Uhl. 1990. "Interactions of anthropogenic activities, fi re, and rain forests in the Amazon basin." In Fire in the Tropical Biota: Ecosystem Processes and Global Challenges. Goldammer JG. Berlin, Springer Verlag: 117-134.

Kitoh A., Yatagai, A., and Alpert, P. 2008. First super-high-resolution model projection that the ancient 'Fertile Crescent' will disappear in this century.Hydrological Research Letters, 2, 1–4. The Japan Society of Hydrology and Water Resources.

Kohler, A. 1992. Erosión, Conservación y su contexto socio-económico, el caso Paraguayo-MAGGTZ. Proyecto de Planificación de Manejo de los Recursos Naturales. Hacia una Política de Uso de la Tierra el Paraguay. Asunción, ICONO SRL, Serie 3. 75-92 pp.

Kooistra, L. and E. Meyles. 1997. A novel method to describe spatial soil variability: A case study for a potato-pasture area in the northern Andes of Ecuador. Laboratory of soil Science and Geology, Wageningen Agricultural University, The Netherlands. 65 p.

Kosaka Y, and Xie S. 2013. Recent global-warming hiatus tied to equatorial Pacific surface cooling.Nature, (published online 28 August 2013).

Koster, R.D., et al., 2004b: Regions of strong coupling between soil moisture and precipitation. Science, 305, 1138-1140

Kogan, F.N. (2000). Contribution of remote sensing to drought early warning . In early warning systems for drought preperdiness and drought management , ed D,A. Wilhite and D.A. Wood, 75-87. Geneva: WMO.

Krol, M. S. and Bronstert, A. 2007. 'Regional integrated modeling of climate change impacts on natural resources and resource usage in semi-arid Northeast Brazil', Environmental Modelling & Software, 22: 259-68.

Lehner, B.; Henrichs, T.; Döll, P.; Alcamo, J., 2001. EuroWasser Model- based assessment of European water resources and hydrology in the face of global change. World Water Series 5, Center for Environmental Systems Research, University of Kassel

Mader, T.L., (2003). 'Environmental stress in confined beef cattle'. Journal of Animal Science,81(electronic supplement. 2):110-119.

McCarthy, J.J., O.F. Canziani, N.A. Leary, D.J. Dokken, and K.S. White (eds.),(2001): Climate Change 2001: Impacts, Adaptation, and Vulnerability. Working Group II of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge, UK.

Magalhães, A. R., Filho, H. C., Garagorry, F. L., Gasques, J. G., Molion, L. C. B., Neto, M. D. S. A., Nobre, C. A., Porto, E. R. and Rebouças, O. E. 1988. 'Effects of Climatic Variations on Agriculture in Northeast Brazil', in M. L. Parry, T. R. Carter and N. T. Konijn (eds.), The Impact of Climatic Variations on Agriculture, Dordrecht, Netherlands: Kluwer Academic Publishers.

Magrin G, Marengo J, Boulanger JP, Buckeridge M.S, Castellanos E, Poveda G, Scarano FR, Vicuña S. 2014. Central and South America. In: Climate Change 2014: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. In Press, Cambridge University Press, Cambridge, UK.

Marengo, J. A., J. Tomasella, L. M. Alves, W. R. Soares, and D. A. Rodriguez (2011), The drought of 2010 in the context of historical droughts in the Amazon region, Geophys. Res. Lett., 38, L12703, doi:10.1029/2011GL047436.

Mariotti, A., N. Zeng, J.H. Yoon, V. Artale, A. Navarra, P. Alpert, and L.Z.X. Li, (2008): Mediterranean water cycle changes: transition to drier 21st century conditions in observations and CMIP3 simulations. Environmental Research Letters, 3(4), Art. 044001 (8 pp.)

Mayaux P., Achard F. and Malingreau J.P., 1998. Global tropical forest area measurements derived from coarse resolution satellite imagery: a comparison with other approaches Environmental Conservation, 25, 37-52.

Mayaux P., Bartholomé E., Massart M., Vancutsem C., Cabral A., Nonguierma A., Diallo O., Pretorius C., Thompson M., Cherlet M., Pekel J.F., Defourny P., Vasconcelos M., Di Gregorio A., Fritz S., De Grandi G., Elvidge C., Vogt P. and Belward A., 2003. A Land Cover Map of Africa –Carte de l'occupation du Sol de l'Afrique, EUR 20665, EN (European Commission, Luxembourg), 20 pp.

