Workshop on **C**limate **C**hange and **A**daptation in the **M**aghreb (CCAM)

Climate Change in the Maghreb: Thresholds and Limits to Adaptation

Combining adaptation and mitigation strategies for making agricultural systems in the Casablanca region less vulnerable to climate change

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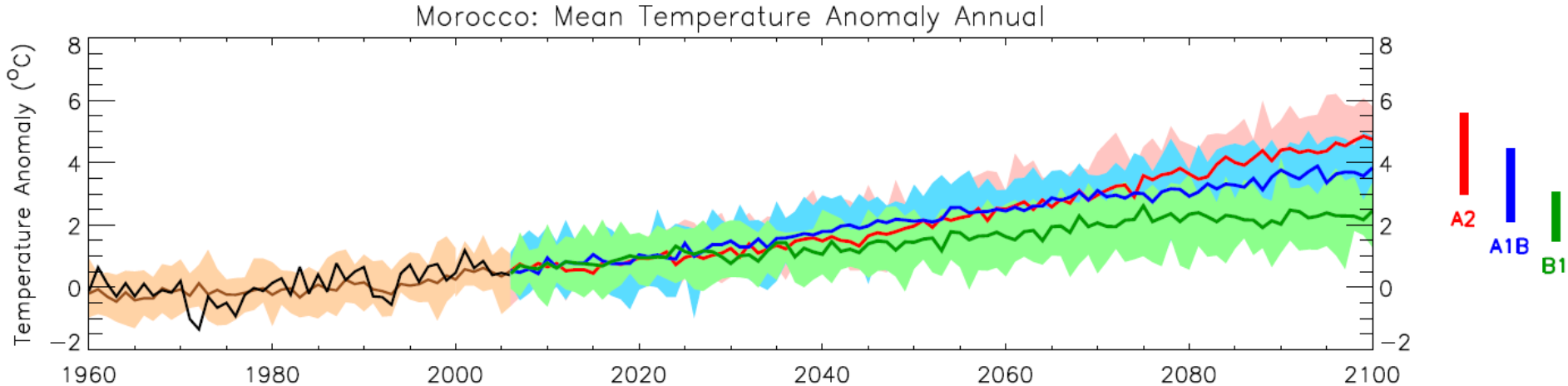
Chair Climatology, Department of Ecology, Technische Universität Berlin (TU Berlin)

Regional climate projections: Annual air temperature

Observed	Mean (°C)
Morocco	17.6
Casablanca	17.8

SRES A2	Min (K)	Median (K)	Max (K)
Morocco	2.9	**4.9**	5.6
NW coast	2.0	**3.5 / 4.8**	5.2

Casablanca: data source: GHCN V2.0.



Trends in annual and seasonal mean temperature for the recent past and projected future. All values shown are anomalies, relative to the 1970-1999 mean climate.

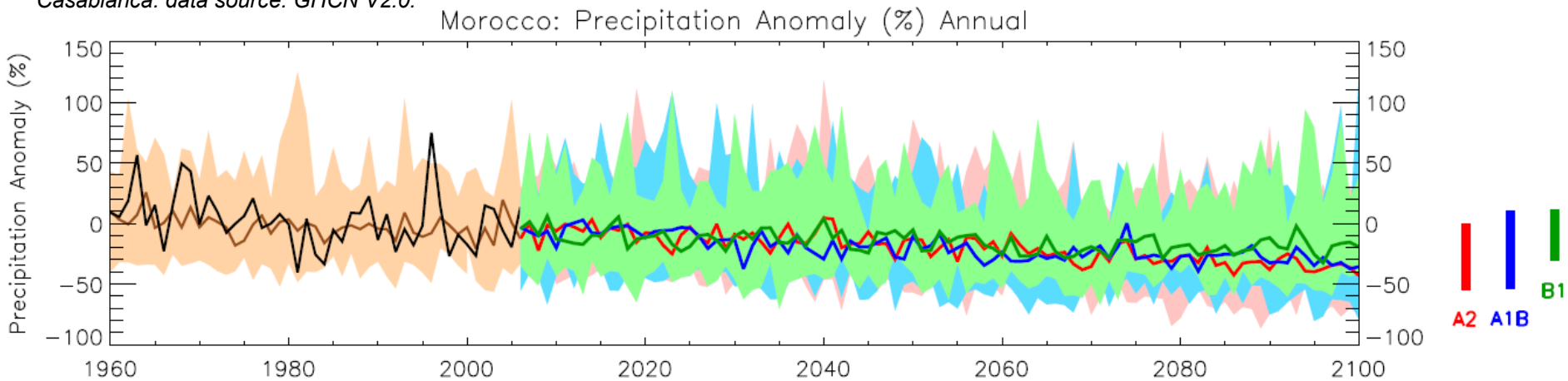
McSweeney et al., 2008, UNDP Climate Change Country Profiles: Morocco, (*http://country-profiles.geog.ox.ac.uk)*

Regional climate projections: Annual precipitation

Observed	Mean (mm/month)
Morocco	23.6
Casablanca	28.8

SRES A2	Min (%)	Median (%)	Max (%)
Morocco	-52	**-29**	-1
NW coast	-57	**-36 / -35**	0

Casablanca: data source: GHCN V2.0.



Trends in monthly precipitation for the recent past and projected future. All values shown are percentage anomalies, relative to the 1970-1999 mean climate.

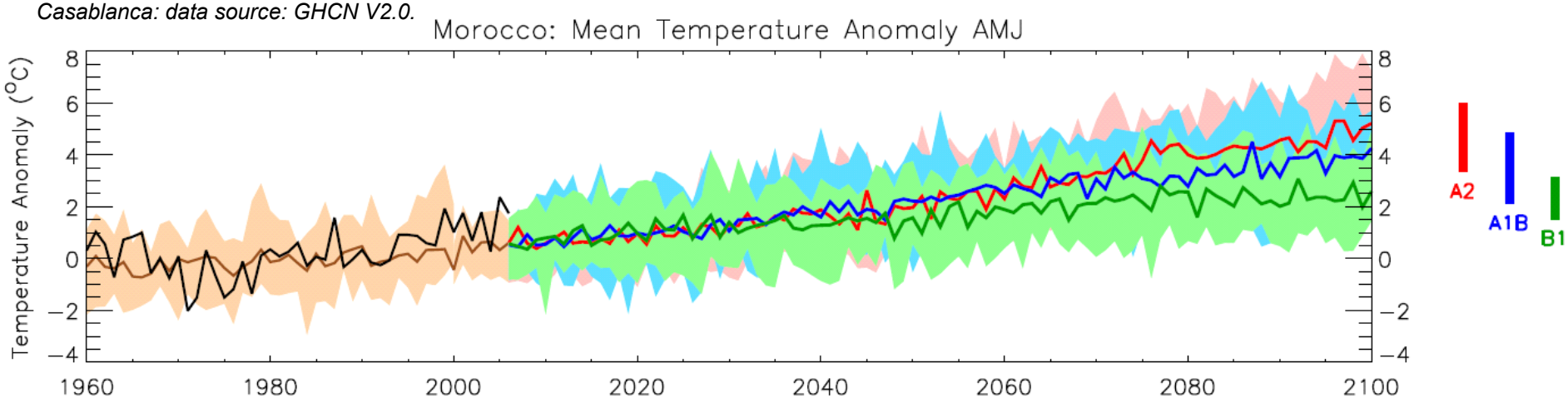
McSweeney et al., 2008, UNDP Climate Change Country Profiles: Morocco, (*http://country-profiles.geog.ox.ac.uk)*

Regional climate projections: AMJ air temperature

Observed	Mean (°C)
Morocco	19.1
Casablanca	17.6

SRES A2	Min (K)	Median (K)	Max (K)
Morocco	3.4	**4.9**	6.0
NW coast	2.2	**3.9 / 5.3**	6.1

Casablanca: data source: GHCN V2.0.



