Geo Factsheet

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DROUGHT

Introduction

Drought is a complex geographical phenomenon, although its fundamental definition is of a shortfall or deficiency of water over an extended time period, usually at least a season. It is not the same as **aridity** which is a permanent climatic condition, whereas drought suggests a need for people to adapt to relatively short term, uncharacteristically dry situations. Drought has a long period of onset, sometimes several years, which makes it difficult to determine whether a drought has begun or whether it is just a dry period.

According to the classic definition of drought, areas of increased drought due to rainfall deficits include the Sahel and East Asia. El Niño, which has increased in frequency and severity in recent decades, also reduces rainfall in these regions.

However, global climate change is increasing the development of drought through increased evaporation, brought on by rising temperatures and the severely affected area has doubled to more than 30% in the past 30 years. Drying of the land surface through evaporation has been significant in Europe, Canada and Asian landmasses, plus eastern Australia.

Measurement of drought

There are various indices to calculate drought, but most use a water balance approach (inputs of precipitation and losses due to evapo-transpiration and runoff):

- **Palmer Drought Severity Index (PDSI):** *this applies to long term drought and uses current data as well as that of the preceding months, as drought is dependent on previous conditions. It focuses on monitoring the duration and intensity of large scale, long-term, drought-inducing atmospheric circulation.*
- **Crop Moisture Index (CMI):** *this is a measure of short-term drought on a weekly scale and is useful for farmers to monitor water availability during the growing season.*
- **Palmer Hydrological Drought Index (PHDI):** *the hydrological system responds slowly to drought, both in reacting to drought and recovering from it, so different models need to be developed for rivers, lakes etc.*

Types of drought

Drought is defined in different, but sometimes interrelated ways, according to its impacts. The following types of drought are sequentially related, as seen in *Fig. 1*.

1. Meteorological drought

This is defined by shortfalls in precipitation and the duration of the dry period. Rainfall deficiency is very variable so meteorological drought is only measured on a regional scale. The causes of rainfall deficiency are:

- Natural variation in the atmosphere conditions
- El Niño events
- Changing land use
- Climate change creating regional and local effects

2. Agricultural drought

This is where rainfall deficiency is linked to plant growth. Essential soil water will not only be controlled by rainfall, but also temperature, evaporation and groundwater levels. A soil moisture budget can show if the deficit stage is protracted or more severe than normal.

3. Hydrological drought

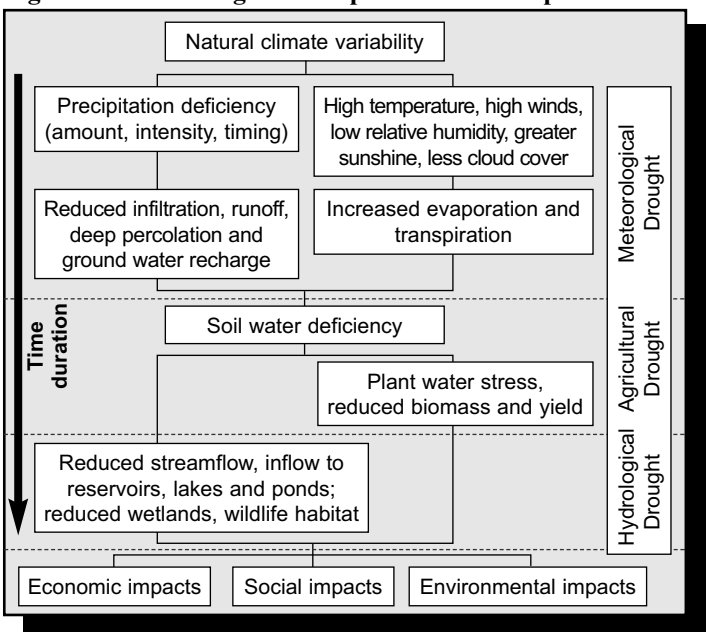
Although all droughts have their origins in a lack of rainfall, lesser amounts of water passing through a river catchment area will create a lag effect. This means that an impending water shortage will not be noticed at the same time as agriculturalists who see that dry topsoil is affecting new plant growth. The clearest indications of hydrological drought are river and reservoir levels which are stores in the system and used for multiple and often competing uses.