Merten G. 1996. Erosión actual en el estado de Paraná, Brazil: sus causas y consecuencias económicas

Mockrin M., 2009. Duiker demography and dispersal under hunting in Northern Congo. African Journal of ecology. 48(1): 239-247.

Mora, S., (2011). Water resources in East Syria; WB, MAAR and A3AD Workshop on: Reducing Vulnerability to climate change in Agricultural Systems in Syria, March 23-24, El-Hassakeh governorate, Syria.

Morid, S., Smakhtin, V., Moghaddasi, M., (2006). Comparison of seven meteorological indices for drought monitoring in Iran. Int. J. Climatol. 26, 971–985.

Mortimore, M. with contributions from S. Anderson, L. Cotula, J. Davies, K. Faccer, C. Hesse, J. Morton, W. Nyangena, J. Skinner, and C. Wolfangel (2009). Dryland Opportunities: A new paradigm for people, ecosystems and development, IUCN, Gland, Switzerland; IIED, London, UK and UNDP/DDC, Nairobi, Kenya. x + 86p.

Morgan, P.B., Ainsworth, E.A., Long, S.P., (2003). How does elevated ozone impact soybean? A meta-analysis of photosynthesis, growth and yield. Plant Cell and Environment 26, 1317–1328.

Narayan N, Paul A, Mulitza S, and Schulz M. 2010. Trends in coastal upwelling intensity during the late 20th century. Ocean Science, 6:3, 815-823.

Nashawatii, H. (2011). Climate Change: impacts and adaptation in Syria, , during WB, MAAR and A3AD workshop: Reducing Vulnerability to Climate Change in Agricultural Systems: Building Response Strategies, 23-24., Hassakeh Governorate, Syria.

Nicholson S. E., C. J. Tucker,+ and M. B. Ba, (1998). Desertification, Drought, and Surface Vegetation: An Example from the West African Sahel, Bulletin of the American Meteorological Society

Olmos, E. and H. Montenegro. 1987. Inventario de los problemas de la erosión y degradación de los suelos de Colombia. IN: Congreso Colombiano de la ciencia del suelo, 4 y Coloquio la degradación de los suelos en Colombia,9. Neiva (Colombia), 18-21 de agosto de 1987. Resúmenes. Neiva, Sociedad Colombiana de la Ciencia del Suelo. 23 p.

Patt, A., R. Klein, and A. Vega-Leinert, (2005): Taking the uncertainty in climate-change vulnerability seriously. Geoscience, 337, 411-424.

Patt, A.G., D. Schröter, R.L.T. Klein, and A.C. Vega-Leinert, (2009): Assessing Vulnerability to Global Environmental Change. Earthscan Publications, London,UKPlanton, S., M. Deque, F. Chauvin, and L. Terray, (2008): Expected impacts of climate change on extreme climate events. Comptes Rendus Geoscience, 340(9-10), 564-574

Pla, I. 1988. Riego y desarrollo de suelos afectados por sales en condiciones tropicales. Soil Technology. 1: 13-35 pp.

Rathore, M. (2005). State level analysis of drought policies and impacts in Rajasthan, India. Colombo, Sri Lanka: International Water Management Institute.

Reuveny, R. (2007). Climate change-induced migration and violent conflict. *Political Geography* 26 (6): 656–673.

Safriel, U., Adeel, Z., Niemeijer, D., Puigdefabregas, J.,White, R., Lal, R., Winslow, M., Ziedler, J., Prince, S.,Archer, E., and King, C. 2005. Chapter 22: Dryland systems. In: Hassan, R., Scholes, R. and Ash, N. (eds.) Millennium Ecosystem Assessment. Vol. 1. Ecosystems and human well-being: Current state and trends. World Resources Institute, Washington, DC. pp. 623-662.

Schulz N, Boisier J.P, and Aceituno P. 2012. Climate change along the arid coast of northern Chile. International Journal of Climatology, 32:12, 1803-1814.

Seneviratne, S.I., T. Corti, E.L. Davin, M. Hirschi, E. Jaeger, I. Lehner, B. Orlowsky, and A.J. Teuling, 2010: Investigating soil moisture-climate interactions in a changing climate: A review. Earth Science Reviews, 99(3-4), 125-161

Shongwe, M.E., G.J. van Oldenborgh, B.J.J.M. van den Hurk, B. de Boer, C.A.S. Coelho, 1 and M.K. van Aalst, (2009):Projected Changes in Mean and Extreme precipitation in Africa under Global Warming. Part I: Southern Africa. Journal of Climate, 22(13), 3819-3837.