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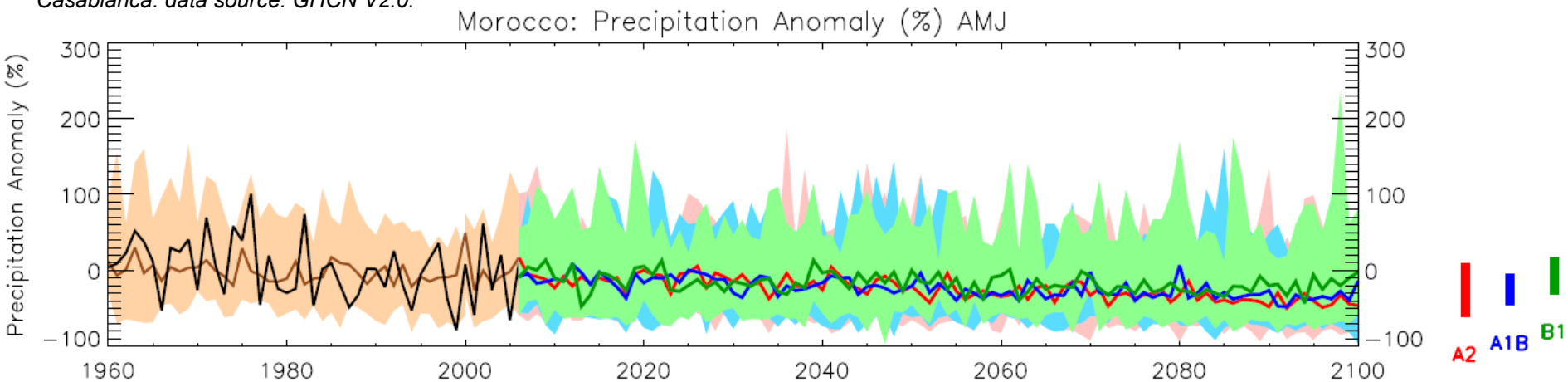
McSweeney et al., 2008, UNDP Climate Change Country Profiles: Morocco, (*http://country-profiles.geog.ox.ac.uk)*

Regional climate projections: AMJ precipitation

Observed	Mean (mm/month)
Morocco	18.5
Casablanca	20.0

SRES A2	Min (%)	Median (%)	Max (%)
Morocco	-58	-34	9
NW coast	-74	-34 / -36	0

Casablanca: data source: GHCN V2.0.



Trends in monthly precipitation for the recent past and projected future. All values shown are percentage anomalies, relative to the 1970-1999 mean climate.

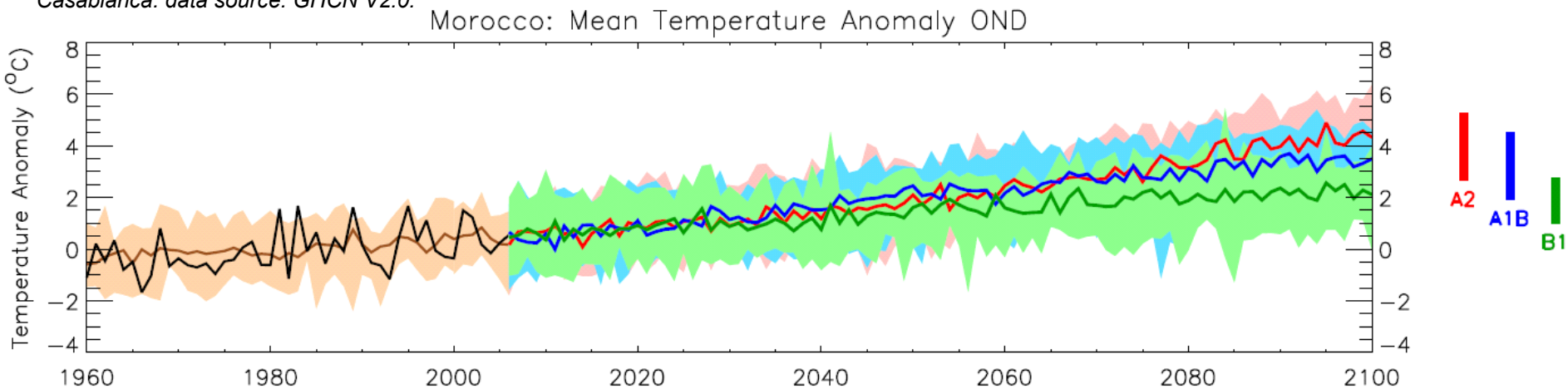
McSweeney et al., 2008, UNDP Climate Change Country Profiles: Morocco, (*http://country-profiles.geog.ox.ac.uk)*

Regional climate projections: OND air temperature

Observed	Mean (°C)
Morocco	14.4
Casablanca	16.0

SRES A2	Min (K)	Median (K)	Max (K)
Morocco	2.7	**4.2**	5.3
NW coast	1.9	**3.6 / 4.1**	5.6

Casablanca: data source: GHCN V2.0.



Trends in annual and seasonal mean temperature for the recent past and projected future. All values shown are anomalies, relative to the 1970-1999 mean climate.

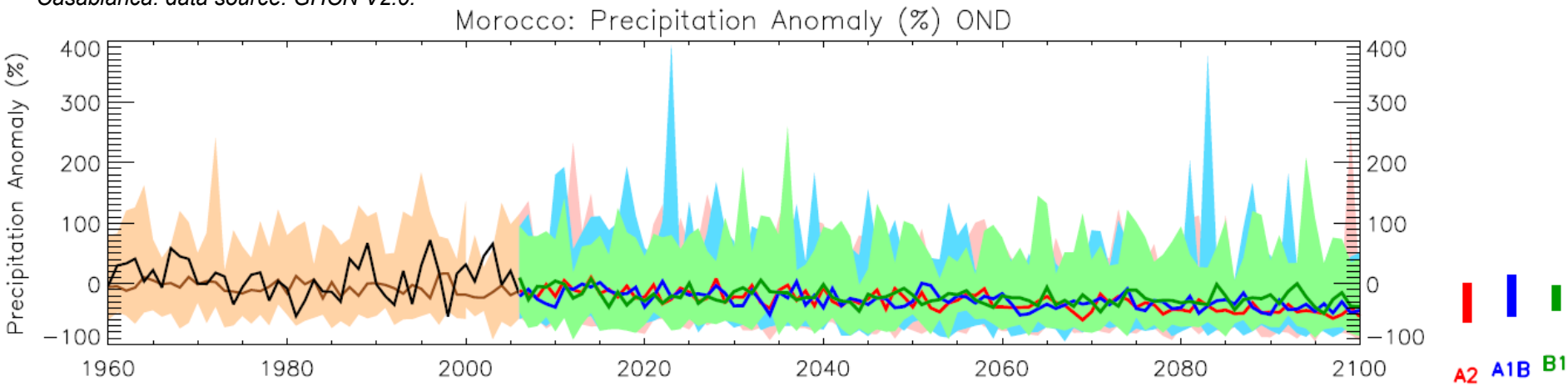
McSweeney et al., 2008, UNDP Climate Change Country Profiles: Morocco, (*http://country-profiles.geog.ox.ac.uk)*

Regional climate projections: OND precipitation

Observed	Mean (mm/month)
Morocco	33.2
Casablanca	54.1

SRES A2	Min (%)	Median (%)	Max (%)
Morocco	-61	**-35**	2
NW coast	-67	**-45 / -44**	23

Casablanca: data source: GHCN V2.0.



