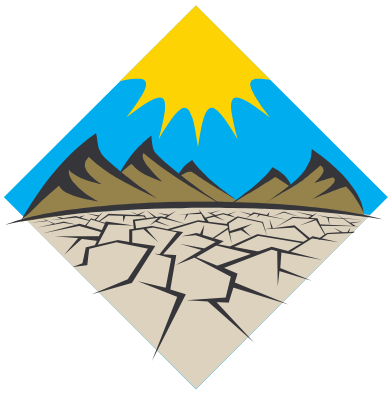
UNIVERSITE VICTOR SEGALEN BORDEAUX 2

# HEALTH IMPACTS OF DROUGHTS

## A REVIEW OF EVIDENCE

Darivianca Elliotte Laloo



**Master's thesis submitted to the Universite Victor Segalen Bordeaux 2 in partial fulfilment of requirements for the award of tropEd- European Master of Science in International Health. September, 2008.**

## Thesis supervisors:

Joanna Orne-Gliemann, ISPED, Institut de Santé Publique et de Développement.
Dr. Franziska Matthies, Global Change and Health, WHO Regional Office for Europe.
Dr. Bettina Menne, Global Change and Health, WHO Regional Office for Europe.

## Jury:

Dr. Pascal MILLET, Centre René Labusquière
Pr. Denis MALVY, Centre René Labusquière
Pr. Jean Louis KOECK, Centre René Labusquière
Pr. Annie SASCO, ISPED, Institut de Santé Publique et de Développement
Pr. Piero OLLIARO, World Health Organization, Geneva

**DECLARATION**

Where other people's work has been used (either from a printed source, internet or any other source) this has been carefully acknowledged and referenced in accordance with departmental requirements.

The thesis; Health Impacts of Droughts, A review of evidence is my own work.

Signature: ……

Total word count: 15,959.

Date: 08-09-2008.

## Acknowledgement

*I would like to acknowledge my work to my supervisors Dr. Franziska Matthies, Dr. Bettina Menne and Joanna Orne-Gliemann who have held my hand throughout the journey and have taken the patience to guide me and get me out of a state of being tangled. The Jury members for their kind guidance.*

*Big gratitude to Professor Millet who has been our pillar of strength here in Europe and has encouraged us to make the right decisions in all aspects.*

*The TropEd network and the Erasmus Mundus programme for turning our dreams into reality.*

*A very big Thank you to people who have helped me in all step of the way especially Tanja Wolf, Christian Schweizer and Vitali Skharuba who I keep running to for the simplest of problem be it computer or scientific.*

*My parents for letting me leave home and be somebody. My good friend and classmate Shirley who is more than a friend but a sister.*

*The churches in Berlin, Bergen, Bordeaux and Rome for making me feel at home. The saviour almighty who has never left my side.*

*Last but not least to the man I love Massimo Darchini for inspiring me to be brave and spread my wings.*

## List of Abbreviations

| | |
|---|---|
| CDC | Centre for Disease Control |
| CI | Confidence Interval |
| CRED | Centre for Research on the Epidemiology of Disasters |
| EM-DAT | Emergency events Database |
| IPCC | Intergovernmental Panel on Climate Change |
| NCHS | National Centre for Health Statistics |
| NDMC | National Drought Mitigation Centre |
| PEM | Protein Energy Malnutrition |
| RF | Relapsing Fever. |
| SLEV | Saint Louis encephalitis Virus |
| WHO | World Health Organization |
| WG II | Working Group |
| WMO | World Meteorological Organization. |

## Contents


1. Executive Summary…… 6

2. Background…… 8

3. Study Objectives……14

4. Study Methods: …… 15

4.1 Study Design……15

4.2 Search and Selection strategy…… 15

(A) Literature Sources…… 15

(B) Published time…… 15

(C) Language of Literature…… 16

(D) Inclusion criteria…… 16

(E) Exclusion criteria…… 17

(F) Key words……17

4.3 Quality Assessment…… 20

4.4 Data Extraction…… 20

4.5 Data Analysis…… …. 20

5. Results……21

6. Discussion…… 57

7. Conclusion…… 71

8. References…… 75

9. Annexes.

# 1. Executive Summary

Droughts like the other forms of natural disasters have been projected to increase in frequency with extreme weather events and climate change. Natural disasters like floods, earthquakes, hurricanes, etc have a fast onset but a drought is an insidious process and has not proven to be quite as frightening as its more sudden counterparts in terms of disaster preparedness. This could be due to limited studies that have been published on the direct and indirect health impacts of droughts. The purpose of this study is to systematically review the available literature on the health impacts of droughts which could prove beneficial to policy makers to prioritise prevention measures. Searching through main scientific databases, 19 studies on health impacts directly or indirectly associated with droughts were included. Overall we identified health impacts that occur during a drought period like Malnutrition, Trachoma, etc and health effects immediate post drought period like Schistosomiasis. These health effects were both directly linked to drought or indirectly by its consequences like an increase in migration and overcrowding. Overall, the literature review revealed that limited literature on this topic is available, however, allowing the identification of research and information gaps. Further research on the health effects of each type of drought affecting a particular region would have to be undertaken. Still, a few recommendations

can be made based on our study results. Malnutrition as a result of drought proves to be the most prevalent in rural areas in Africa leading to increased susceptibility to infectious diseases. Malaria prevention measures should continue even in drought situations. Trachoma is a disease to be more alert to especially now that WHO has set a target for its elimination by the year 2020.