Associated with hydrological drought on a river basin scale is the impact of changing land use. It is well-known that deforestation contributes to a drier climate as evapotranspiration decreases and this is seen in the Amazon basin, particularly on the east coast where 95% of the Atlantic rainforest has been cleared. When deforestation occurs on a massive scale, it feeds into meteorological drought which then affects regions outside the area of changed land use.

4. Socio-economic drought

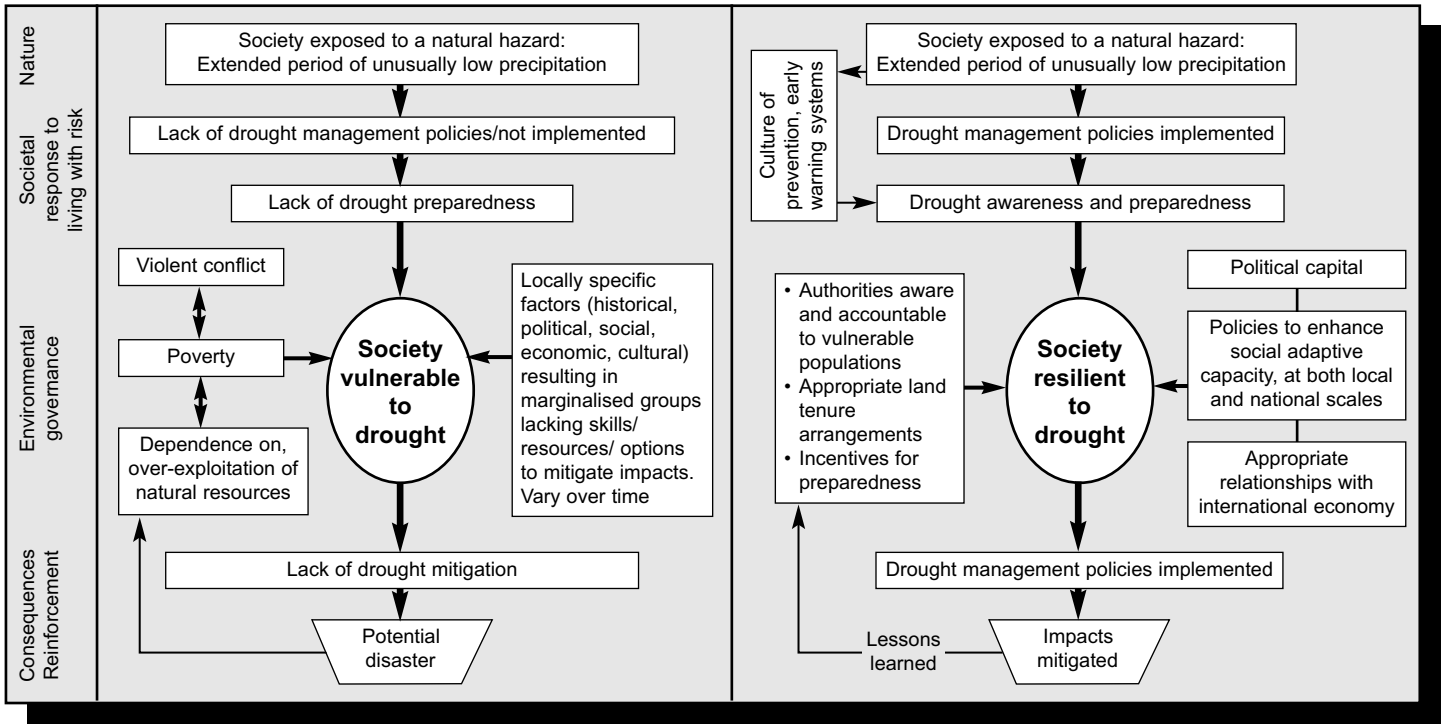
As societies increase and develop, so does their water demand. Natural variability in climate can cause a decline in water supply and stores are not replenished. As climate change occurs and some areas become more susceptible to drought, so people will also become more vulnerable.

Fig 1 Model of drought development and its impacts.



Source: *National Drought Monitoring Centre www.drought.unl.edu/whatis/concept.htm*

Fig. 2 Model showing factors affecting vulnerability.