Trends in monthly precipitation for the recent past and projected future. All values shown are percentage anomalies, relative to the 1970-1999 mean climate.

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Urban Agriculture (UA) as an Integrated Factor of Climate-Optimised Urban Development, Casablanca / Morocco

Moroccan-German research project funded by the German Federal Ministry of Education and Research (BMBF) as part of the research programme

Research for Sustainable Development of the Megacities of Tomorrow

Energy- and climate-efficient structures in urban growth centres

www.emerging-megacities.org

- Hassan II University Ain Chock in Casablanca, School of Sciences, Chair of Hydroscience
- National Institute of Urban Planning in Rabat INAU)
- Hassan II University Mohammedia in Casablanca, School of Sciences Ben M'Sik
- Institut of Agronomy and Veterinary Medicine Hassan II in Rabat, Waste Water Treatment and Reuse Unit (IAV)
- Association Synergie Civique, Casablanca
- Regional Authority of Land-Use Planning, Water and Environment in Casablanca (IRHUAE)
- Regional Authority of Agriculture in Casablanca (DPA)
- City Planning Authority in Casablanca (AUC)
- National Weather Service in Casablanca (DMN)
- Moroccan National Airport Office in Casablanca (ONDA)
- Association Terre et Humanisme
- School of Oulad Ahmed, Douar Hmar (…)

- Berlin Institute of Technology (TU Berlin):
  - Department of Landscape Architecture and Environmental Planning / Open Space Planning *(project leader)*
  - TU Berlin, Department of Ecology / Climatology
  - TU Berlin, Department of Process Engineering / Chemical Engineering
  - TU Berlin, Kubus – Center for Cooperation
- University of Hohenheim, Socio-Economic Agriculture and Communication
- University of Wuppertal, Economy of Planning and Building
- Association for Rainwater Harvesting and Water Utilisation (fbr e.V.), Darmstadt

Research partnerships

13 Moroccan partners and 7 German partners

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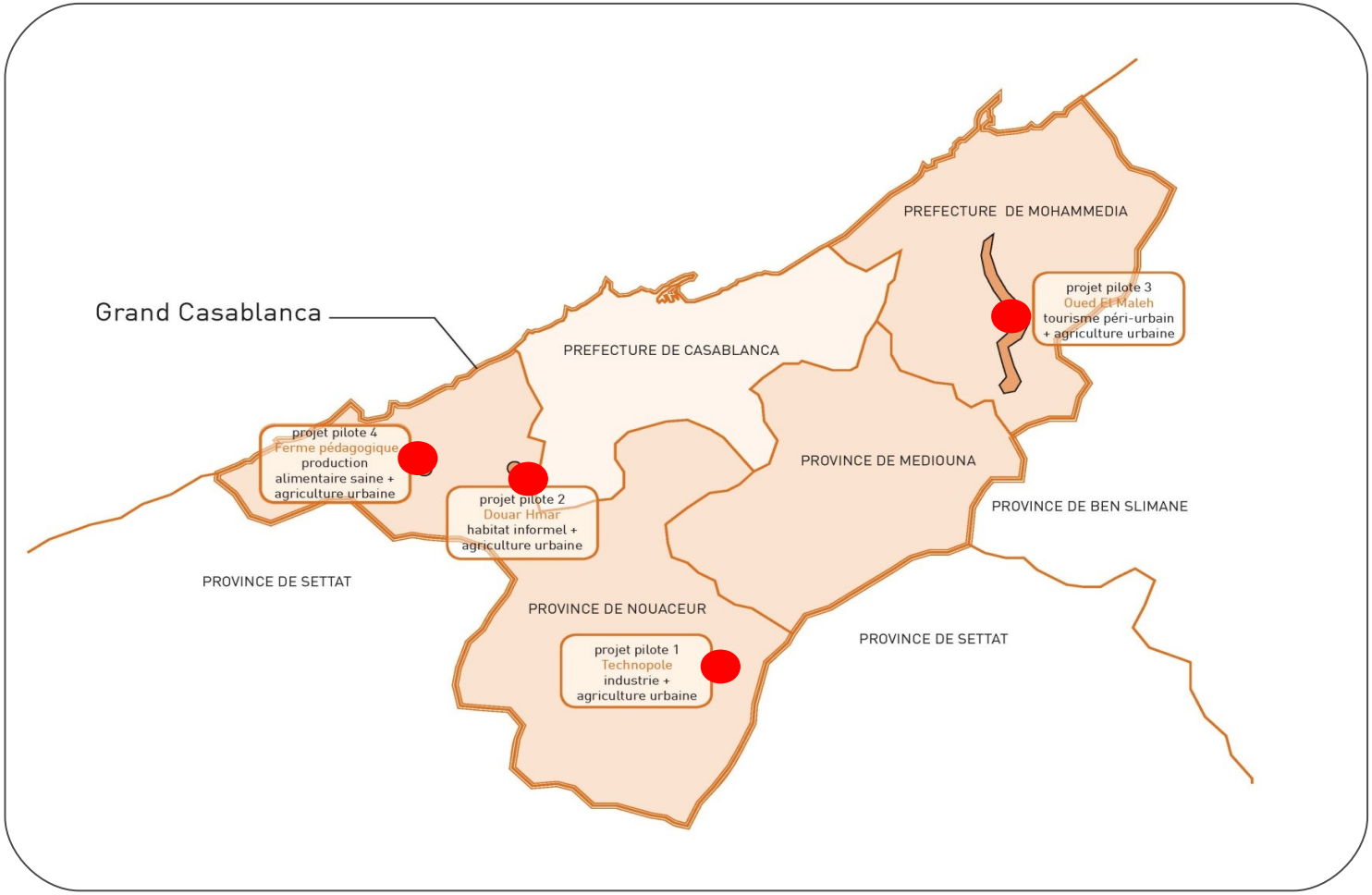
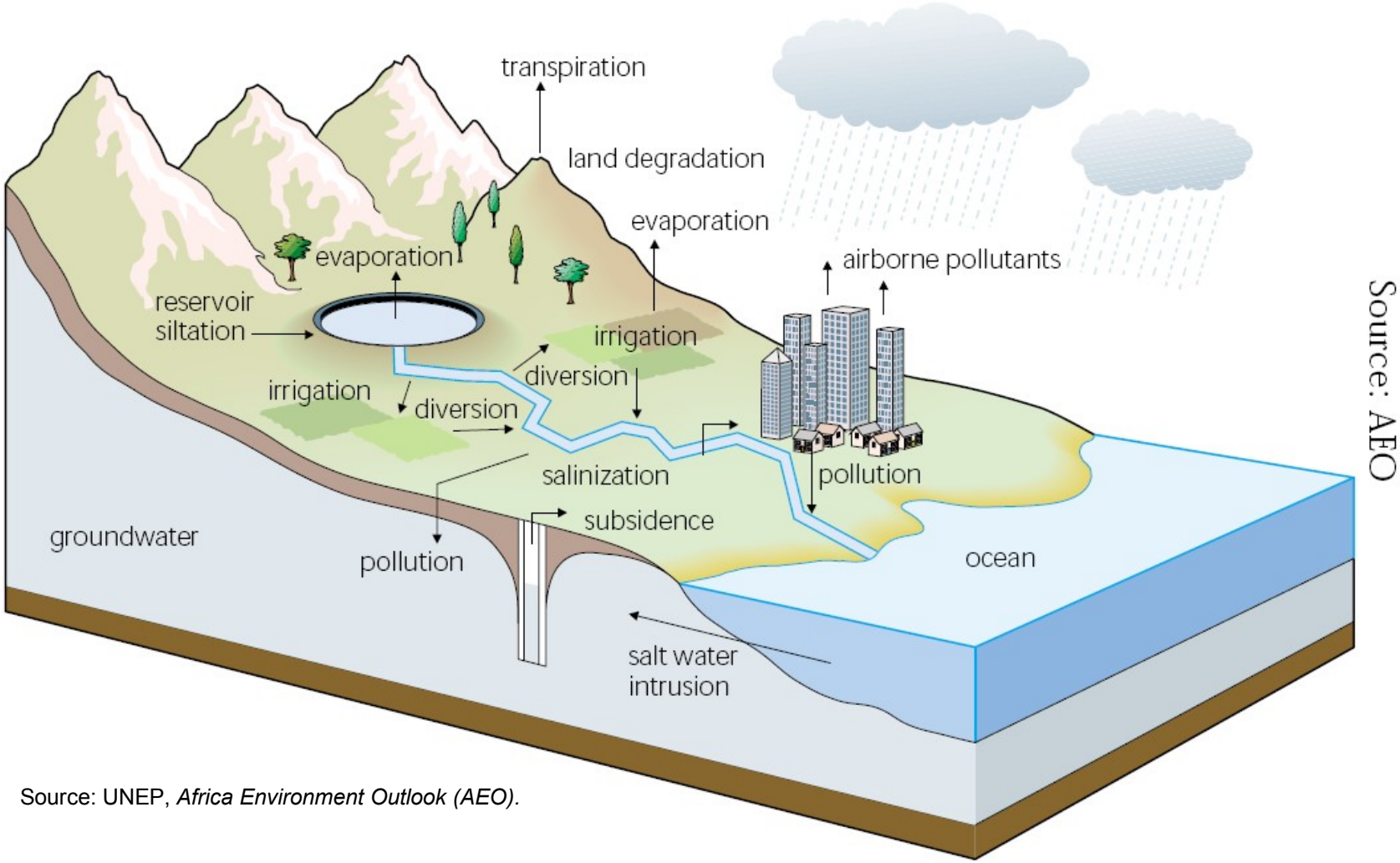
++ food provision +++ regional products and markets +++ recreational space +++ beautiful landscape +++ natural heritage ++ joint water use +++ water treatment systems +++ risk management +++ income generating activities +++ open space production +++ healthy habitat development +++ resource and energy efficient cycles +++ peri-urban tourism +++ adapted technologies +++ city as an innovation multiplier +++ reduction of CO_2 emissions +++ network