This study hopes to give evidence of the health effects that can occur in drought situations with whatever limited information we have so preventive measures can be prioritized by the policy makers to be included in a disaster preparedness plan for communities decreasing morbidity and mortality in the affected population.

## 2. Background

Natural disasters[1] have direct implications on human health with an increase on mortality and morbidity. For example, more than 255 million people were affected on average by natural disasters globally between 1994 and 2003, with a range of 68 million to 618 million affected (Guha-Sapir, CRED, 2004) and droughts contributes to that figure.

Droughts fall into the climatological classification of natural disasters as defined by CRED (Figure 1) (CRED, 2007).

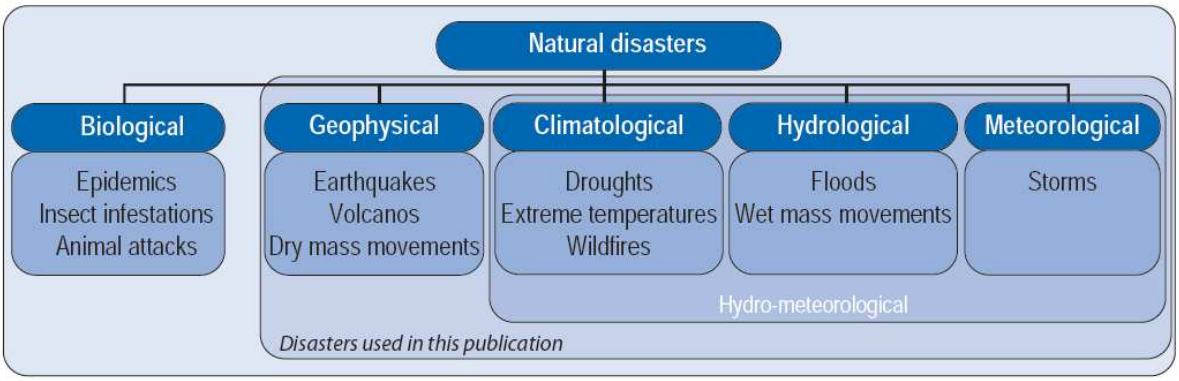



**Figure 1: Classification of Natural Disasters. (Accessed from Annual Disaster Statistical review, Number and trends 2007, CRED)**

During the 2000-2006 periods, climatological disasters accounted for 38% of the total number of victims affected by natural disasters worldwide. 54 climatological events were reported in 2007 of which 11 were drought events (CRED, 2007). Looking back however

[1]CRED defines a disaster as "a situation or event which overwhelms local capacity, necessitating a request to a national or international level for external assistance; an unforeseen and often sudden event that causes great damage, destruction and human suffering"

droughts have affected nearly 2 billion people worldwide from 1900 to 2007 in 549 reported drought events (EM-DAT, 2008) (Annex 1). Although in the present scenario, the number of persons affected by droughts has been reduced by 63% between 1989– 2003 when compared to 1974 -1988 (Table 1) possibly due to an increase in knowledge and an awareness of droughts (CRED, 2007).

**Table 2 - Proportion of change in ratio of affected to killed by disaster type: 1974-1988 versus 1989-2003**

| | 1974-1988 | | 1989-2003 | | Proportion of change between the two periods |
|---|---|---|---|---|---|
| | Total number of disasters (1) | Mean number of pesons affected for one killed | Total number of disasters (1) | Mean number of pesons affected for one killed | |
| Drought | 17 | 119,883 | 17 | 44,748 | -63% |
| Earthquake | 160 | 20,780 | 248 | 8,143 | -61% |
| Extreme temperature | 6 | 2,545 | 48 | 14,915 | +486% |
| Flood | 351 | 9,503 | 874 | 11,763 | +24% |
| Slide | 39 | 1,193 | 144 | 335 | -72% |
| Volcano | 14 | 5,395 | 17 | 11,960 | +121% |
| Wave/surge | 3 | 61 | 4 | 3,096 | +4,975% |
| Wildfire | 11 | 995 | 39 | 2,523 | +153% |
| Windstorm | 346 | 5,977 | 655 | 21,225 | +255% |
| Total | 947 | 11,526 | 2,046 | 13,706 | +19% |

(1) Only entries included with both killed and affected data

**Table 1: Comparative table showing the proportion of change in ratio of affected persons globally. (Accessed from Annual Disaster Statistical review, Number and trends 2007, CRED)**

Drought events have been projected to very likely or likely[2] increase by the Intergovernmental panel on Climate Change[3] (IPCC) (IPCC, 2007). Changes in precipitation and temperature lead to changes in runoffs and water availability due to high rates of decrease in rainfall and increased evapotranspiration. The increase is around 10 to 40% in runoffs in various regions like the high altitude and wet tropical

[2] The likelihood of an occurrence, an outcome or a result, where this can be estimated probabilistically (IPCC,2007)

[3] The IPCC have been established by the World Meteorological Organization (WMO) and the United Nations Environment Programme in 1988 to assess the understandings of all aspects of climate change.

regions (e.g. East and South East Asia) and in dry regions of mid latitude and dry tropics. There is also an increase in water availability in semi-arid areas (e.g. Mediterranean basin, southern Africa, western United States, and north-eastern Brazil) (IPCC, 2007).