Rammig, A., W. Cramer, W. Lucht, K. Thonicke, and U. Heyder. 2009. "Brazil: Risk analysis for Amazon dieback, 2009." Report produced by the Potsdam Institute for Climate Impact Research (PIK) for the World Bank as a background for this report.

Rijsberman joined the CGIAR Consortium as CEO in May (2012). Previously, he was director of water, sanitation, and hygiene strategy at the Bill & Melinda Gates Foundation. From 2000 to 2007 Rijsberman served as director general of the International Water Management Institute (IWMI), one of the 15 CGIAR Consortium research centers.

Rodríguez-Iturbe, I., Porporato, A., (2004). Ecohydrology of water-controlled ecosystems.Cambridge.

Rosenzweig, C. and Hillel, D. 1998. Climate Change and the Global Harvest: Potential Impacts of the Greenhouse Effect on Agriculture. Oxford, United Kingdom: Oxford University Press.

Rosenzweig, C., Parry, M. L., Fischer, G. and Frohberg, K. 1993. 'Climate Change and World Food Supply', Research Report No. 3, 28. Oxford, United Kingdom: Environmental Change Unit, Oxford University.

Shean, M., 2008a. Iran: 2008/09 wheat production declines due to drought. United States Department of Agriculture, Foreign Agricultural Service. May 9. Accessed 30.05.08.

Shean, M., 2008b. Iraq: drought reduces 2008/09 winter grain production. United States Department of Agriculture, Foreign Agricultural Service. May 9. Accessed 30.05.08.

Shean, M., 2008c. Syria: wheat production in 2008–09 declines owing to season-long drought. United States Department of Agriculture, Foreign Agricultural Service.May 9. Accessed 30.05.08.

Skaff, M. and Masbate, Sh., (2010). Precipitation Change, and Its Potential Effects on Vegetation and Crop Productivity in Syrian Al Jazerah Region. The Arab Journal for Arid Environments 3 (2):71 - 78.

Smith, R.B., J. Foster, N. Kouchoukos, P.A. Gluhosky, R. Young and E. De Pauw.(2000) : Spatial analysis of climate, landscape, and hydrology in the Middle East: modeling and remote sensing. Center for Earth Observation Report No.2., Yale University, New haven, USA

Soares-Filho B S, D C Nepstad, L M. Curran, G C Cerqueira1, R A Garcia, C A Ramos, E Voll, A McDonald, P Lefebvre and & P Schlesinger2005 Modelling conservation in the Amazon basin, Nature 440, 520-523

Soltani, S., Modarres, R., Eslamian, S.S., (2007). The use of time series modeling for the determination of rainfall climates of Iran. Int. J. Climatol. 27, 819–829.

Souza C M., Jr , J V. Siqueira 1, M H. Sales, A V. Fonseca, J G. Ribeiro, I Numata, M A. Cochrane, Cr P. Barber, Dar A. Roberts and J Barlow 2013. "Ten-Year Landsat Classification of Deforestation and Forest Degradation in the Brazilian Amazon", Remote Sens, 5, 5493-5513

Sternberg T , (2012) "Chinese drought, bread and the Arab Spring," Applied Geography 34: 519–524.

Thenkabail, P. S.; Gamage, M. S. D. N.; Smakhtin, V. U. 2004. The use of remote sensing data for drought assessment and monitoring in Southwest Asia. Research Report 85. Colombo, Sri Lanka: International Water Management Institute.

Trigoa R M.,b,, Célia M. Gouveiaa,c, David Barriopedroa 2010, The intense 2007–2009 drought in the Fertile Crescent: Impacts and associated atmospheric circulation Agricultural and Forest Meteorology 150 1245–1257

Udelhoven, T., (2006). TimeStats: a software tool for analyzing spatial-temporal raster data archives: In: 1st conference on Remote Sensing and Geo-information. In: A. Röder and J. Hill (Editors), Proceedings of the 1st International Conference on "Remote Sensing and Geo-information Processing in the Assessment and Monitoring of Land Degradation and Desertification. In support of the UN Convention to Combat Desertification, Trier, Germany, pp. 247-255UNISDR, 2009. Global Assessment Report on Disaster Risk Reduction. Geneva, Switzerland: United Nations International Strategy for Disaster Reduction.

UNHCR (2014) "Syria tops world list for forcibly displaced after three years of conflict" http://www.unhcr.org/5321cda59.html

UNISDR, (2011). Global Assessment Report on Disaster Risk Reduction. Geneva, Switzerland: United Nations International Strategy for Disaster Reduction.