Pilot projects

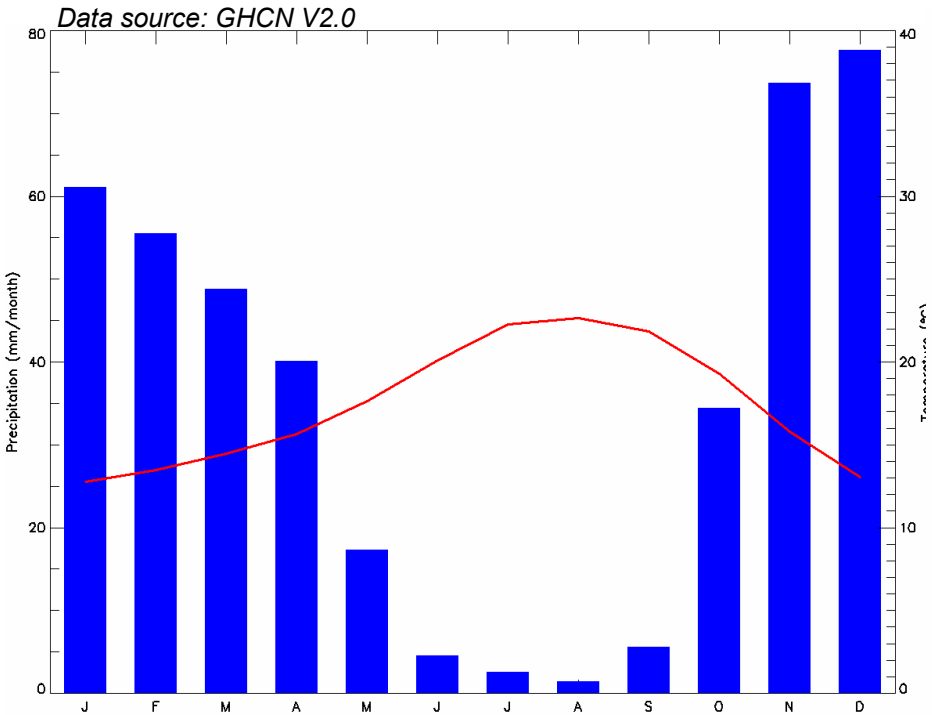


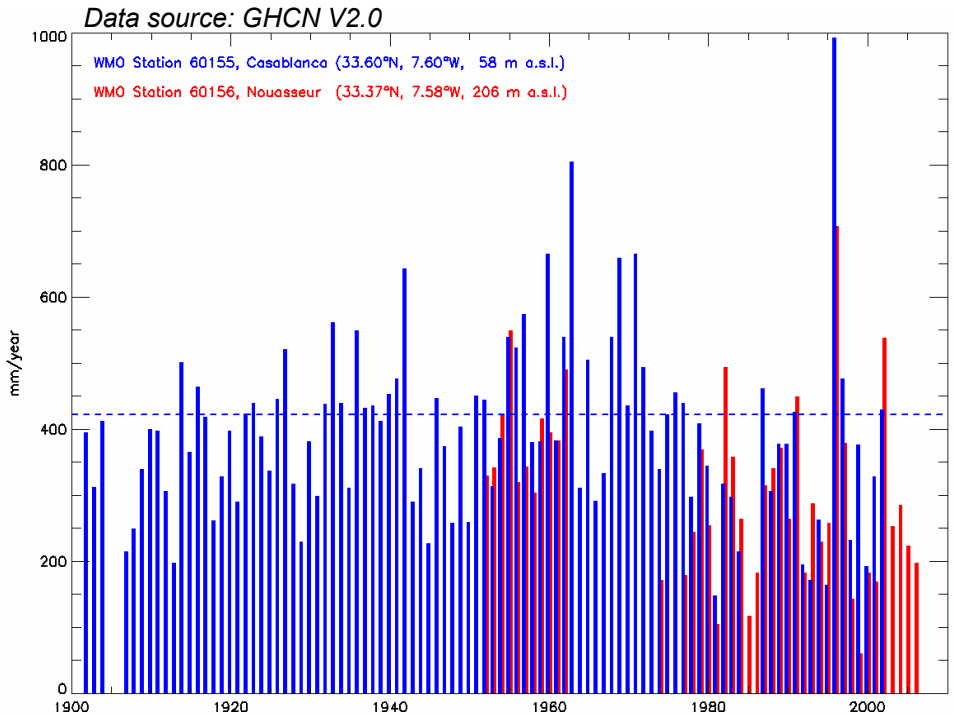
Interlinked stresses on water and land resources