Before we go into the health impacts of droughts we need to understand what they are all about. Defining the different types of droughts poses a challenge. There are many ways to define droughts as they are regional in extent with each region having their specific climatic characteristics. Droughts in the North American Plains would differ from the droughts in Western Europe and in Sub-Saharan Africa (WMO. 2006). The mechanism of environmental changes during drought conditions bring different consequences to different sectors such as water management, agriculture sector, the hydroelectric sector, wildlife biology etc, hence have been defined accordingly. The National Drought Mitigation Centre looked on the disciplinary perspective of droughts and has classified them as follows (NDMC, 2006):

(1) Meteorological droughts – occur when the actual rainfall in an area is significantly less than the climatologically mean of that area in a predetermined period. This depends on the monthly, seasonal and annual variability of precipitation in that area.

(2) Agricultural droughts – occur when there is inadequate soil moisture needed to support the growth of crops resulting in crop stress and fall in agricultural productivity.

(3)Hydrological droughts – are associated with the effects of periods of precipitation on surface or subsurface water supply over a period of time leading to mark depletion of surface water and drying of water reservoir. The usage of water by various sectors also plays a big role in the depletion of surface and subsurface water such as irrigation, recreation, tourism, flood control, transportation, hydroelectric power production, domestic water supply, protection of endangered species and environmental and ecosystem management and preservation thereby diminishing water availability.

(4) Socio economic droughts – occur when the water demand exceeds the supply or when the physical water supplies are so low that they negatively affect the community where the drought is occurring.

Agricultural, hydrological and socio-economic droughts consider the human or social aspects of drought, showing the relation between the natural characteristics of meteorological drought and human activities that depend on precipitation (Figure 2). The first sector to be affected when drought begins is the agricultural sector because it depends on stored soil water. Soil water gets depleted

over a prolonged dry period. If precipitation deficiency increases further then people who use other water resources feel the water shortage effects quicker than people who rely on surface water (i.e. water reservoirs and lakes) and also feel it last when the rains comes due to the delay in replenishing these reservoirs. In this study the definition of droughts given by the IPCC in their latest report is used (IPCC, 2007). This definition describes droughts as ……"the phenomenon that exists when precipitation is significantly below normal recorded levels, causing serious hydrological imbalances that often adversely affect land resources and production systems'.

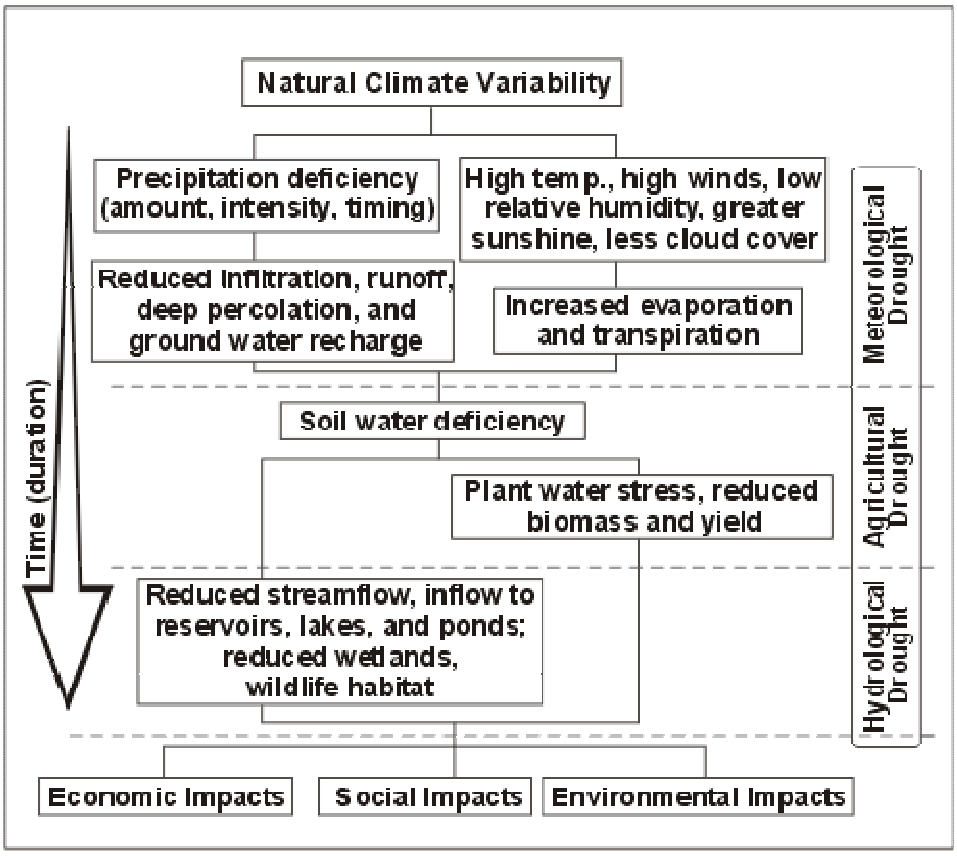



**Figure 2: Sequence of drought occurrence and impacts for commonly accepted drought types. (Accessed from the National Drought Mitigation Centre, University of Nebraska-Lincoln homepage http://drought.unl.edu/whatis/concept.htm)**

