



Mapping and Modeling Agriculture Drought Hazard In Africa

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Director of Land and Water Uses Division - ACSAD 2002 - 2014
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Advisor World Bank 2011 - 2012 - 2015 - 2017

☐ **Developing Agriculture Drought Hazard Map**

Step 1: Computing Vegetation Healthy Index

Agriculture drought intensity

Step 2: Developing Agriculture Drought Hazard Map

Agriculture drought intensity

Agriculture drought frequency

Agriculture drought consecutive

Agriculture drought variability

☐ **Impact of Drought on Land Cover/Land use Map**

☐ **Developing Vegetation degradation Map**

☐ **Combining the Agriculture Drought and degradation Maps**

☐ **Exposing Land Use Map to ADH and LD Map**

☐ **Measuring Crop Losses**

☐ **Measuring Vulnerability**

☐ **Drought Complexity**

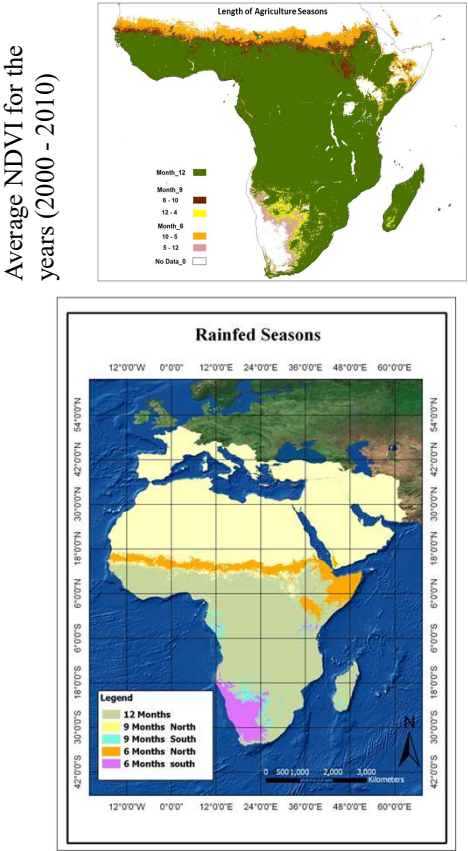


❑ **Developing Agriculture Drought Hazard Map**

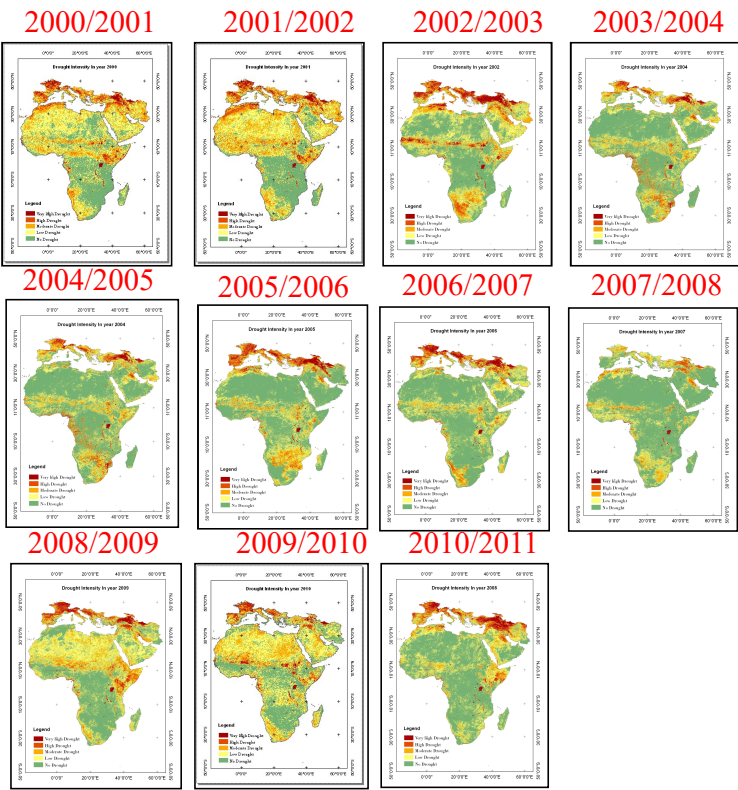
Step 1: Computing Vegetation Healthy Index

Agriculture drought intensity

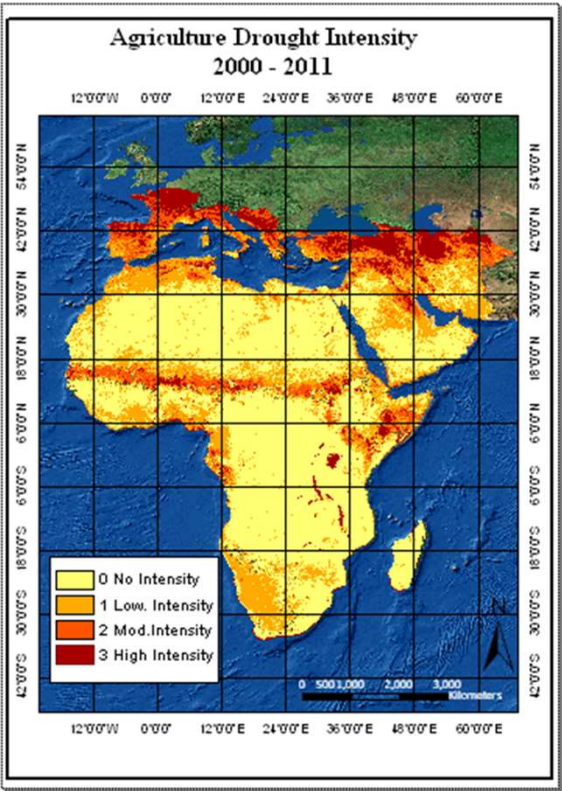
Agriculture Season



Annual Drought VHI - Intensity



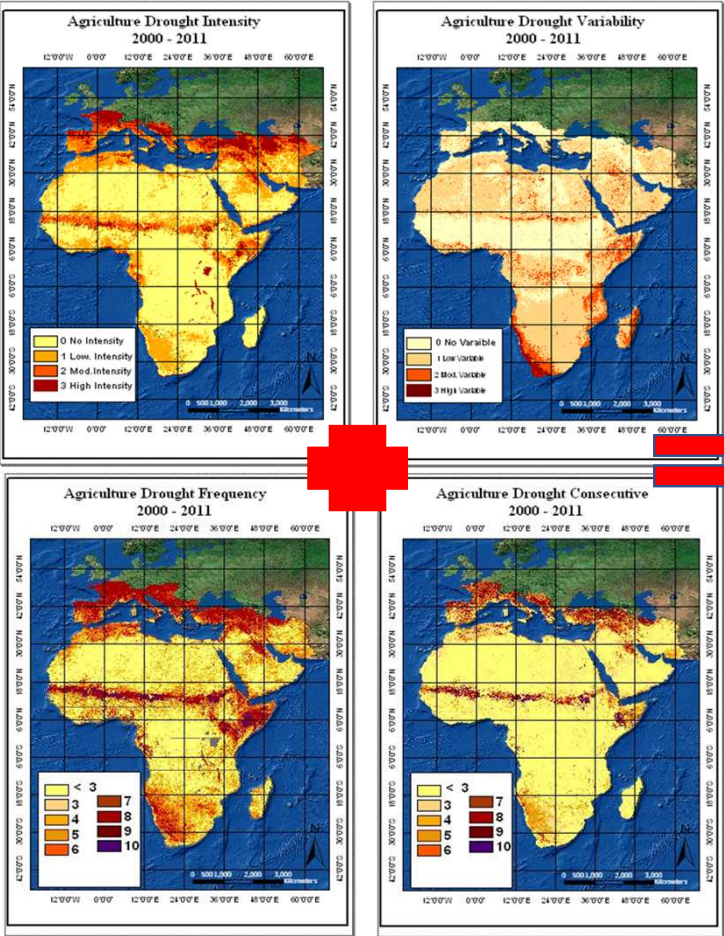
Multi Years Agriculture Season



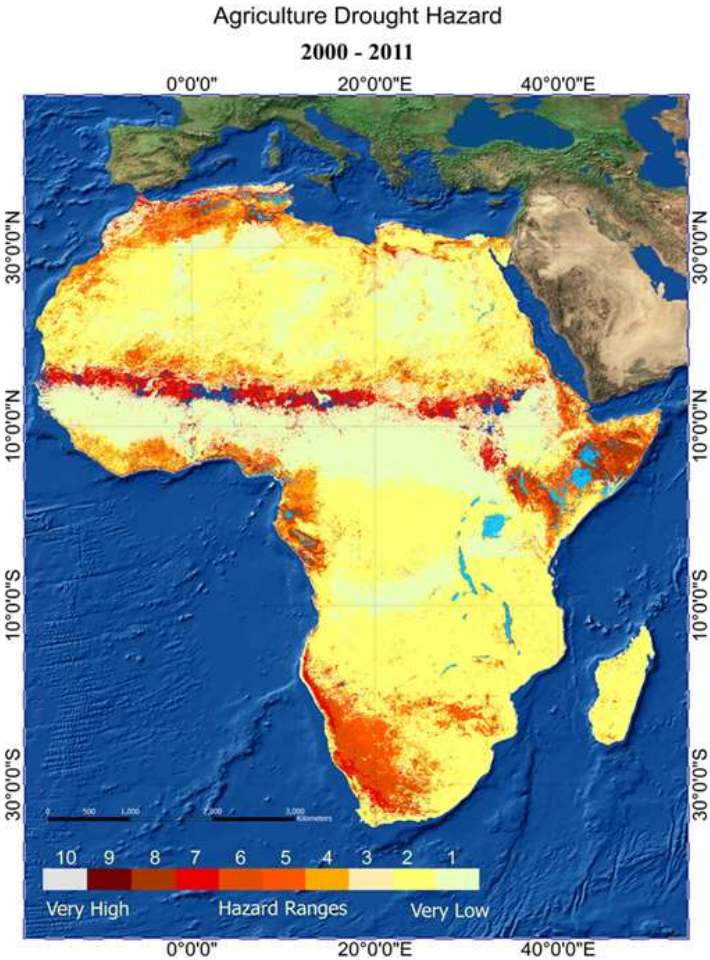
❑ **Developing Agriculture Drought Hazard Map**