Source: UNEP, *Africa Environment Outlook (AEO).*

Vulnerability of agriculture in the Casablanca region

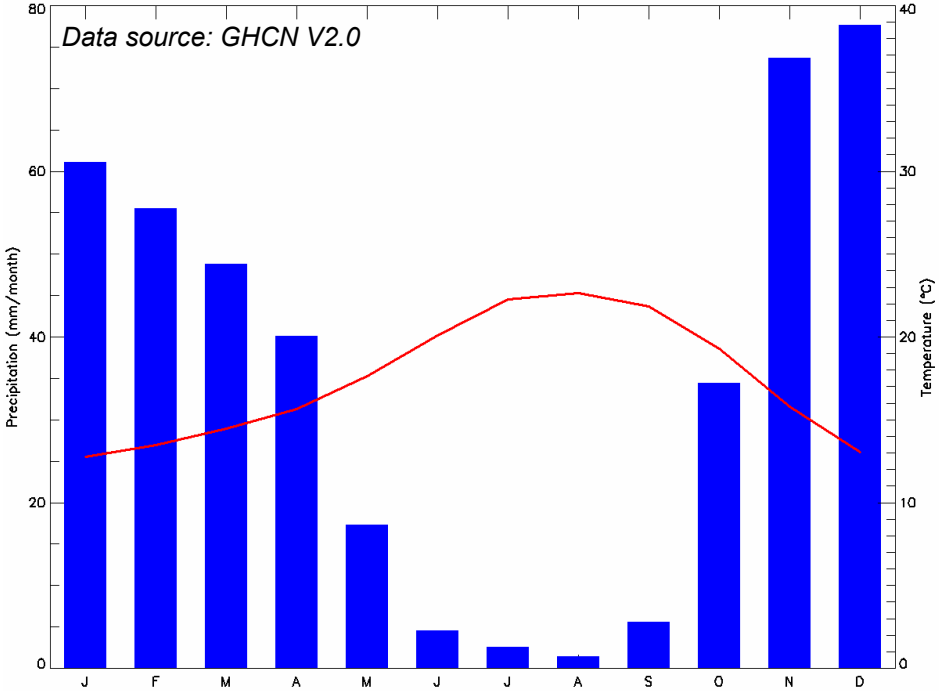


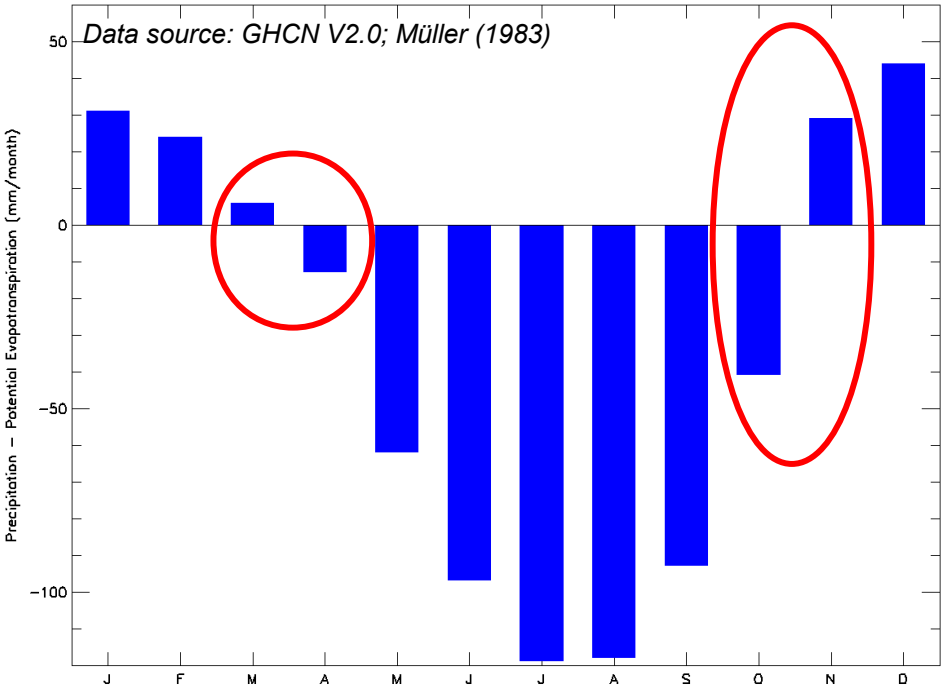


shortage of water resources

flood risks

Shortage of water resources





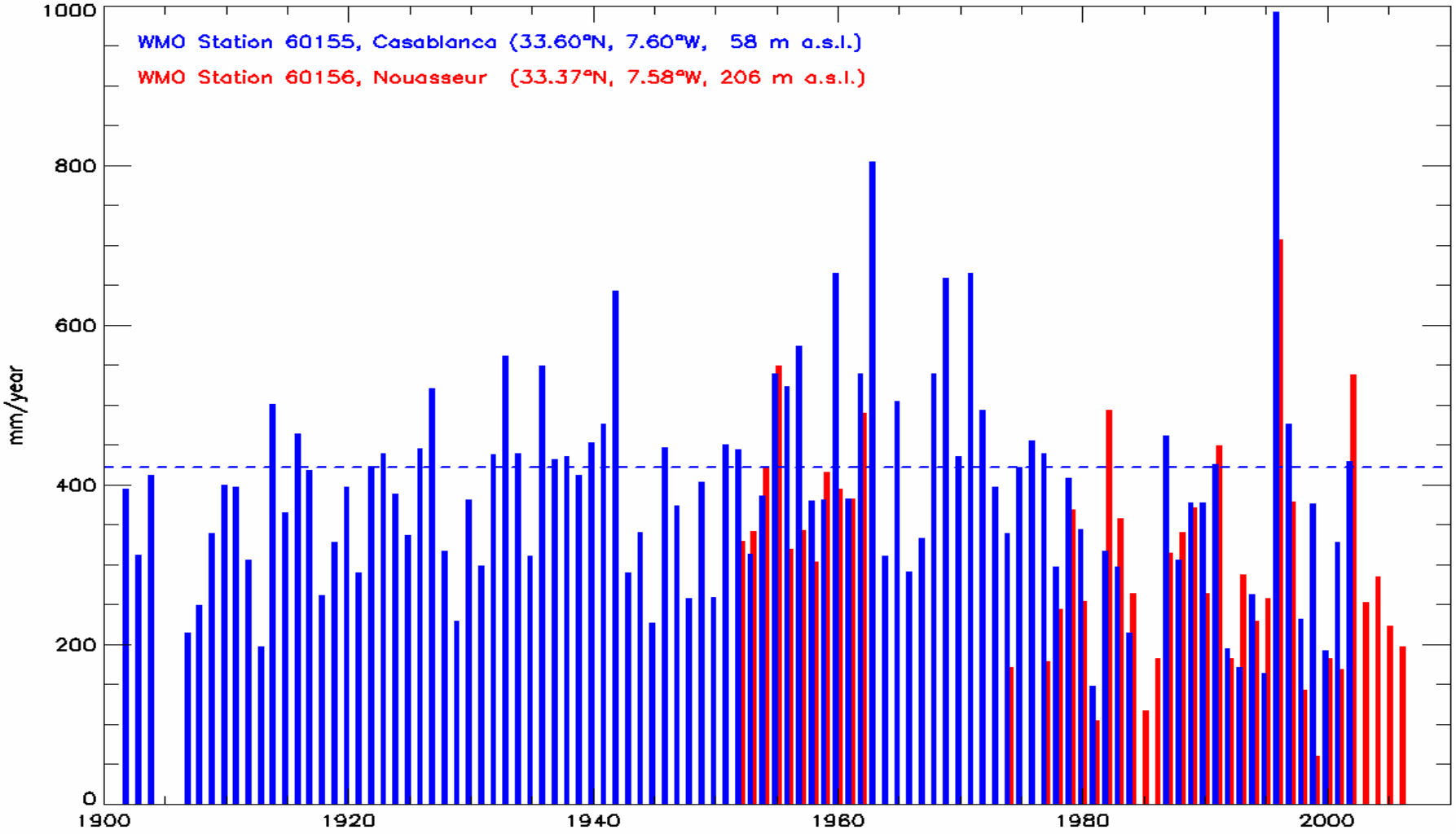
decreasing precipitation
increasing air temperatures