Droughts have major effect on the various sectors beginning with agriculture, forestry and ecosystems in which massive land degradation is projected yielding lower crops or crops damage with increased livestock deaths and increased risk of wildfires. More widespread water stress on water resources, effects on industry and settlement in the form of water shortage and decrease hydroelectric generation and potential of human migration (IPCC, 2007) The effect of drought on health include deaths, malnutrition (under nutrition, protein energy malnutrition, and/or micronutrient deficiency), infectious disease and respiratory diseases (Menne et al., 2000) . Droughts and the loss of livelihoods triggers population movement particularly from rural to urban areas possibly leading to an increase in communicable diseases and a lack of safe water, food and shelter (Choudhury et al, 1993) and also increase HIV/AIDS transmission (White, 2003).Warmer, drier conditions will lead to more frequent and prolonged droughts, as well as to a longer fire season and increased fire risk (IPCC, 2007). With all the potential health effects that droughts can trigger there are however **few and limited studies on the evidence base for health effects, making it difficult to plan adaptation strategies by policy makers and come to a state of preparedness by the affected communities.** To date no systematic literature review has been published specifically on droughts and their health impacts except when discussed under natural disasters (IPCC, 2007).

## 3. Study Objectives

### Main research objective:

The aim of this study is to describe the direct and indirect health effects of droughts and discuss their implications for public health preparedness.

# 4. Study Methods

## 4.1: Study design

The study is a systematic review of available literature on the health impacts of droughts.

## 4.2: Search and selection strategy

(A) Literature Sources:

Electronic databases that were searched included Pubmed, Medline, Scopus, Cochrane, and Centre for reviews and dissemination. Psychinfo (OVID) and Embase to identify scientific peer-reviewed publications.

Reference list of selected articles and relevant websites like IPCC (International Panel on Climate Change), WHO (World Health Organisation), WMO (World Meteorological Organisation), WHO Regional Office for Europe, EM-DAT (Emergency Events Database), and CDC (Centre for Disease Control) were also looked into.

(B) Time period of publication:

There was no restriction of time of publication and each database was explored from its beginning to 2008.

(C) Language of literature:

Studies that were published in English, French, German and Spanish were selected when available.

(D) Inclusion criteria:

The literature selected had to fulfil one or more of the below criteria;

- evaluate the epidemiological situation in relation to droughts in any geographical regions

- discuss the direct and indirect health impacts to decrease precipitation, low water availability, and droughts

- discuss various determinants like age, sex, socioeconomic status, etc. on the health impacts caused by droughts

- use the following epidemiological methods: descriptive (quantitative and qualitative), interpretive (appraisal and assessment), evaluative (experimental and non-experimental), or predictive (modelling and scenario analysis)

- have an adequate description of the following questions;

1. Did the study address the scope of the health problem?
2. Was the evidence of the health impacts attributable to droughts?
3. Were the study results relevant to the research question?
4. Was the research executed in the following way?
   a) Study population
   b) Keywords defined
   c) Methodology of the study described
   d) Inclusion and Exclusion criteria given

e) Homogeneity of the results across the groups of studies

(E) Exclusion criteria for peer-reviewed scientific publications:

- Letters and editorials without epidemiological evidences

(F) Keywords: An initial brainstorming was performed on a Mind manager using the software to link the mechanism of a drought to possible consequence