Step 2: Developing Agriculture Drought Hazard Map

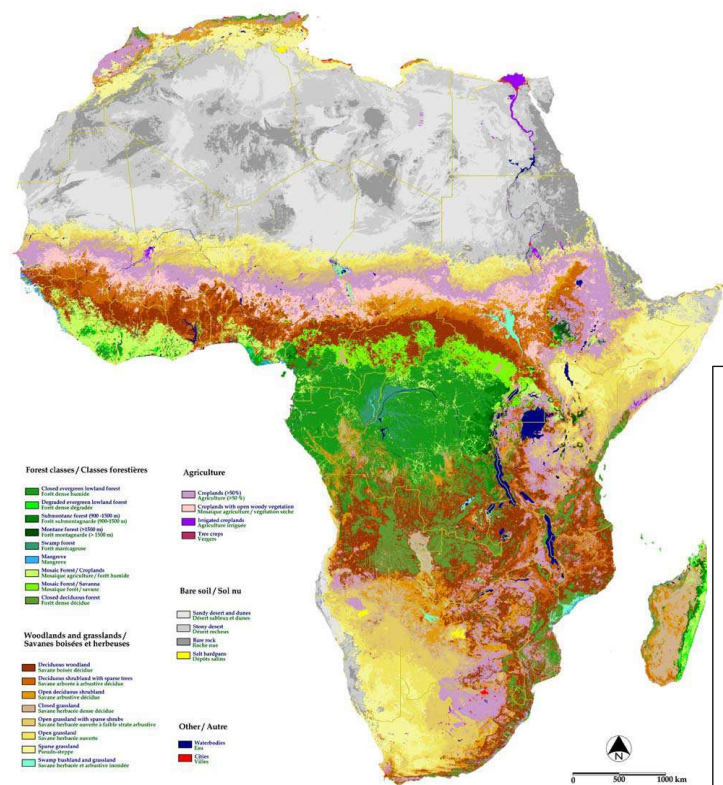
Agriculture drought intensity  Agriculture drought frequency  Agriculture drought consecutive  Agriculture drought variability



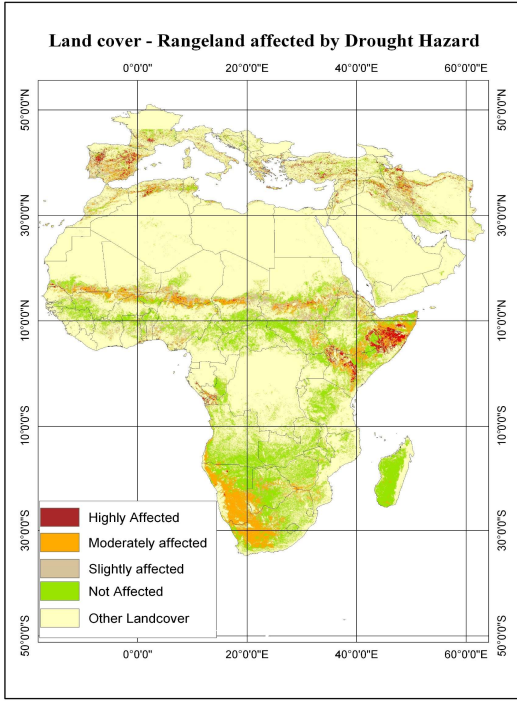
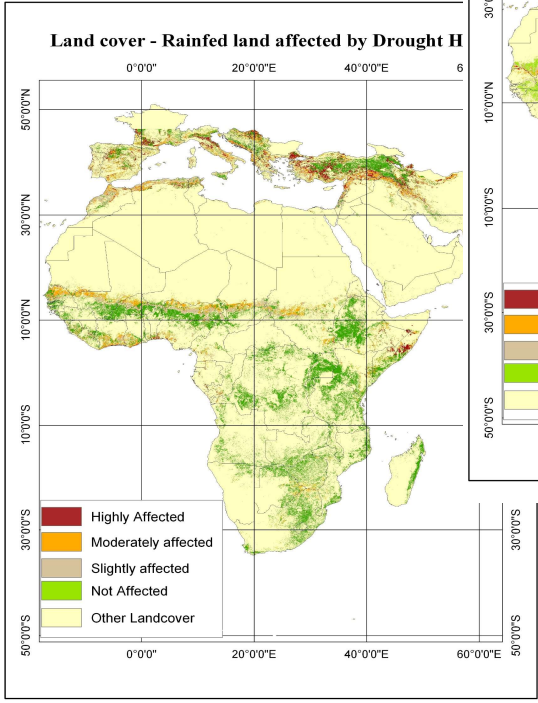
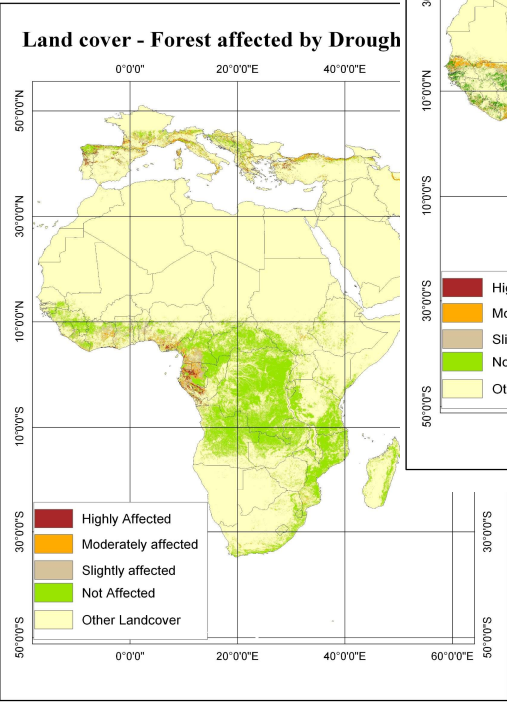
Drought Groups	Km ²	%
No Drought Hazard	25055375	61.9
Slight Drought Hazard	6138593	15.1
Moderate Drought Hazard	5687104	14.1
High Drought Hazard	1732693	4.3
Areas covered with snow wet lands, and marshy lands	908058	2.2
Water Bodies	1732693	2.4
TOTAL	40484680	100



❑ Impact of Drought on Land Cover/Land use Map



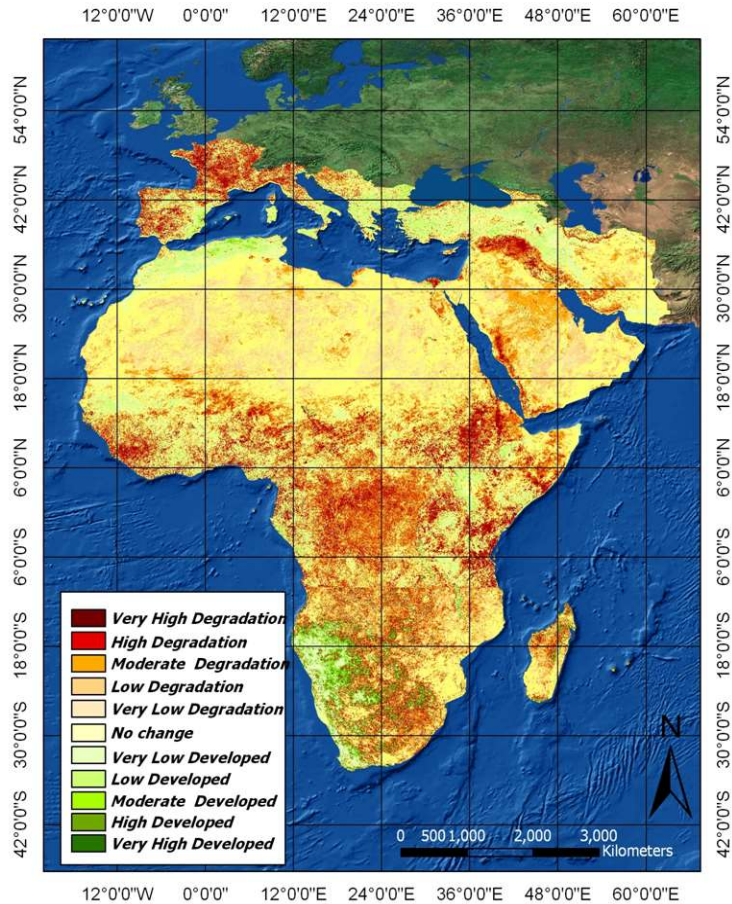
Global Land Cover Map of Africa, ESA 2009