too high water consumption
overexploitation of ground water

→

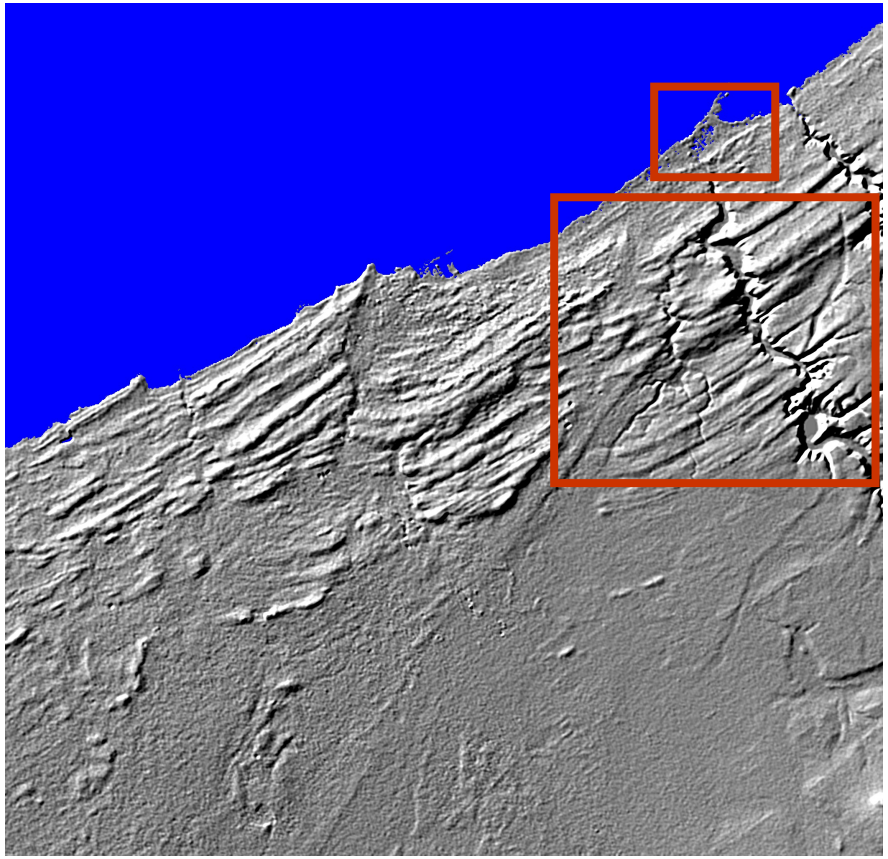
increasing evapotranspiration
decreasing ground water recharge
increasing drought risks
soil degradation (esp. salinisation)

Flood risks

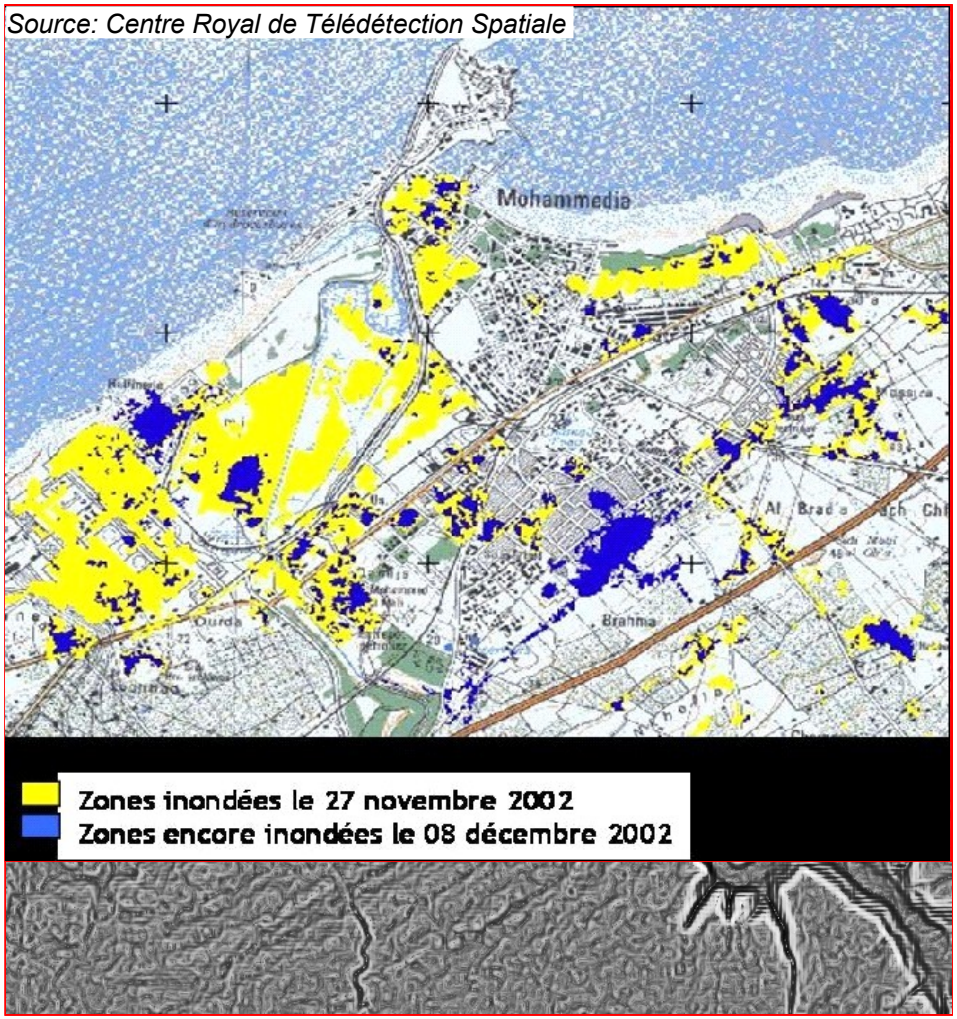
Data source: GHCN V2.0



Flood risks linking agriculture and cities



Data source: SRTM V2.0.