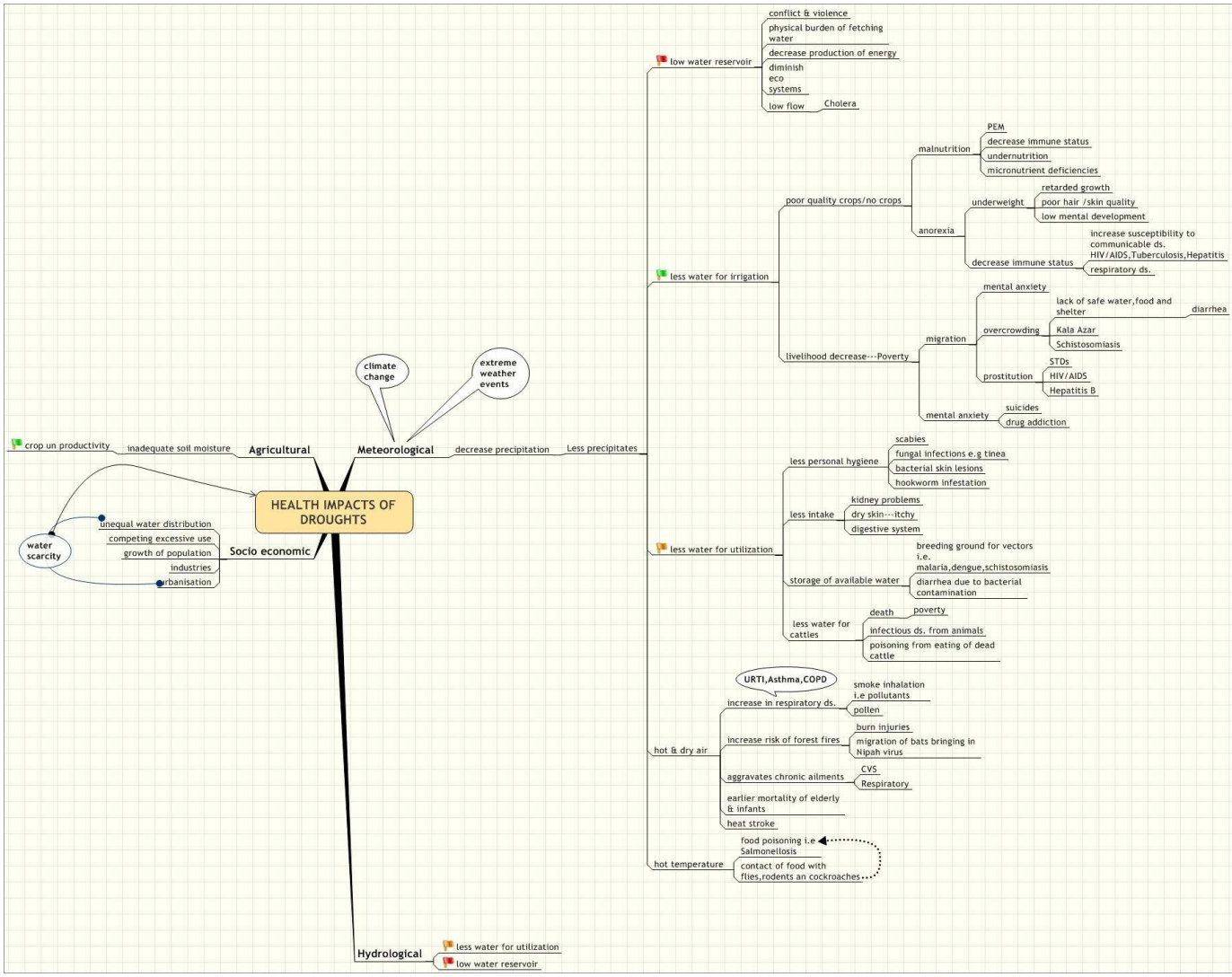



Figure 3. Brainstorming for possible health effects of droughts leading to the definition keywords. leading to ill health

With this result, a flow chart was made with the mechanism and health effects by exposure (in green) to disease outcome (in yellow) (Figure 4).

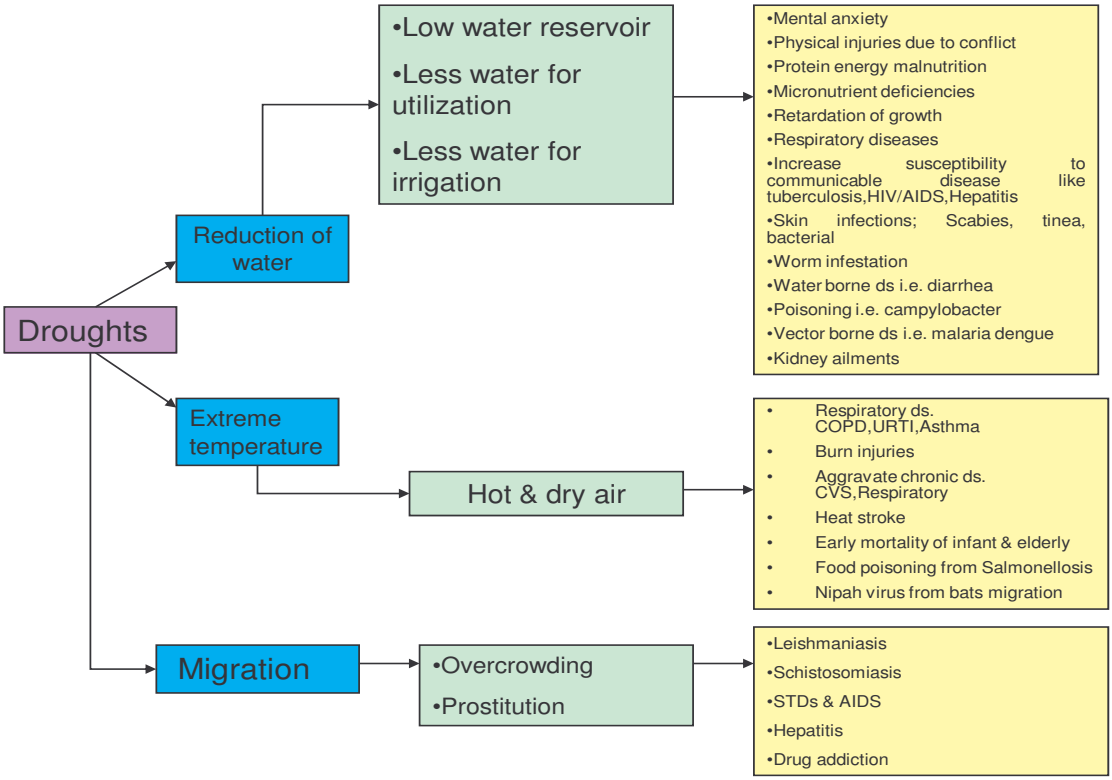



Figure 4:.Possible mechanisms and pathways of health effects of droughts.

Another flowchart was created to link the effects of the exposure to the outcome by disease group (Figure 5).