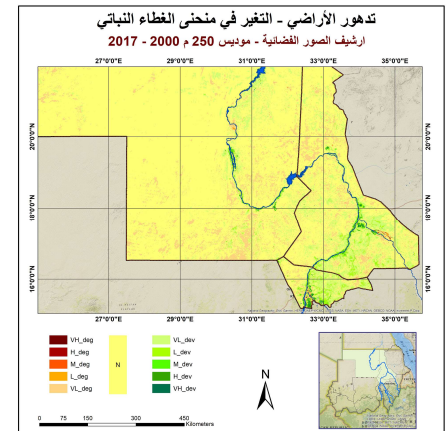
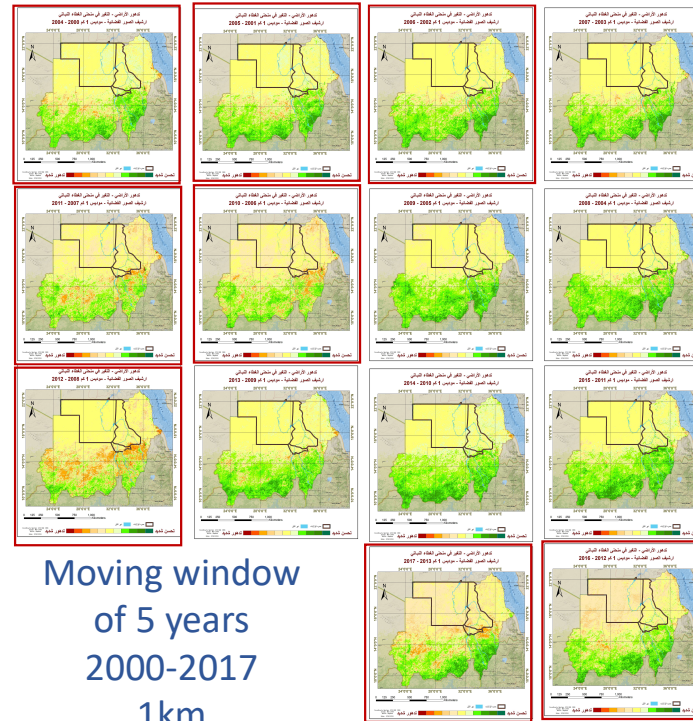
Different Affect Land Use Types by Drought

❑ Developing Vegetation degradation Map

Monitoring Vegetation Change 2000 - 2011

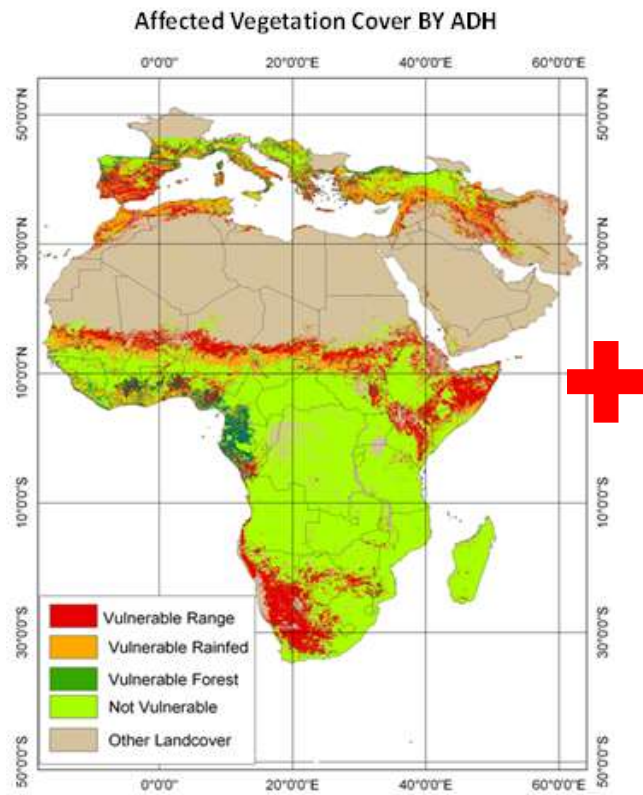


Trendline Analysis

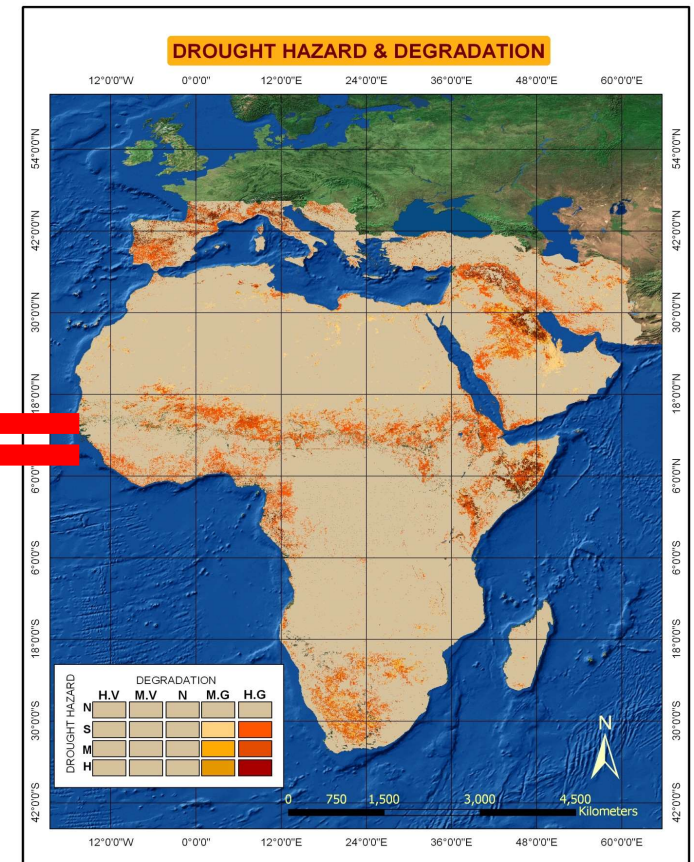
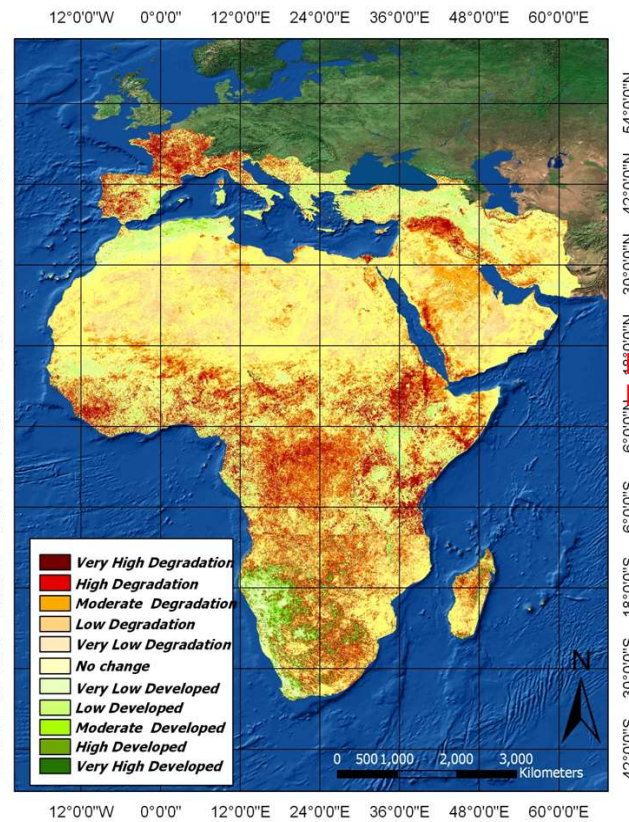