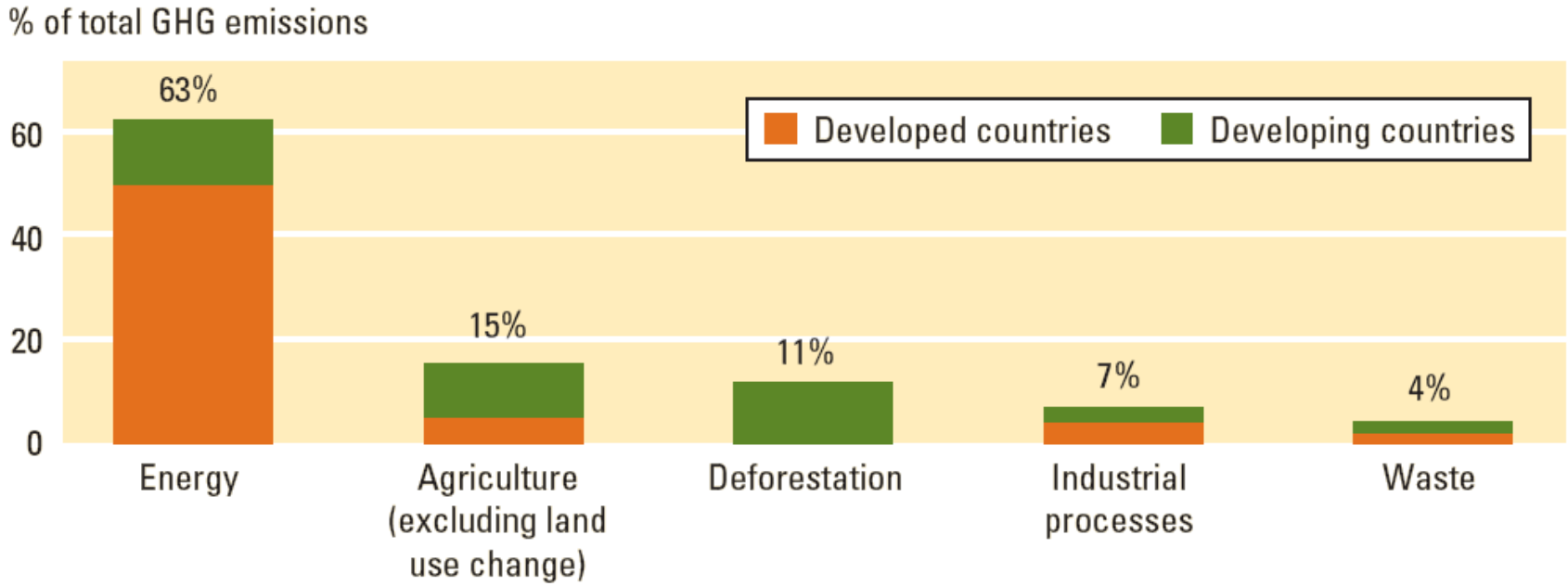
	Environment	Economy	Society
Space	land cover natural resources natural hazards	land use use of resources natural risks	land ownership access to resources refuge areas
Time	environm. variability environm. change predictability	market variability economic growth economic risk	population dynamics age distribution migration
Culture	environm. awareness environm. regulations agricult. engineering	products markets income structures	education system traditions, religion politics, institutions, system

Climate Change

Thematic areas for adaptation/mitigation strategies

- evapotranspiration
- ground water uptake/recharge
- soil moisture
- water storage in artificial lakes
- surface runoff and interflow
- flood forecasting and risk assessment
- retention areas and intermediate water storage
- crop growth and yield forecasting
- irrigation scheduling
- soil salinisation and pollution

Figure F.1 Agriculture and the associated deforestation are major sources of GHG emissions

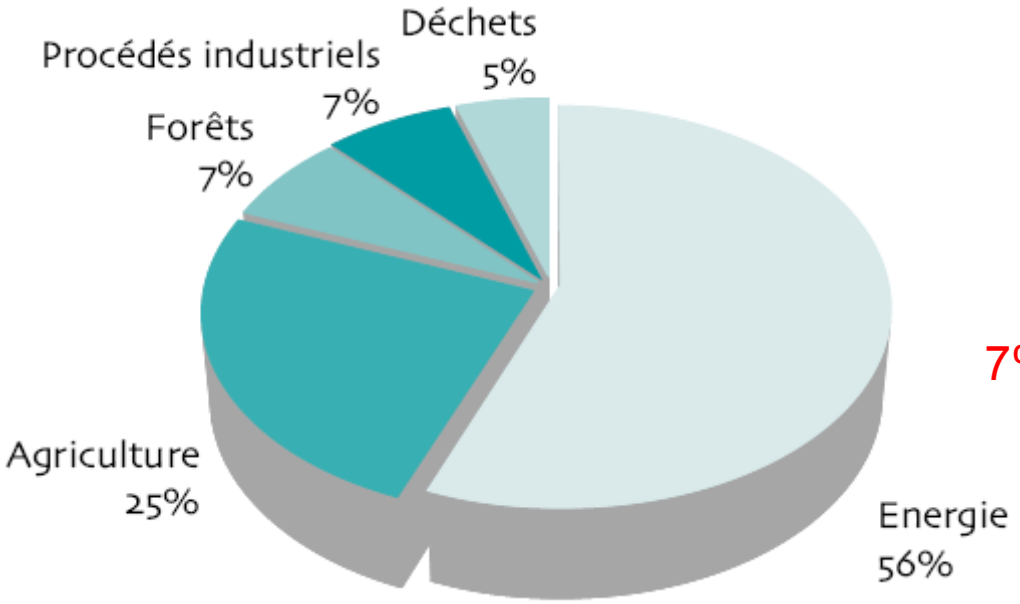


Source: WDR 2008 team based on data from the United Nations Framework Convention on Climate Change, www.unfccc.int.

Note: These are the latest available data for developing countries as a group, and consistent comparisons using UNFCCC data are possible only for 1994 data. There is a large range of uncertainty about gross emissions from land use change (mainly from deforestation). The best estimate of the contribution of emissions from land use change to total emissions is 20 percent (with a range from 10 to 30 percent) of total global emissions during the 1990s (Watson and others 2000). The UNFCCC estimate of total emissions from deforestation based on emissions inventories as reported by developing countries (11.4 percent) is a low-range estimate.