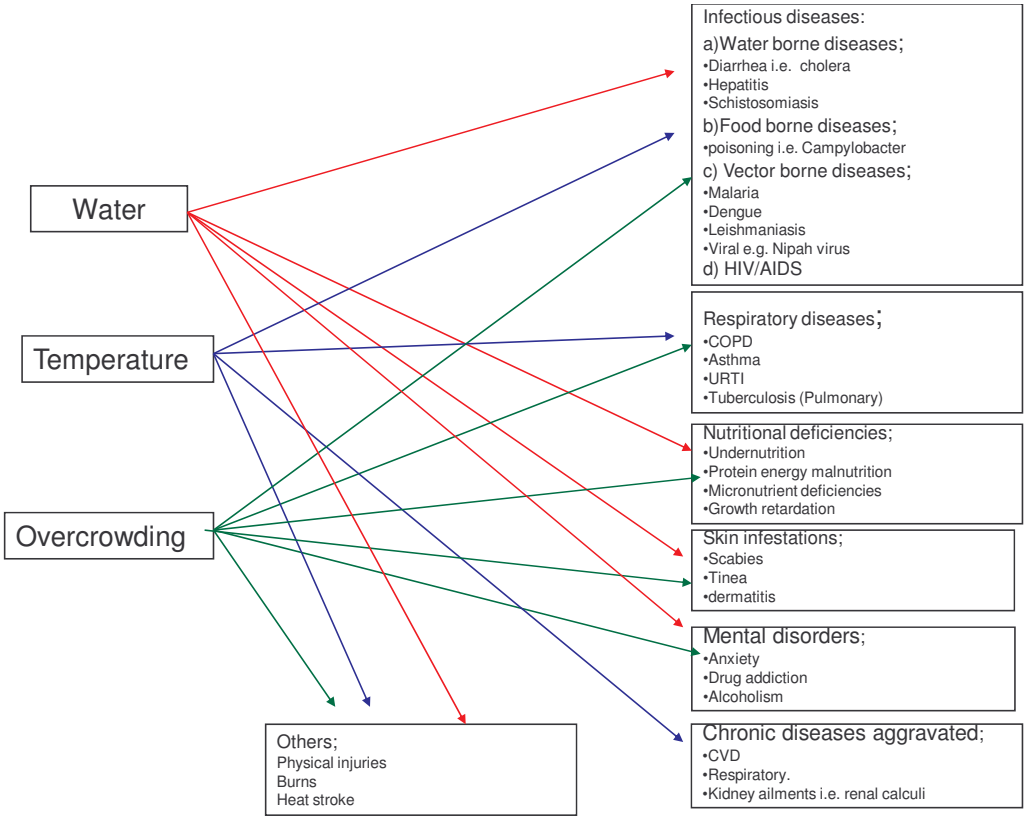



Figure 5: Linking exposure to outcomes (disease wise).

The following keywords (Table 2) were defined and a search of literature from databases was carried out using 'Endnote' as a search tool. First a more general search was performed and then specific diseases were looked for in relation to drought consequences.

Table 2: Keywords

| | |
|---|---|
| **Droughts And** | mortality, infectious disease, respiratory disease, overcrowding, migration, malnutrition, growth retardation, mental effects, intoxication, Aral Sea, food prices |
| **Overcrowding AND** | health effects, diarrhea, malaria, tuberculosis, dengue, leishmaniasis, respiratory disease, mental effects, scabies |
| **High temperature AND Droughts AND** | health effects, fire, hot air AND respiratory diseases |
| **Water scarcity AND** | health effects, diarrhea, schistosomiasis, hepatitis, malaria, scabies, migration, malnutrition |
| **Water availability** | health effects, hygiene AND health effects, Trachoma |

### 4.3: Quality Assessment

The criteria for assessment were;

Q1. Did the study have a clear objective and hypothesis?

Q2. Were the setting and study population clearly described?

Q3. Were droughts and health effects explicitly defined?

Q4. Were results presented in an understandable way?

Q5. Were results and conclusions comprehensively discussed by the authors?

A table was compiled for quality assessment and filled accordingly with all selected studies (Table 3).

### 4.4: Data extraction

Data from selected articles were extracted according to a pre-determined format and filled in accordingly and the main results marked for the results table. An example of the data extraction form is given as Annex 2.

### 4.5: Data analysis

All information was entered into a result format (Annex 3) and is presented in the form of tables

# 5. Results

## (A) Search results:

The keywords were put on the software (endnote) and a search on various databases was carried out. The following were the results in each database searched:

**Pubmed**; A more general search started with 'droughts' AND 'health effects', exclusion of other disaster events from title, exclusion of general climate change studies and only relevant to drought effects.

**Total studies = 225**

| | | |
|---|---|---|
| **Droughts And** | mortality, infectious disease, respiratory disease, overcrowding, migration, malnutrition, growth retardation, mental effects, intoxication, Aral Sea, food prices | 171 |
| **Overcrowding AND** | health effects, diarrhea, malaria, tuberculosis, dengue, leishmaniasis, respiratory disease, mental effects, scabies | 31 |
| **High temperature AND …..Droughts AND** | health effects, fire, hot air AND respiratory diseases | 4 |
| **Water scarcity AND** | health effects, diarrhea, schistosomiasis, hepatitis, malaria, scabies, migration, malnutrition | 7 |
| **Water availability AND** | health effects, hygiene AND health effects, Trachoma | 12 |

**Scopus;** The keywords combinations used were the same and the total results = 317 most of them being not relevant or were duplicates of the ones found from pubmed hence no new studies were added from Scopus.