Source: *UNDP – ISDR 2003.*

Vulnerability to drought

Where populations are directly dependent on the land, they will be more vulnerable to drought or floods, which often go together, due to the fact that when drought ends, the land is baked hard, rainfall cannot infiltrate and soil erosion occurs due to overland flow. This then lowers yields and increases food insecurity in the region which can ultimately develop into famine conditions. The UNDP's Vulnerability Report 2003 assessed drought as the most damaging natural hazard on a global scale.

Fig. 2 shows how differing attitudes to living with risk determines future impacts. Vulnerability is increased if a family or society has no means of diversifying their livelihoods and are dependent on growing a single crop. Alternative means of generating income means that groups are more likely to survive climatic disruptions to their environment. Preparedness for drought has a major effect on vulnerability from national to individual scales.

If there is a long recurrence interval of drought in a region, people may be unaware of the hazard or take risks in times of adequate rainfall by implementing inappropriate farming practices, or governments may encourage settlement in otherwise fragile areas. Only when the environment later becomes stressed by water shortage can these past practices be seen to have actually increased people's vulnerability.

Impacts of droughts

Whilst drought is a consequence of rainfall deficiency, the impacts of water shortage increase in areal extent and severity due to rising populations, increased demand and mismanagement of resources. Areas most at risk are where rainfall variability is greatest, such as sub-Saharan Africa and Asia. Not only do people suffer but also animal health is compromised by degraded grazing land and drought creates problems for long-term agricultural sustainability, which affects the national economy as imports and exports of foodstuffs change. Famine is the extreme consequence. Environmentally, drought increases the risk of dust storms and bush fires which can cause habitat destruction, human deaths and loss of homes. *Table 1* details some of the direct and indirect impacts of droughts.

Table 1 Types of drought impacts.

Type of impact	Direct impacts	Indirect impacts
Economic	• Decreased agricultural productivity, both arable and pastoral	• Reduced income for farmers • Increased price for food • Losses to secondary industries e.g. food processing factories
	• Reduced water levels	• Loss of ecosystem productivity • Increased water bills due to extra pumping and filtration • Restricted river navigation
Environmental	• Fire hazard	• Reduced air quality with possible long-term human respiratory diseases • Damage to ecosystems
	• Soil erosion	• Long term lowering of agricultural yield • Sedimentation of fisheries in rivers and coastal regions
Social	• Food shortage • Increased health risk, including death	• Conflicts between water users • Lower quality of life • Increased concentration of pollutants, with additional health risks • Population migration

Coping with drought

Due to the slow onset of drought, response to it is often reactive, causing unnecessary conflicts between water users and higher costs, when a more anticipatory approach can conserve water resources and minimise impacts. Also, there is a recognition that drought resilience needs to be built into sustainable development projects from the outset, rather than drought being managed as an isolated natural hazard. Diversifying income-generating activities enable people to be more resilient, but this is difficult when there is such deep poverty and food insecurity. Farmers can stagger planting so that demand for water is spread more evenly over time and pastoralists may migrate to new areas, though this is not always possible as settlement has increased so markedly in drylands. Wilhite et al have developed a management model as seen in *Table 2*.

Table 2 Ten-step planning process. ***Source:*** *Adapted from National Drought Mitigation Center, Nebraska, USA.*

	Planning outline	Explanation
Step 1	Appoint a drought taskforce	Multidisciplinary – government officials, academics, interest groups etc
Step 2	State the purpose and objectives of the drought preparedness plan	E.g. identify groups/activities most at risk; develop appropriate mitigation plans
Step 3	Seek stakeholder participation and resolve conflict	Tensions increase between different user groups with different values during drought; pressure groups can wield disruptive power if not included
Step 4	Make an inventory of resources and identify groups at risk	Water - its location, quality etc; grassland and forest quantity and quality. Past records of frequency, intensity and duration of event. Vulnerability to drought is caused by social factors such as population growth, migration, changing land use, government policies etc.
Step 5	Write the drought preparedness plan	1. Monitoring, early warning and prediction of drought 2. Risk and impact assessment 3. Mitigation and response
Step 6	Identify research needs and fill institutional gaps	Concurrent with Steps 4 and 5
Step 7	Integrate science and policy	Improve communication between academics and policy makers
Step 8	Publicise drought preparedness plan and build public awareness	Publish news stories of impact as well as success stories of mitigation
Step 9	Develop education plans	Raise awareness so that public awareness is not lost in non-drought years
Step 10	Evaluate and revise drought preparedness plan	Ongoing – new technology, new laws, change in political leadership Post-drought – economic and social consequences, examples of failure and resilience