Vegetation
Degradation
trend
2000-2017
250m

❑ Combining the Agriculture Drought and degradation Maps

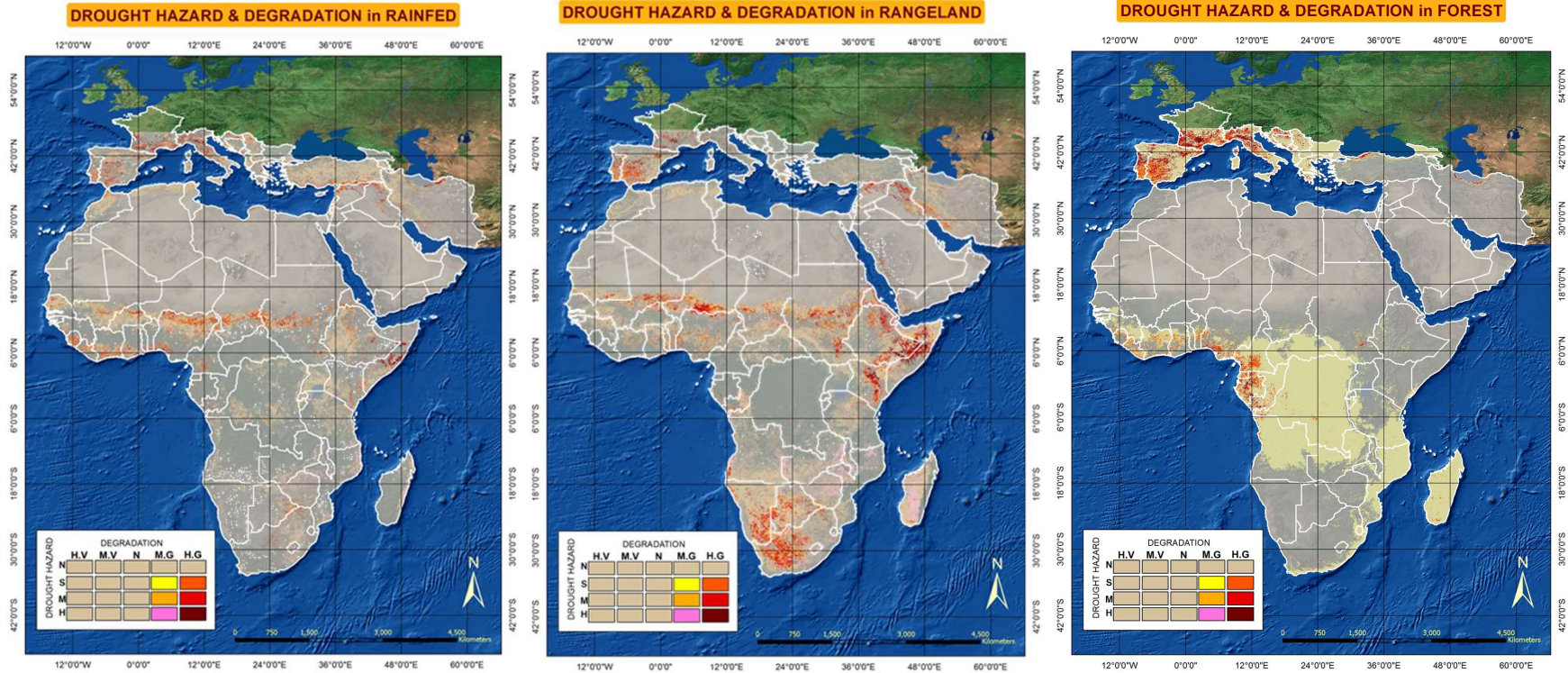


Monitoring Vegetation Change 2000 - 2011

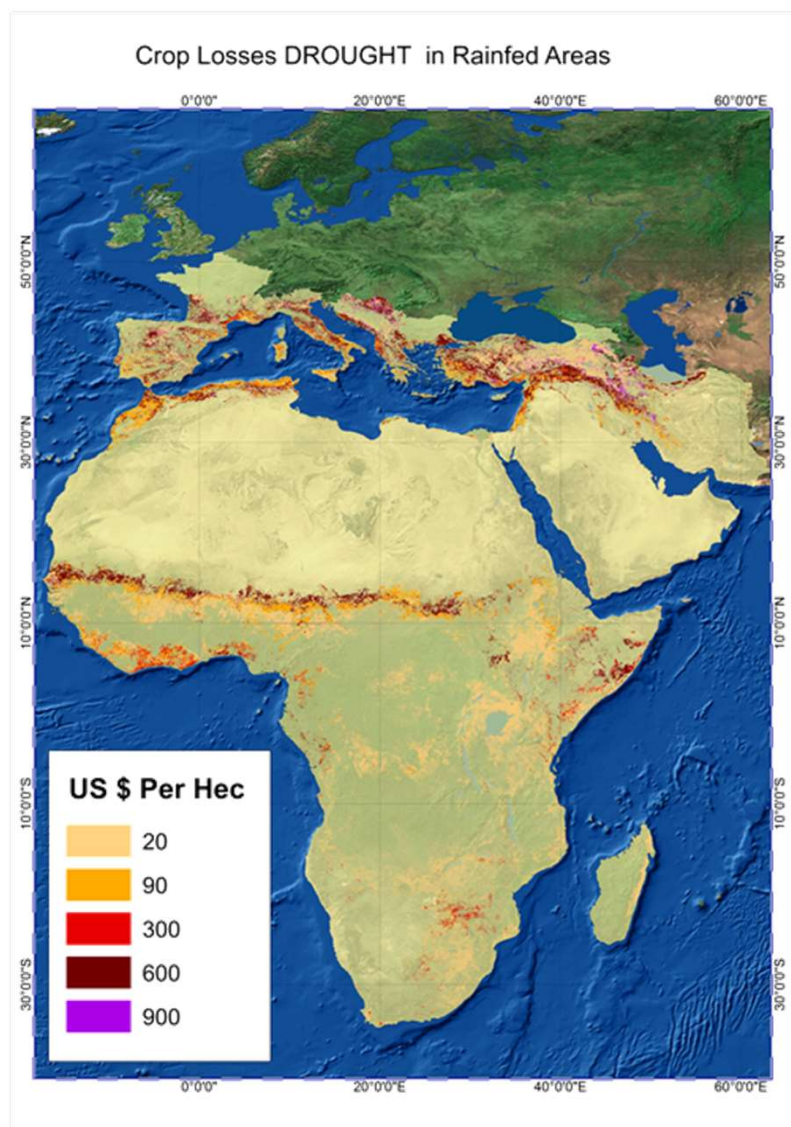


❑ Exposing Land Use Map to ADH and LD Map

Impact of drought and Land Degradation on



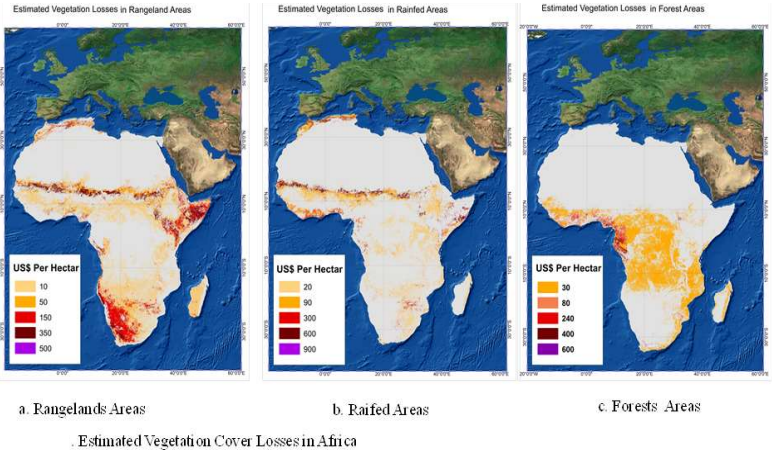
- Drought severely affected (moderate and high) areas represents 15.08% of the total Africa area.
- Total effected areas by land degradation represents 52% of the total Africa area
- The total affected area by combined ADH and represents 5.51 % of Africa area
 - almost 49% of the total Africa rainfed croplands
 - almost 19.4 % from total Africa Rangeland
 - almost 3.96% of the total Africa forests



Potential Estimated Losses in RAINFED CROPLANDS			
TOTAL Studied Countries	Losses in Million Ha	Losses in Million US\$	No. of Worker lost Jobs in Million
	235.22	82.47	201.49

Few Countries Ranked	Losses in Million Ha	Losses in Million US\$	No. of Worker lost Jobs in '000
Congo, DRC	28055794.1	11172.79	27912.00
Ethiopia	21878255.59	8418.26	20911.37
Nigeria	17538679.04	5717.73	13771.03
South Africa	16032279.37	6004.53	14846.67
Tanzania	12089148.92	4762.85	11877.77
Zimbabwe	9036187.4	3433.42	8510.55
Sudan	8806895.77	2306.84	5276.82
Somalia	8236064.16	2683.34	6461.93
Uganda	8039381.63	3213.51	8032.86
Kenya	7823062.7	2840.00	6983.38
Botswana	7009433.62	2501.73	6132.53
Zambia	6467461.31	2575.98	6435.53
Chad	6466895.06	2135.89	5157.93
Mozambique	5226077.9	2034.93	5064.95
Burkina Faso	5082968.03	1669.01	4025.68
Mali	3446490.43	1076.53	2569.53
Cote d'Ivory	2921362.89	762.44	1742.33
Madagascar	2872512.67	1143.79	2857.36
Guinea	2386557.87	907.66	2250.22
Cameroon	2343408.28	780.19	1887.10
Sierra Leone	2036319.53	656.00	1576.07
Senegal	1751423.53	511.31	1201.98

❑ Measuring Crop Losses



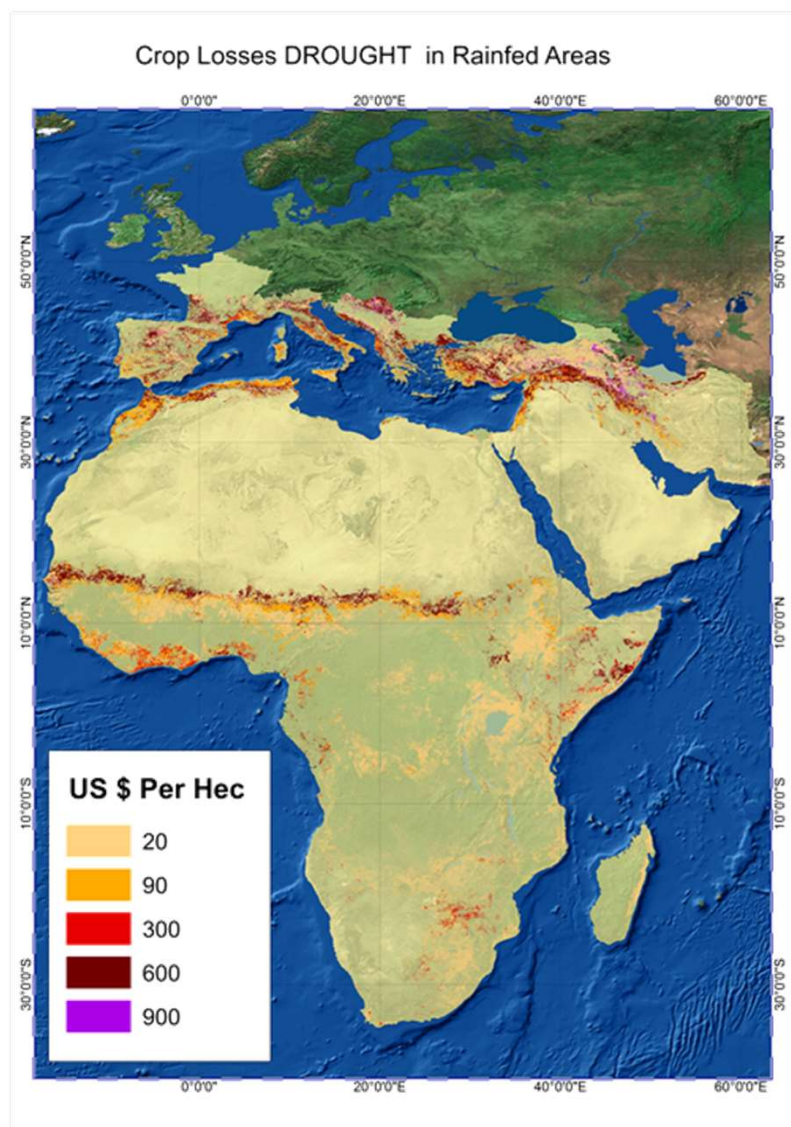
Total Affected Land Use Type	Level of Severity								
	Sevier	Moderate	Slight	Sevier	Moderate	Slight	Sevier	Moderate	Slight
Rangelands	Production losses in %			Lost land value US\$			Number of workers lost Job		
	60	35	15	160	90	30	0.25	0.1	0.07
	Sevier	Moderate	Slight	Sevier	Moderate	Slight	Sevier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