**Cochrane**; yielded 1 result which was a review article of malnutrition (vitamin A deficiency)and not related to droughts hence not included for the study.

**Embase and Psych info**; could not be accessed without a user identity.

**Centre for reviews and dissemination,** had no results in relation to drought and health effects.

**WHO website;** =1, a general report hence not included.

**CDC website;** = **4 studies**

**Overall Total = 229 studies.**

On further search applying inclusion criteria and exclusion criterias a total of **38** were selected , out of which only **19** articles were available as **full text** and **19** articles were only available as **abstracts** and had to either be purchased as full text . The contact details of the authors were not available for correspondence.

A Quality Assessment was done on the **19 articles** and filled in a table. (Table 3).The quality assessment of the articles were done taking into account the published year of the article, author( first), study area, study population, study period, objective of the study , case definition of droughts, and the questions ( Section 4.3) which

weighted the selection of the articles in relevance to this study question. Data extraction from the article was done by using the Data Extraction Format on each of the articles, (Annex 3). Data Extraction format had prescribed questions such as basic information , eligibility, a background description, methodology of the study, results of the study followed by conclusions and remarks by the author/s. A result table (Table 4) was filled with main results summarized and whether the determinants like age, sex, etc. Played a role on the severity of the health problem mentioned. The selected articles in the table are articles based on the relevance to the research question either directly or indirectly judged by reasons for inclusion and are not specified disease wise or by geographical location.

# Table 3: Quality assessment (see Sec 4.3)

| Published Year | Author (First) | Study Area | Population affected | Study Year | Hypothesis/ objective | Drought defined | Health Impacts | Quality Assessment | | | | | Result |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Q 1 | Q 2 | Q 3 | Q 4 | Q 5 | |
| (1) 1985 | Dondero, T. J, Jr. | Sudan, refugee camp | ND | January to March 1985 | assessments of nutrition and health needs in the drought-affected African nations | Agricultural | Direct & Indirect | O | O | O | X | X | 3/5 |
| (2) 1990 | Mary A. Carnell | Mali, Timbuktu region | 8291 persons in 1019 households | 1983-1985 | describes the demographic and nutritional status | Agricultural ( Sahel) | Malnutrition | O | O | O | X | O | 4/5 |
| (3) 2005 | Gitau. R. | Lusaka, Zambia | 429 women | June 2001 to December 2004 | investigate the effects on maternal micronutrient status and infant growth due to rise in food price | Agricultural | Micronutrient deficiency and growth retardation | O | O | O | X | O | 4/5 |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (4)<br>2007 | Rebekah J. Kent | Southern Province of Zambia | 20 loci | 3 transmission seasons and covered a wet year-drought year-wet year cycle | effects of drought on the genetic structure of Anopheles A. | Hydrological | Malaria | X | O | O | O | X | 3/5 |
| (5)<br>2005 | Michael A Sattler | Central Dar es Salaam, Tanzania | 3 million people | March 1 to May 29, 2003 | Habitat characterization and spatial distribution of Anopheles sp. mosquito larvae | Meteorological | Malaria | X | O | O | X | O | 3/5 |
| (6)<br>1985 | Donald L. Unger | Southern California desert | 4 Emergency rooms in 4 hospitals | 14 day period including the day of the sandstorm( 26th March 1984) | To determine the immediate effects of sandstorms on Asthma and other respiratory problems | ND | Asthma & respiratory ds. | X | X | O | X | O | 2/5 |
| (7)<br>1985 | M. A. Awad El Karim | Port Sudan, Red Sea Province and South Kordofan | 300,000( Port Sudan) & 1.5 million ( South Kordofan ) | May 1979-December 1982 | investigate the relationship between quantity and chemical, physical and bacteriological qualities of water and the prevalence of water-related diseases. It was | Hydrological | diarrhoeal, eye communicable diseases | O | O | O | X | O | 4/5 |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Province | | | also intended to draw comparison between the two regions. | | | | | | | | |
| (8)<br>2003 | Ian Small | The Aral sea region - Uzbekistan & Kazakhstan | ND | 1960 -1980 (not clearly defined) | Impact of water depletion | Hydrological | -direct; diarrhoeal disease ,hepatitis, malnutrition, Inhalation of pesticides -Indirect, living in conflict areas | O | O | O | X | X | 3/5 |
| (9)<br>2006 | Sarah Polacka | Village of Shimbi Mashiriki Rombo District, Northern Tanzania | 914 children | August and September 2003 | relationship between active trachoma in children and detailed measures of water | ND | Trachoma | O | X | O | X | O | 3/5 |
| (10)<br>2001 | Scheman n, J | Mali, African region | 30 clusters(15,187 children under 10 years of age) | March 1996 to June 1997 | To study the prevalence of trachoma and potential risk factors | ND | Trachoma | O | X | O | X | O | 3/5 |
| (11)<br>2007 | A Abdou | Maradi, Niger | 651 children | Not mentioned | To determine the association of personal and household risk factors for trachoma and ocular Chlamydia | ND | Trachoma | O | X | O | X | O | 3/5 |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | trachomatis infection in Niger. | | | | | | | | |
| (12)<br><br>1992 | James D. Arthur | Thai-Cambodian border, Cambodian children camp Surin,Thailand. | 408 chidren | May and October 1989 | Cause of diarrhoea | Overcrowding and ds. | Diarrhea | O | X | X | O | O | 3/5 |
| (13)<br><br>2001 | Abraham Hodgson | Kassena-Nankana district (KND), Northern Ghana | 140 000 | Not mentioned | Overcrowding and meningitis | overcrowding | Meningitis | O | X | O | O | O | 4/5 |
| (14)<br><br>1977 | R. Mansell Prothero | Over all | ND | Not mentioned | ND | migration | Discussed health effects in general | X | O | O | X | O | 3/5 |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (15)<br><br>1994 | Sally E. Findley | The Upper Senegal river valley stretching from Matam, Senegal to Diamou, Mali | 7079 individuals in 309 households | 1982 (pre drought) 83-85(drought years | ND | ND | Migration | X | O | O | X | O | 3/5 |
| (16)<br><br>1993 | Bemt Lindtjgm | Pastoralist Boran community of Dubluk and in the agricultural community of Elka, Southern Ethiopia | 605 households | 2years,1989 -1991 (The population in Dubluk experienced drought and famine between 1983 and 1985 and in Elka the drought lasted from 1984 to 1988) | examines fertility, mortality and patterns of migration in 2 rural communities | Meteorological | Migration | O | O | O | X | O | 4/5 |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (17)<br><br>1986 | Appleton , C. C | North eastern South Africa | NR | February to September 1984 | To assess the resumption of Schistosomiasis.H. transmission after drought and subsequent flood | Hydrological | Schistosomiasis | X | O | O | X | O | 3/5 |
| (18)<br><br>2002 | Jeffrey Shaman | Indian River County, Florida | NR | 1986 through 1991I | to simulate water table depth (WTD) and quantify the relationship between Saint Louis encephalitis virus (SLEV) transmission and hydrologic conditions | ND | Saint Louis encephalitis virus | X | O | O | X | O | 3/5 |
| (19)<br><br>2007 | Annika Nordstrand | northern dry savannah and the southern tropical high plateau of Togo | 244 random sampled | March 2002 through September 2004 | to investigate the presence of RF in Togo | ND | Tick borne relapsing fever | O | X | O | X | O | 3/5 |