Case study - Australian drought 2006-7

The drought that affected SE Australia reached its peak between December 2006 and February 2007 and was connected to an El Niño event. Although it was not as strong as in 1998, and its slow onset led some scientists to question whether an El Niño would develop, conditions in October and November ranked it the fifth most severe since 1950 (NOAA). It then weakened during March-May 2007. The drought was broken by La Nina, where the equatorial Pacific cools and easterly Trade winds strengthen, bringing higher-than-average rain. However, although predicted to continue at least until March 2008, the rains have not been sufficient to recharge storages in the natural system.

The drought issue pitted ***"town against country"****. Are lives more important than livelihoods?*

The 1-in-1000 year drought in 2006-7 was exacerbated by population development and water demand. The River Murray is the main water source for agriculture and drinking water and this extraction has meant that no water has flowed at the mouth of the River Murray for the last four or five years. Adelaide uses 11% of the Murray's water and 80% of the city was in severe danger of running out of water.

Climate change by 2030 might reduce rainfall at Adelaide by 15% (CSIRO - Australia's national science agency). At the same time, a rising population is expected to cause water prices to rise by a factor of 5-10. Future responses to El Niño-induced drought might include:

- *Building desalination plants*
- *Large sewage recycling schemes*
- *Use of storm water*
- *Expand water trading*
- *Improve water retention and quality though bush regeneration.*

Town arguments	Farmers' arguments
• Rice and cotton should not be grown in drought-susceptible regions because they require 65% of all irrigation water • Farmers have too many licences to abstract water from Murray • City parks essential to reduce temperatures and improve health • Blame irrigators for mismanagement of water	• Drought is due to lack of rain, not agricultural practices • Water needed for all crops – Murray Basin produces 50% of Australia's food • City parks seen as lifestyle choice • City restrictions on water use were minimal – e.g. no sprinklers, time restrictions on handwatering whereas farmers close to ruin • People were wasting water – usage is greater per head than Los Angeles

Case study – USA 2007

California

The Californian fires of October-November 2007 were due to the Santa Ana winds, a type of Fohn wind, blowing out from the Great Plains, between the Rockies and the Sierra Nevada. The air loses its moisture as it is forced to rise by the mountain ranges but the high pressure which develops in the Great Plains high altitude region also heats air adiabatically during its descent, making it even drier. The clockwise circulation draws winds from the interior towards the coast, rather than the usual westerly winds at this latitude. Humidity was as low as 15% and this, coupled with temperatures above 90o F, resulted in nearly half a million acres of burnt chaparral vegetation.

2007 (at going to press) was set to become the driest year on record - some places received only 25% of their average rainfall, so the ecosystems' water stores were reduced, drying out forest and grasslands. Also, snowfall in the Sierra Nevada which supplies much of California's drinking water, was significantly lower. The Colorado River experienced its sixth year in seven of below average discharge.