Potential Estimated Losses in RANGELANDS			
Losses in Million Ha		Losses in Billion US\$	No. of Worker lost Jobs in 'Million
195.22		113.8	36.68

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235.22		82.47	201.49

Potential Estimated Losses in FORESTS			
Losses in Million Ha		Losses in Billion US\$	No. of Worker lost Jobs in Million
62.53		28.64	18,36

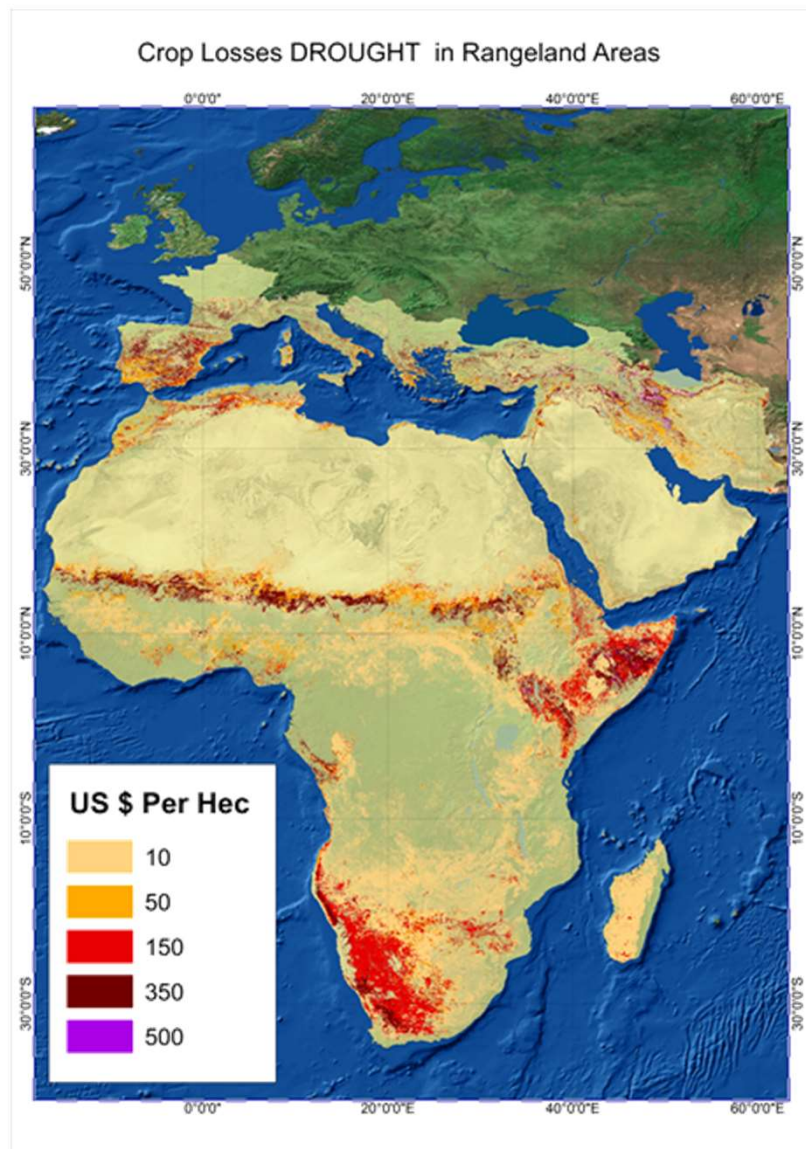
Potential Total Estimated Annual Losses in Africa			
	Losses in Million Ha	Losses in Billion US\$	No. of instable Jobs in Million
	492.97	224.91	256.53



Potential Estimated Losses in RAINFED CROPLANDS

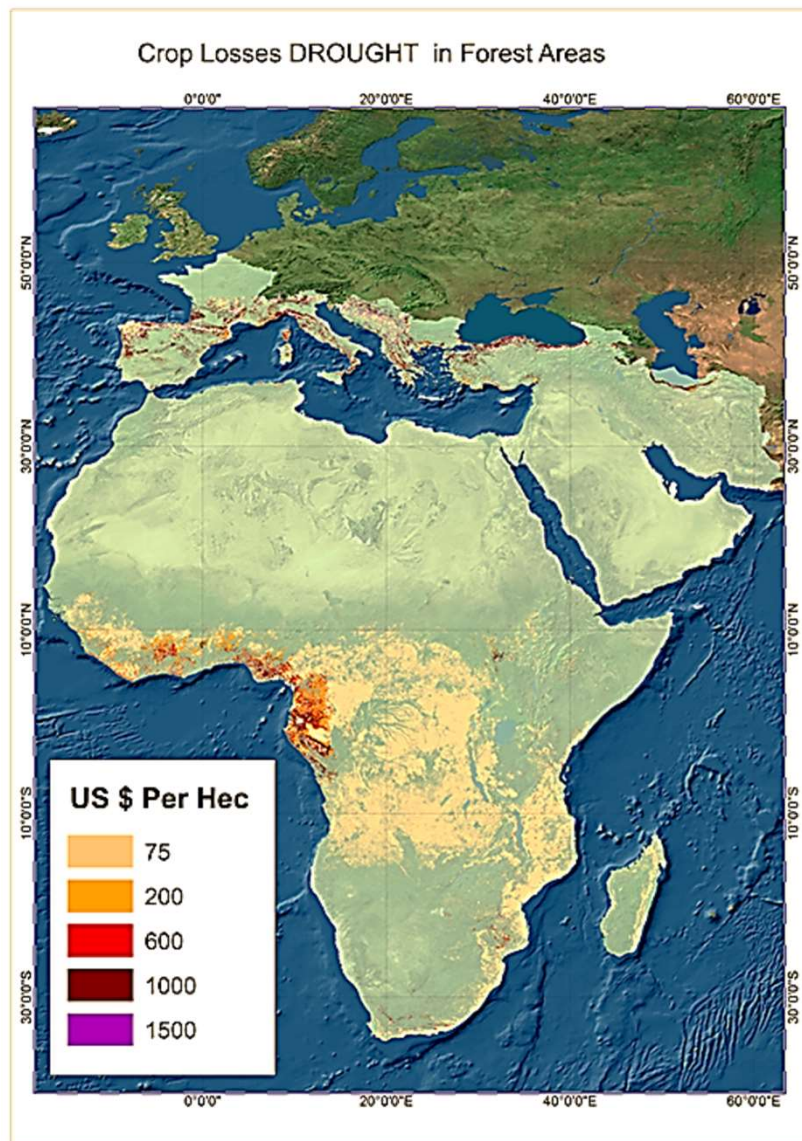
TOTAL Studied Countries	Losses in Million Ha	Losses in billion US\$	No. of Worker lost Jobs in Million
	235.22	82.47	201.49

Few Countries Ranked	Losses in Million Ha	Losses in Million US\$	No. of Worker lost Jobs in '000
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	195.22	113.8	36.68

Few Countries Ranked	Losses in Million Ha	Losses in Million US\$	No. of Worker lost Jobs in '000
South Africa	22318579.74	3153.29	5001313.44
Sudan	19837639.34	1795.65	3050895.59
Ethiopia	19174720.34	2457.87	3948947.89
Botswana	16889275.68	1773.38	2936139.99
Somalia	12605124.55	1951.65	3061040.64
Niger	12106218.71	1276.87	2112533.50
Namibia	10253835.66	1580.14	2479730.92
Kenya	9015467.87	1229.61	1959126.59
Mali	7414864.38	727.80	1218764.89
Nigeria	7249065.45	644.53	1098745.83
Chad	6572948.15	554.25	954499.77
Eritrea	2571093.61	231.92	394297.37
Mauritania	1831670.96	204.31	335023.86
Angola	1808280.97	204.95	335245.10
Zimbabwe	1454235.96	180.04	290675.60
Congo	1410963.20	149.82	247600.58
Burkina Faso	1300985.55	174.35	278436.06
Ghana	1074881.73	76.36	136322.86



Potential Estimated Losses in FORESTS			
TOTAL Studied Countries	Losses in Million Ha	Losses in Billion US\$	No. of Worker lost Jobs in Million
	62.53	28.64	18,36