UNISDR (2013) From Shared Risk to Shared Value –The Business Case for Disaster Risk Reduction. Global Assessment Report on Disaster Risk Reduction. Geneva, Switzerland: United Nations Office for Disaster Risk Reduction (UNISDR).

Verhegghen A., Defourny P., 2010. A new 300 m vegetation map for Central Africa based on multi-sensor times series. in: Sobrino J.A. (Ed.), Third Recent Advance in Quantitative Remote Sensing. Publicaciones de la Universitat de Valencia,Valencia, Spain.

Vicente-Serrano, S.M., Heredia-Laclaustra, A., (2004). NAO influence on NDVI trends in the Iberian Peninsula (1982–2000). Int. J. Remote Sens. 25, 2871–2879.

Vicente-Serrano, S.M., (2007). Evaluating the impact of drought using remote sensing in a Mediterranean, semi-arid region. Nat. Hazards 40, 173–208, doi:10.1007/s11069-006-0009-7.

Villa, M. A. 2000. Vida e Morte no Sertão. São Paulo: Editora Atica.

Wang, G.L., (2005): Agricultural drought in a future climate: results from 15 global climate models participating in the IPCC 4th assessment. Climate Dynami3, 25, 739-753.

Weiss, H., Bradley, R.S., (2001). What drives societal collapse? Science 291, 609–610.

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

Wittmann F, J Schöngart, J Carlos Montero, T Motzer, W J. Junk, M T. F. Piedade, H L. Queiroz and M Worbes, 2006. "Tree species composition and diversity gradients in white-water forests across the Amazon Basin", Journal of Biogeography, Volume 33, Issue 8, pages 1334–1347,

White, S. and F. Maldonado. 1991. The use and conservation of natural resources in the Andes of southern Ecuador. In: Mountain Research and Development. 11 (1): 37-55 pp.

World Bank,(1998). New Opportunities for Development: The Desertification Convention. The World Bank, Washington D.C,48p.World Bank (2011). "Middle-East and Northern Africa Water outlook."

World Bank, 2010. Assessment of the Risk of Amazon Dieback, Environmentally and Socially Sustainable Development Department Latin America and Caribbean Region, Main Report, p 50 .

World Bank (2012)." Adaptation to a Changing Climate in the Arab Countries MNA", Flagship Report, Sustainable Development Department Middle East and North Africa Region, Report N° 64635 – MNA

Xu L, Samanta A, Costa M H, Ganguly S, Nemani R R and Myneni R B 2011 Widespread decline in greenness of Amazonian vegetation due to the 2010 drought Geophys. Res. Lett. 38 L07402

Zaitchik, B.F., Evans, J.P., Geerken, R.A., Smith, R.B.,(2007). Climate and vegetation in the Middle East: inter-annual variability and drought feedbacks. J. Climate 20,3924–3941.

Zheng, Y.Q., G. Yu, Y.F. Qian, M. Miao, X. Zeng and H. Liu, (2002). 'Simulations of regional climatic effects of vegetation change in China'. Quarterly Journal of the Royal Meteorological Society, 128:2089-2114,Part B.

Assessment Agriculture Drought Hazard

Effects of Drought and Land Degradation on Vegetation Losses: in Africa, Arab Region, Drought and Conflict in Syria, Drylands in South America and Forests of Amazon and Congo Rivers Basins.

By: Prof. Wadid Erian

Lead Author

Senior Advisor

Climate Change Adaptation and Disaster Risk Reduction

The League of Arab States - LAS

UNDP Regional Arab Climate Resilience Initiative (ACRI)

Contributors

Eng. Bassem Katlan, Senior Researcher

Eng. Naji Assad , Remote Sensing Specialist,

Eng Sanaa Fouad Ibrahim, GIS Specialist

The Arab Centre for the Studies of Arid Zones and Dry Lands ACSAD

Use the following reference to cite the paper:

Erian W, B Katlan, N Assad and. S Ibrahim 2014. "Effects of Drought and Land Degradation on Vegetation Losses in Africa, Arab Region with Special Case Study on: drought and conflict in Syria, South America and Forests of Amazon and Congo Rivers Basins", Background paper prepared for the 2015 Global Assessment Report on Disaster Risk Reduction. Geneva, Switzerland: UNISDR

Table OF CONTENTS Page

LIST OF TABLES

	List of Figures	Page