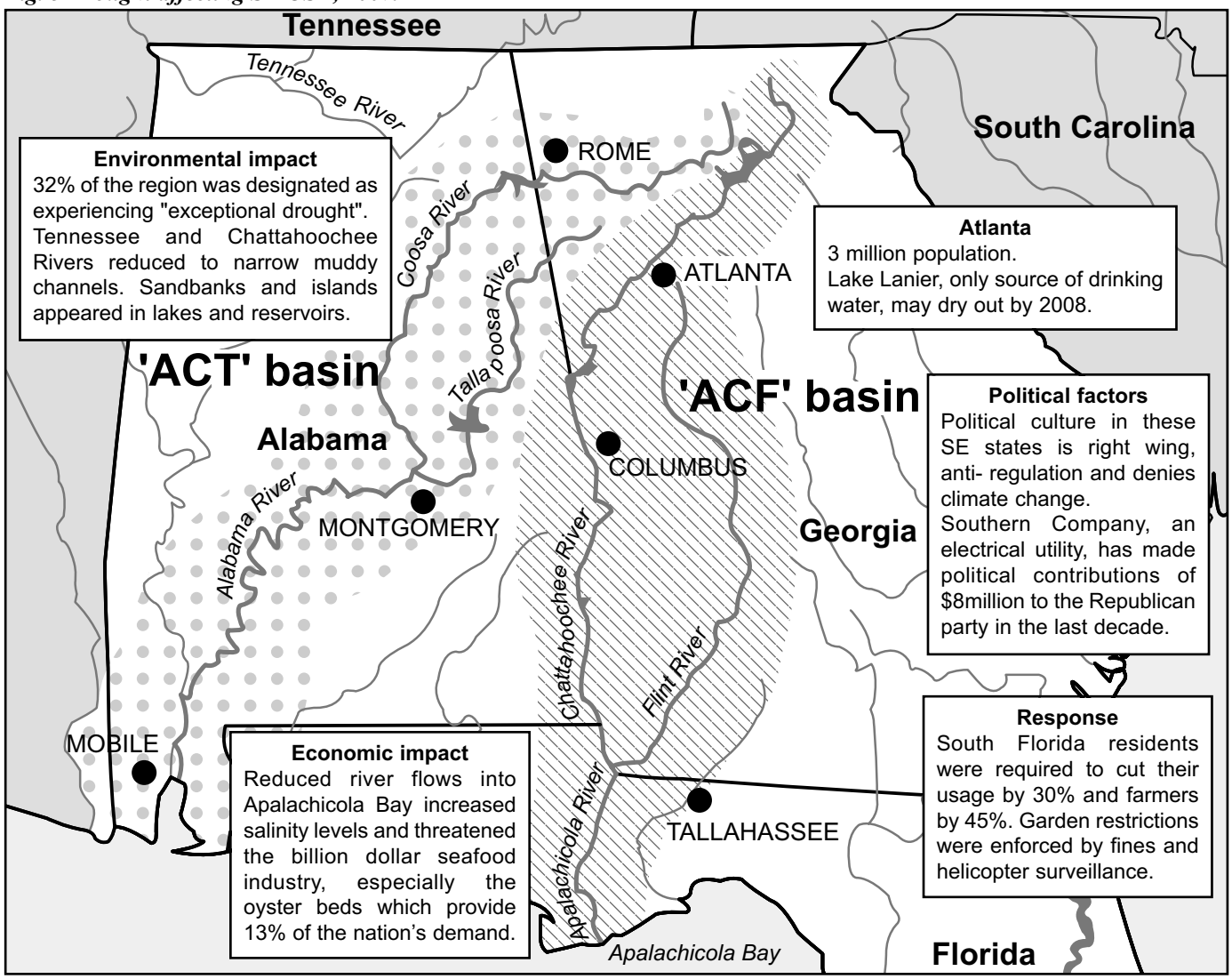
The wildfires in California and evacuation of Hollywood homes meant that the drought received more attention than is usual for such a hazard, as mostly it is a creeping hazard and produces chronic conditions rather than extremely sudden and violent ones.

Seven people died but numbers were low due to mass evacuation. The Californian Governor Arnold Schwarzenegger proclaimed a state of emergency which meant that funds were available for firefighting units and emergency response programmes. Homes, business and infrastructure were destroyed and parts of the state lost power.

Florida, Georgia, Alabama

The Apalachicola River forms at the confluence of the Chattahoochee and Flint Rivers at the Florida-Georgia border and flows into the Gulf of Mexico (see Fig. 5). In November 2007 Georgia suffered its worst ever drought since records began 118 years ago, despite being one of the wettest regions of the country. Conditions were worsened by previous population growth and unplanned demand for water, particularly from the growth of Atlanta, which angered water users downstream. Politicians argued for a reduction of water levels of between 16-60% to cope with the drought, whilst declaring it a state of emergency. During this time Georgia asked to be exempt from discharging water into fragile wetlands, a requirement under the Endangered Species Act, arguing that people are more important. This could be a very shortsighted approach as wetlands are a major store of water and provide many ecosystem services. The widespread drought meant that it was estimated that several inches of rain per day for 6-7 weeks was needed to recharge natural stores.

Fig. 5 Drought affecting SE USA, 2007.