Few Countries Ranked	Losses in Million Ha	Losses in Million US\$	No. of Worker lost Jobs in '000
Gabon	5800186	2666.96	1710209
Cameroon	5116982	1270.45	696985.8
Nigeria	4312830	1481.81	895712.4
Congo	2500443	1179.78	759815.9
Cote d'Ivory	2413521	501.19	255214.9
Liberia	1817647	370.10	186690.6
Ghana	1783878	381.84	197184.9
Congo, DRC	1696863	478.93	274357.7
Benin	1219047	272.51	143433.9
Angola	1019811	278.33	157755.1
Guinea	896073.9	179.66	89943.88
Madagascar	825736.2	178.84	92840.58
Sierra Leone	793430.4	163.83	83200.47
Algeria	722952.3	146.34	73610.17
Equatorial Guinea	624223.2	173.06	98585.66
Sudan and South S	589337.2	160.04	90564.6
Mozambique	467505.9	101.95	53090.24

i. ECONOMICAL 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 agri worker (USD) 2009-1999
- EcH. : Evaluation of the Value of Total Agri.\$ Food Production
- EcI : Value (millions of 2004-2006 in (\$).
- EcJ : Change in crop production value per ha %

ii. POPULATION (Po)

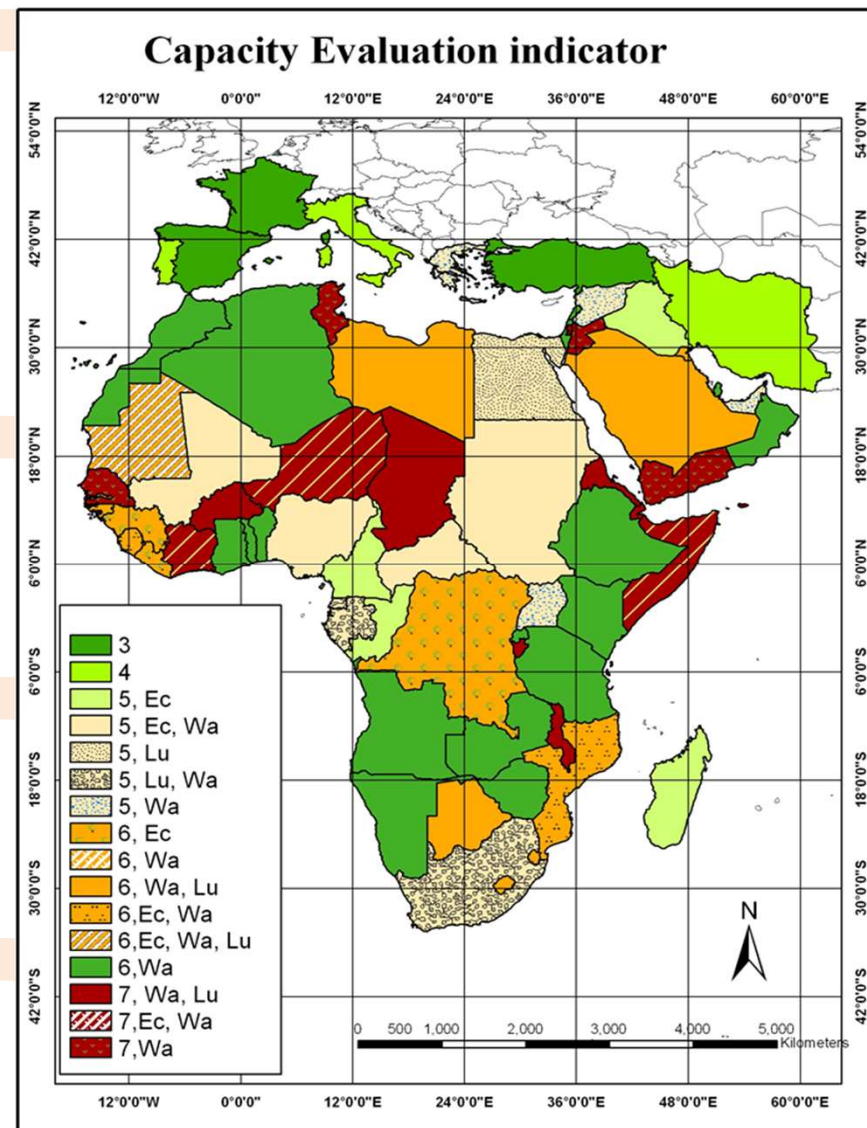
- PoA : Mean Population Density person/Km2
- PoB : People in working age (15-64) years %
- PoC. : Population growth rate
- PoD. : Net migration rate: for each 1000 person
- PoE. : Females % of Labour force in Agriculture- 2011.
- PoF. : Average Agriculture population Change 2011 - 2001%

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



❑ Measuring Vulnerability

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)