The World Bank: World Development Report 2008, Agriculture for Development

Annual emission of E-CO2 in Morocco (1994)
47.9 Mt = 1.84 t per person



7% by agriculture

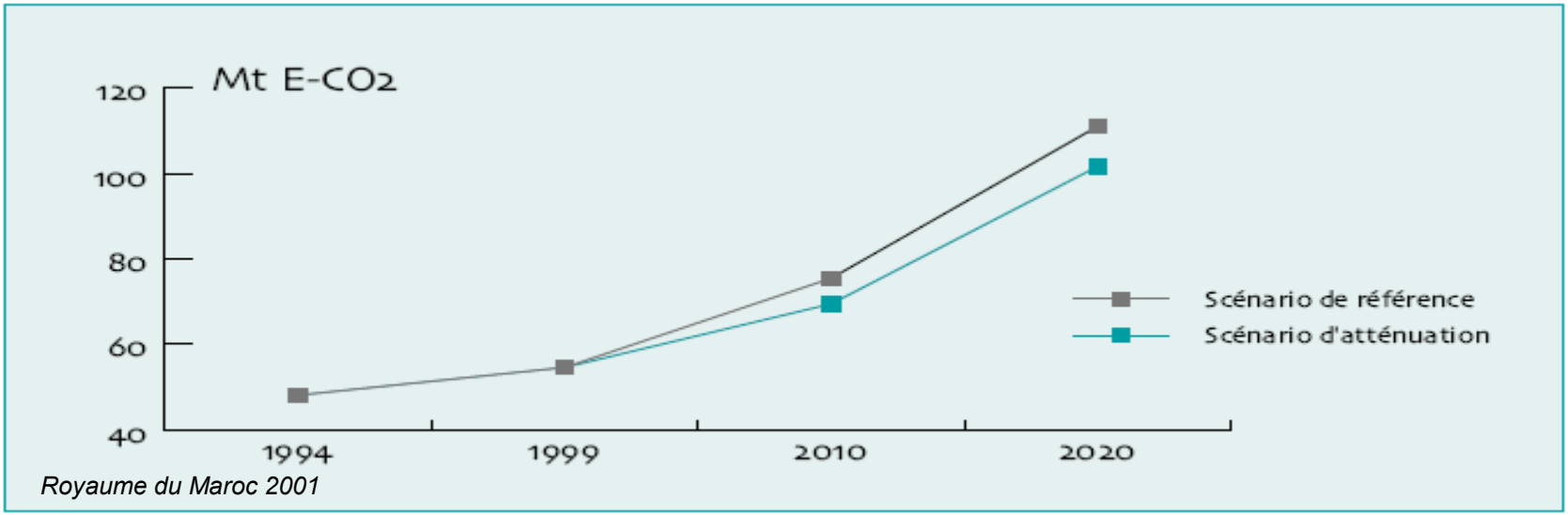
Royaume du Maroc 2001

1994	CO_2	CH_4	N_2O	E-CO_2	%	%	%
Total en kilotonnes	**31908**	**349**	**28**	**47917**	**100.0**		
Energie	**25205**	**64**	**1**	**26859**	**56.1**	**100.0**	
Energie (combustion)	**25205**	**55**	**1**	**26670**	**55.7**	**99.3**	**100.0**
Industries de l'énergie	8603	7	0	**8750**	**18.3**	32.6	32.8
Industries manuf. et de const.	4694	0	0	**4694**	**9.8**	17.5	17.6
Transports	5815	1	0	**5836**	**12.2**	21.7	21.9
Tertiaire	459	4	0	**543**	**1.1**	2.0	2.0
Résidentiel	2390	43	1	**3603**	**7.5**	13.4	13.5
Agriculture et Pêche	3244	0	0	**3244**	**6.8**	12.1	12.2
Energie (émissions fugitives	**0**	**9**	**0**	**189**	**0.4**	**0.7**	**100.0**
Procédés industriels	**3158**	**0**	**0**	**3158**	**6.6**	**100.0**	
Ciment	3133	0	0	**3133**	**6.5**	99.2	
Chaux	11	0	0	**11**	**0.0**	0.3	
Soude	14	0	0	**14**	**0.0**	0.4	
Agriculture	**0**	**192**	**26**	**12092**	**25.2**	**100.0**	
Fermentation entérique	0	184	0	**3864**	**8.1**	32.0	
Gestion du fumier	0	7	5	**1697**	**3.5**	14.0	
Rizières	0	1	0	**21**	**0.0**	0.2	
Sols agricoles	0	0	21	**6510**	**13.6**	53.8	
Forêts	**3544**	**0**	**0**	**3544**	**7.4**	**100.0**	
Emissions	**8634**	**0**	**0**	**8634**	**18.0**	**243.6**	**100.0**
Bois de feu	8055	0	0	**8055**	**16.8**	227.3	93.3
Autres utilisations du bois	537	0	0	**537**	**1.1**	15.2	6.2
Incendies	42	0	0	**42**	**0.1**	1.2	0.5
Absorptions	**-5090**	**0**	**0**	**-5090**	**-10.6**	**-143.6**	**100.0**
forêts naturelles	-2675	0	0	**-2675**	**-5.6**	-75.5	52.6
reboisements	-1835	0	0	**-1835**	**-3.8**	-51.8	36.1
arboriculture	-580	0	0	**-580**	**-1.2**	-16.4	11.4
Déchets	**0**	**94**	**1**	**2284**	**4.8**	**100.0**	
Déchets solides	0	93	0	**1953**	**4.1**	85.5	
Eaux usées	0	1	0	**21**	**0.0**	0.9	
Déjections humaines	0	0	1	**310**	**0.6**	13.6	

Data source: Royaume du Maroc 2001

E-CO_2 = CO_2 + 21 CH_4 + 310 N_2O

Reduction scenario for annual emission of E-CO_2 in Morocco



Royaume du Maroc 2001

	1994	2010	2020
Emissions brutes kt E-CO_2	53007	81155	117396
Absorptions de CO_2 kt	5090	5700	6300
Emissions nettes kt E-CO_2	**47917**	**75455**	**111096**
Population (M)	26.0	33.2	37.4
par habitant	**1.84**	**2.27**	**2.97**

Data source: Royaume du Maroc 2001

beyond the threshold of 2

2 t E-CO per p. and a.

Reduction scenario for annual emission of E-CO_2 in Morocco

	Observed		Reference		Reduction	
Emissions nettes kt E-CO_2	**1994**	**1999**	**2010**	**2020**	**2010**	**2020**
Energie	26839	31139	45836	72764	41522	65492
Procédés industriels	3158	2826	4080	5698	3525	5143
Agriculture	12092	13981	18064	23894	18064	23894
Forêts	3544	3835	2318	1155	1720	56
Déchets	2284	2850	5158	7586	4694	7122
Total	**47917**	**54631**	**75455**	**111096**	**69525**	**101707**
%	**100.0**	**114.0**	**157.5**	**231.9**	**145.1**	**212.3**
Reduction (%)					**7.9**	**8.5**

Data source: Royaume du Maroc 2001

No reduction is considered for agriculture

Both adaptation and mitigation strategies are required!

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