Case study – sub-Saharan Sahel region

In 2000, 2 billion people were living in the world's drylands, occupying half of the total land area. Water availability is the controlling factor in these areas and the environment is very susceptible to climatic shifts, on local and regional scales. Rainfall is dependent on the ITCZ and at the outer tropics this becomes very variable. Even if rainfall occurs, it might not be sufficient. In the first half of the 20th century, rainfall was high enough to support large populations, due to migration into the area and an increasing lifespan. As population increased (18.5% in 1990s) and rainfall belts shifted in the latter part of the 20th century, leading to a fall of 15-30% in places, desertification has occurred. There is evidence that rainfall is becoming more erratic – see Fig. 6.

Fig. 6 Recent trends in African droughts.

Dates	Countries	Nos. affected	Deaths
2005-6	Burundi	2,150,000	120
2005-6	Malawi	4,500,000	unlisted
2005	Niger	3,600,000	unlisted
2004-5	Kenya	5,800,000	107
2002	Malawi	2,830,000	500
1999-2002	Kenya	23,000,000	114
1983-5	Sudan	8,400,000	150,000
1983-4	Ethiopia	7,750,000	300,000
1973-8	Ethiopia	3,000,000	100,000
1965	Ethiopia	1,500,000	2,000

Source: *CRED* *www.em-dat.net*

Traditional livelihoods were a mixture of nomadic pastoralism, hunting, gathering and farming giving a flexibility which was perfectly attuned to the variability of conditions. The growth in population changed food production to a more sedentary and cultivated lifestyle so grasslands became degraded. Globalisation and the growth of export markets have often had the effect of increasing agricultural productivity at unsustainable levels during wetter years. In drylands, this exacerbates food insecurity and in drought years creates conditions leading to potential famine.

The impact of drought in the African Sahel is more severe as people are more marginalised and therefore more vulnerable. They have less ability to influence policy decisions and the high population growth rates, coupled with slow development of health and education services makes societies unable to cope with drought conditions. Cyclical drought has insidious long term effects, as it makes societies less able to respond to each successive event.

The famine in Niger 2005 was due to two main factors – drought and locust infestation during the previous year, which affected grasslands and pastoralism, with food production decreased by 15%. For a country ranked 176 out of 177 in the Human Development Index, this increased its already critical food insecurity situation. The main impacts were:

- *A rapid increase in cereal prices immediately following the harvest*
- *Unavailability of local food commodities*
- *Human consumption of cereal seeds, leaving little in store for the next year*
- *Drop in the price of small livestock, which deprives households of an important source of income*
- *Massive early departure of migrants, especially male labourers from villages looking for work elsewhere*
- *Early transhumance of herders leading to increased herder-farmer conflicts because it occurs "out of season".*

Case study - Eastern Africa and Horn of Africa

Five years of very low rainfall culminated in the severe drought in this region in 2006. Population had doubled in the previous 30 years and is expected to increase by 40% by 2015. About 10% of the population - 3.5 million people - faced starvation in 2006. Livelihoods were drastically affected due to a heavy reliance on agriculture, as tens of thousands of livestock also died or suffered from malnutrition. Not only was production low, but also there was little held in reserve.

The Kenya Red Cross Society launched a year-long relief programme. This consisted of buying and slaughtering cattle and goats, giving the meat back to communities. The livestock market had collapsed so families either sold their animals at much reduced prices which meant they could not afford to buy other commodities, or they kept them but at the risk of them dying anyway and becoming an economic loss to families, as well as degrading the grazing lands which were under severe water stress.

Other support was for water management of clean water and the setting up of mobile health clinics, to treat and educate people in hygiene.

As mentioned before, floods are often associated with droughts and three months of heavy rain at the end of 2006 washed away any of the progress that had been made, emphasising the point that disaster-resilience should be part of any sustainable development planning. Food stocks and agricultural machinery were lost as well as massive soil and riverbank erosion. Although the rains were beneficial to some highland regions, the drought-stricken east and coastal areas suffered the most, and 85,000 people were evacuated, as well as 300,000 people isolated due to broken transport links. The same people became even more vulnerable when an outbreak of Rift Valley Fever meant a total restriction on livestock movement, affecting pastoralists whose main source of food and income came from these markets.

Conclusion

The United Nations has declared a "Decade of Water" from 2005-2015. There is great concern about water demand and unsustainable usage, as well as a decreasing natural supply from precipitation. Trends of drought occurrence and numbers of people affected are increasing and much needs to be done to secure adequate, clean water supplies in the coming century.

Acknowledgements

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