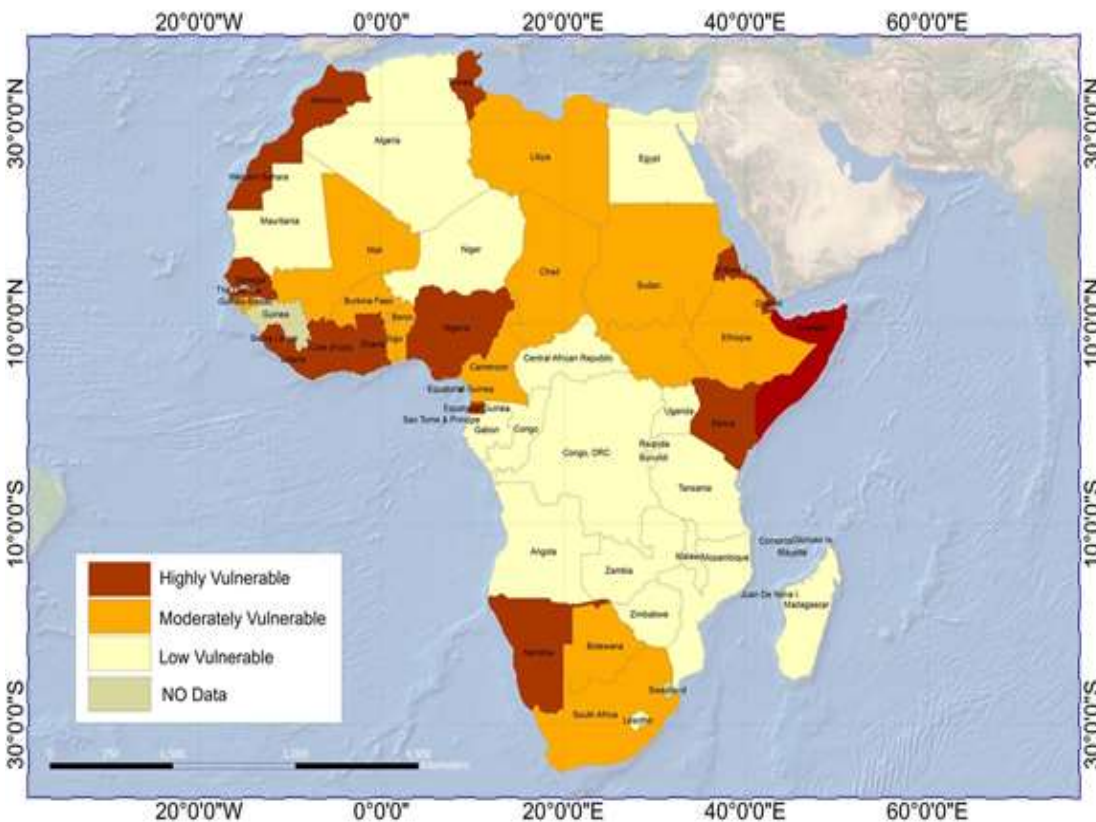
iv. Water Availability

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



❑ Measuring Vulnerability

Ranking Countries to Vulnerability, Resilience Classes

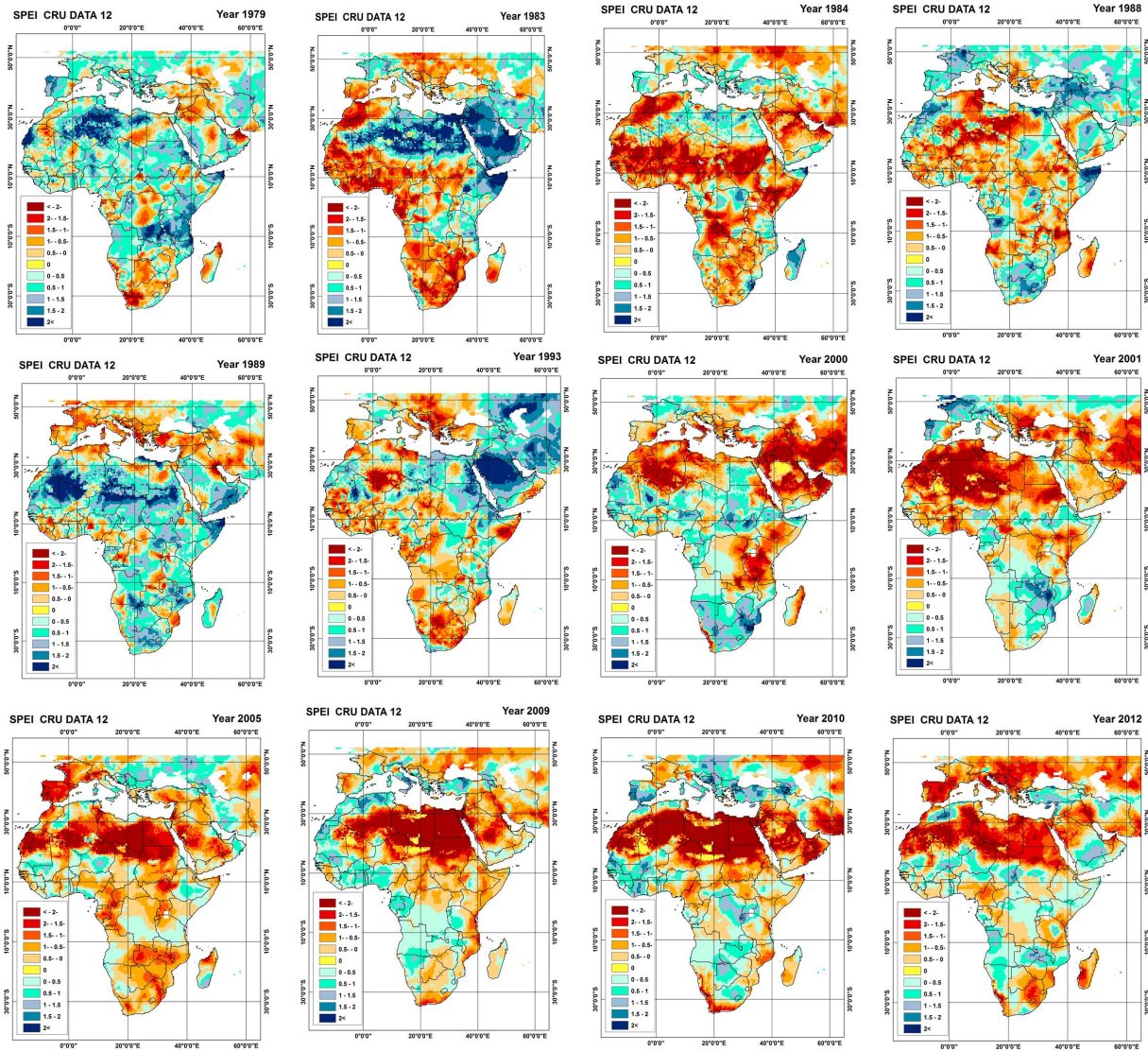


Vulnerability classes	Countries
High to Moderate Vulnerability: moderate coverage of ADH 45-60 %, moderate severity and very Low to low capacity	Somalia, Senegal and Kenya.
Moderate Vulnerability: high coverage of ADH 75 – 85%, moderate severity and moderate capacity	Eritrea, Morocco, Eq Guinea
Moderate Vulnerability: high to moderate coverage of ADH 60-75 %, moderate severity and high to moderate capacity	Tunisia, Djibouti, Namibia, Gabon,
Moderate to Low Vulnerability: moderate coverage of ADH 45-60 %, low severity and very low to low capacity	Cote D Lvoire, Sierra Leanne, Ghana, Liberia and Nigeria
Moderate to Low Vulnerability: moderate to low coverage ADH 30-45 %, moderate to low severity and moderate to low capacity	South Africa, Burkina Faso, Chad, Benin, Togo, Ethiopia, Botswana, Cameroon, Sudan, Mali,
Low Vulnerability: low coverage of ADH 15-30 %, low severity and high to moderate capacity	Niger, Yemen, Mauritania, Algeria, Libya, Malawi, Burundi, Angola, Zimbabwe, Lesotho, Mozambique, Gambia, Tanzania, DR Congo, Zambia, Swaziland, and Rwanda
Low Vulnerability: low coverage of ADH 15-30 %, low severity and low capacity	Egypt, Congo, Guinea, Guinea-Bissau,
Low Vulnerability: low coverage of ADH less than 15 %, low severity and low capacity	Madagascar, Uganda, Central Africa

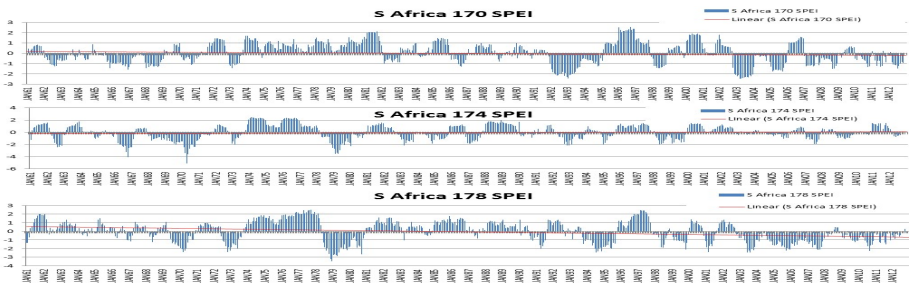
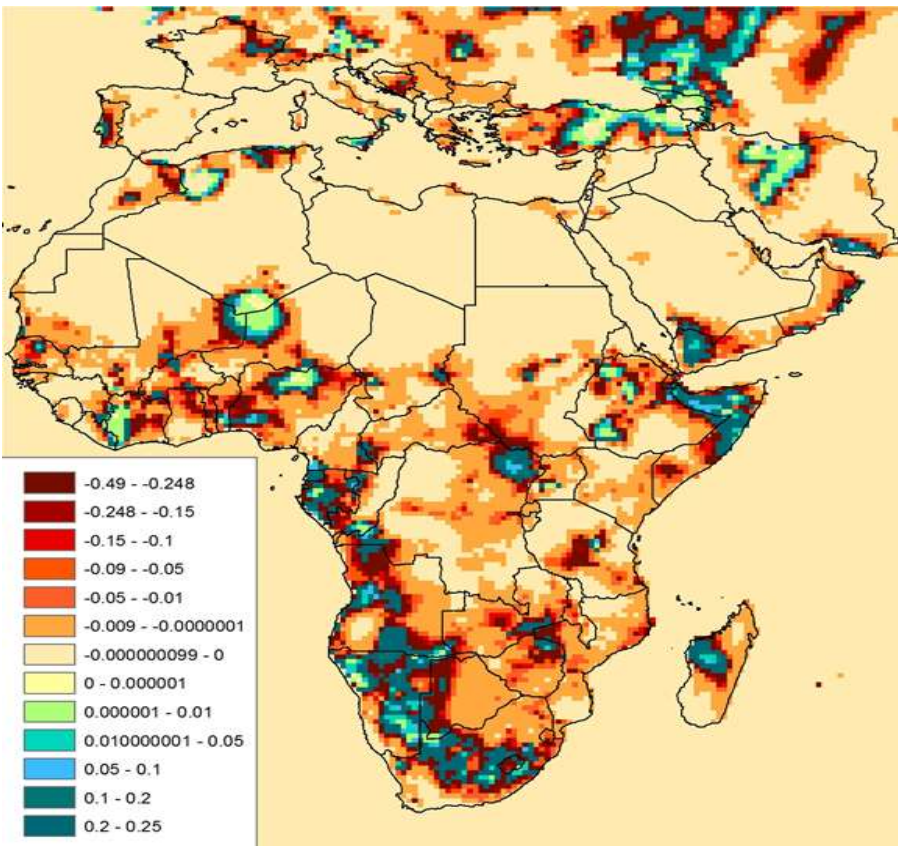
The standard precipitation evapotranspiration index (SPEI)



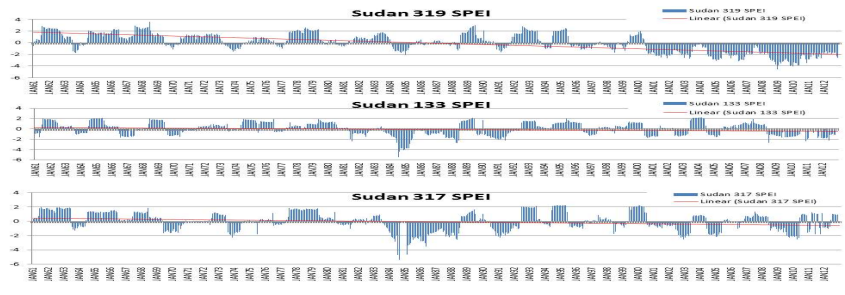
SPEI Value	Drought Classes	Colors
≥ 2.00	Extreme Wet	
$1.50 - 1.99$	Severe Wet	
$1.00 - 1.49$	Moderate Wet	
$0.1 - 0.99$	Slight Wet	
$0.0 - 0.1$ to $0.0 - -0.1$	Normal	
$-0.1 - -0.99$	Slight Drought	
$-1.49 - -1.00$	Moderate Drought	
$-1.99 - -1.50$	Severe Drought	
≤ -2.00	Extreme Drought	



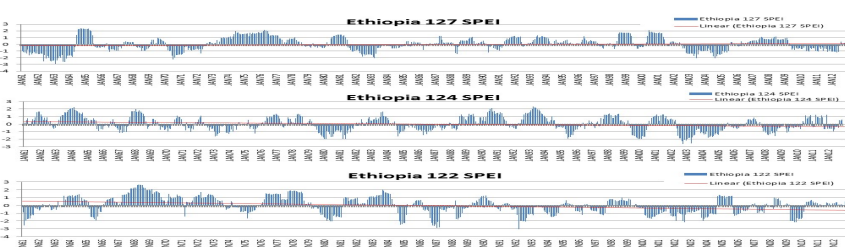
S. Africa



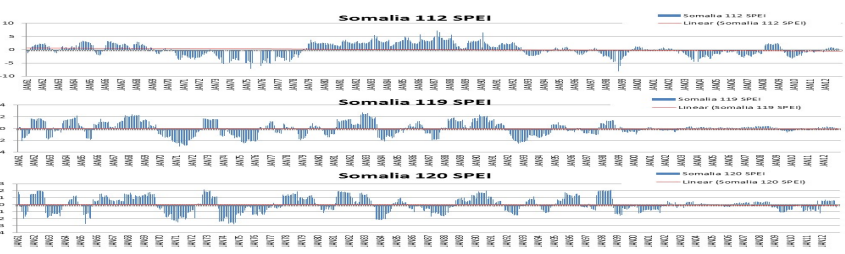
Sudan



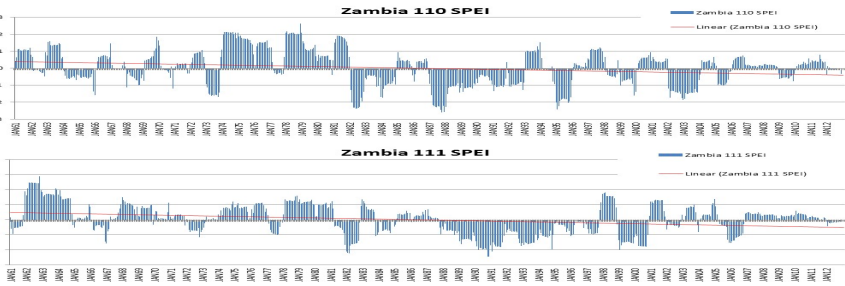
Ethiopia



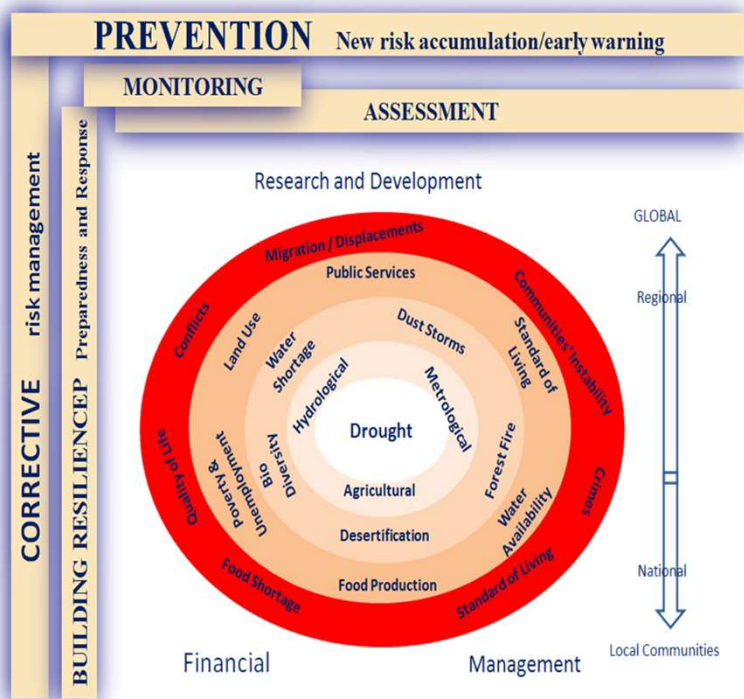
Somalia



Zambia

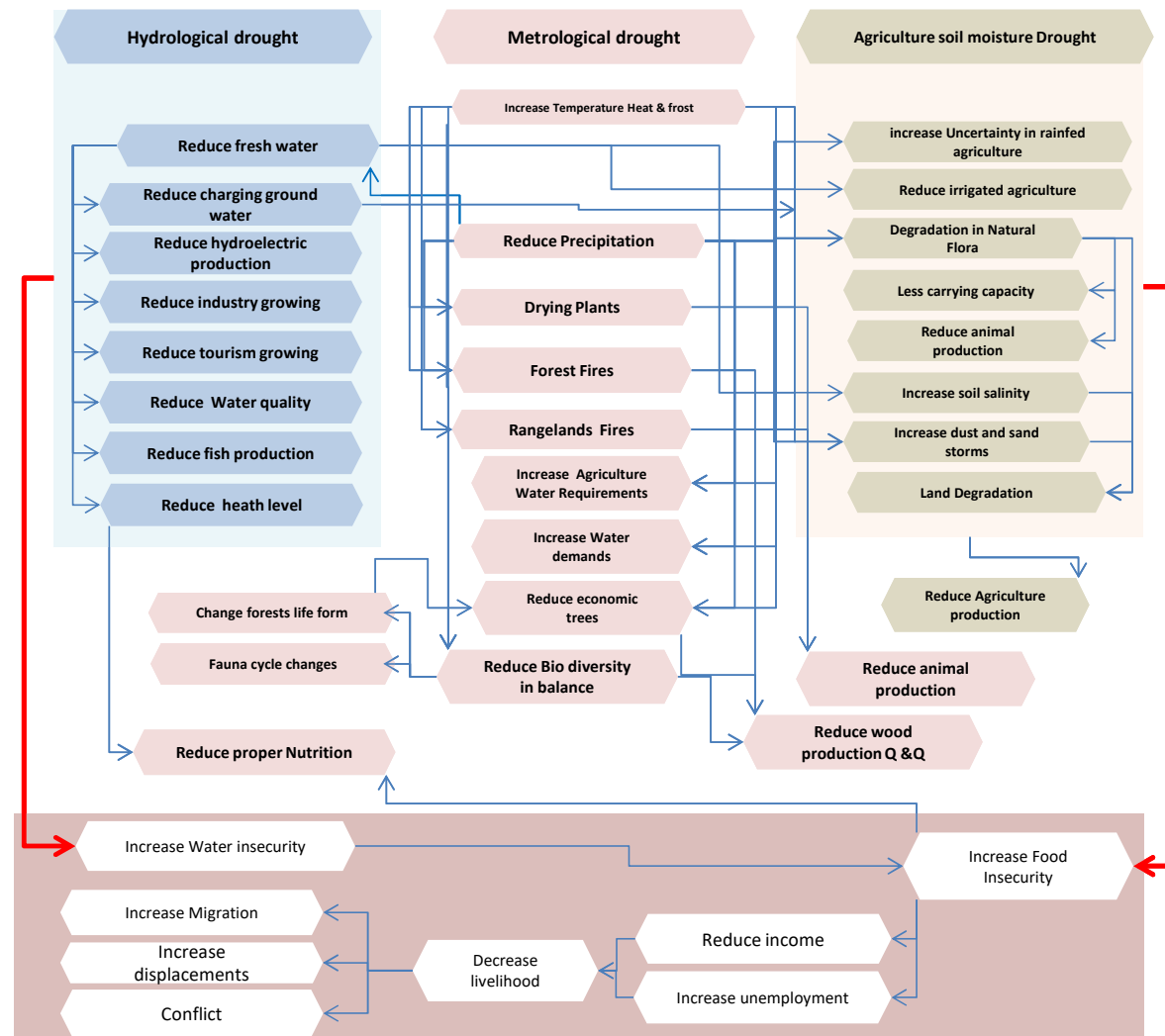


❑ Drought Complexity



Framework for understanding Drought:
Water, Food, and Socio-Economy Nexus, after Erian et al 2014,

Levels of Actions- Multi scale Approach



Complexity of the Drought Phenomena

Direct Impacts of Drought complex interlinking

Metrological drought

Increase Temperature Heat & frost; and Reduce Precipitation and increase variability

- ❑ Drying Plants, increase potentiality to Forest and Rangelands Fires
- ❑ Increase Agriculture Water Requirements and Increase Water demands
- ❑ Affect biodiversity balance and Fauna and flora cycle change leading to Change forests life form, and Reduce economic trees

Hydrological drought

- ❑ Reduce fresh water, Reduce charging ground water and water run off, Reduce hydroelectric production and industry growing, affect negatively on tourism growing,
- ❑ Reduce Water quality
- ❑ Affect fish production
- ❑ Reduce health level

Agriculture soil moisture Drought

- ❑ increase Uncertainty in rainfed agriculture
- ❑ Reduce irrigated agriculture
- ❑ Degradation in Natural Flora
- ❑ Losses in Rangeland carrying capacity
- ❑ Increase Soil and land Degradation

Increase Food Insecurity

- ❑ Reduce Agriculture production
- ❑ Reduce animal production
- ❑ Reduce proper Nutrition

Decrease livelihood level

- ❑ Reduce income
- ❑ Increase unemployment

Increase Social Vulnerability

- ❑ reduce human security and communities Instability
- ❑ Increase Migration, displacements and Conflicts

Indirect Impacts of Drought,
Economical, Social and Environmental Stresses

CONCLUSIONS:

- ❑ Farmers, poor people in rural areas are moving to cities creating pressure on housing and Random settlement areas. By the year 2050 almost 70% of population will be leaving in cities many of them without are jobless or work in informal business job.

Rural – Urban Development Nexus

- ❑ Loosing land and renewable water sources means less food production, degradation, reduction in biodiversity, instability, and increase conflicts, displacement and migration.

Building Risk - Resilience

- ❑ Agriculture share in GDP In Africa around 35%

Investment and Economic Programs are Required

- ❑ Agriculture share in GDP In Africa around 35%

More INVESTMENT and ECONOMIC REFORM is REQUIRED

- ❑ Land degradation is a measure threat to Agriculture and when drought cycles increase in intensity, frequency and duration under high variability the threat turn to Crises. **Prevention, Recovery and Building Resilience Require using our resources better in Research, Education & Training, Implementation & Practice and Policy.**
- ❑ Nature resources are only decreasing in drylands, and shared water resources could become a real threat and reason for conflicts.....

SHARING and MANAGING is the Key

“Drylands” which represent 41% of the globe and 2 billion people), they require better attention, **“Oasis ”** are under threat and severely affected by Nature Metrological Hazards.



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