O = YES, X = N ND = Not defined, NR = Not relevant for the study. The grading (no. /5) = the number of YES to the total five questions as given in the 5 Quality assessment questions (see study design) defining the strength and weakness of the study in relevance to this research and not by itself

**Table 4: Summary of the information available from the selected articles**

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 1 | 1985 | Dondero, T. J, Jr. | January to March 1985 | Sudan, refugee camp | Nutrition in a drought stricken area | Descriptive (case series) | -Health effects caused (a) direct; malnutrition (PEM = 80%) affected 25 to 52 percent in Sudan, 8 – 67 % in Chad and 8 -18 % in Sahel, acute malnutrition leading to deaths. Vitamin A deficiency have led to permanent blindness (b) indirect = infectious diseases like measles (likely due to crowded camp conditions,40% mortality),diarrhoeal diseases, respiratory diseases( whooping cough ,pneumonia), meningitis, typhus, vitamin deficiencies, | None |
| 2 | 1990 | Mary A. Carnell | 1983-1985 | Mali, Timbuktu region | Identification of malnourished children in drought area | Cross sectional study | -No statistically significant differences in malnutrition rates between the two cluster samples<br>-No statistically significant difference was found between malnutrition rates by sex: 27 percent of girls (243/917) and 30 per cent of boys (260/881) were less than - 2 SD of the NCHS median weight-for-height<br>-Children 12-23 months (76-85 cm) were significantly more affected by Malnutrition 44 per cent were less than — 2 SD of the NCHS median weight-for-height and 12 per cent were less than -3 SD of the NCHS median.<br>-Of the nomad children sampled, the malnutrition rates were significantly higher than those of their sedentary counterparts<br>-Children of the Bella and Tamashek ethnic groups were significantly more malnourished than all other groups | Sex, Socio economic |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | -Vaccination coverage against measles for children 12 months to 5 years was established at 47 per cent 'by card' and 60 per cent 'by history ± card' | |
| 3 | 2005 | Gitau. R. | June 2001 to December 2004 | Lusaka, Zambia | Growth retardation due to micro nutrient deficiency in a drought brought on by increase in food prices. | Prospective cohort study | -Decreased maternal plasma vitamin A during pregnancy (P ¼ 0.028) and vitamin E postpartum (P ¼ 0.042), with the lowest values among samples collected after May 2003 (vitamin A: 0.96 mmol l21, 95% confidence interval (CI) 0.84–1.09, n ¼ 38; vitamin E: 30.8 mmol mmol21 triglycerides, 95% CI 27.2–34.8, n ¼ 64) compared with before January 2002 (vitamin A: 1.03 mmol l21, 95% CI 0.93–1.12, n ¼ 104; vitamin E: 38.9 mmolmmol21 triglycerides, 95% CI 34.5–43.8, n ¼ 47)<br>- Infant length at 6 and 16 weeks of age decreased progressively throughout the study (P-values for time of data collection were 0.51 at birth, 0.051 at 6 weeks and 0.026 at 16 weeks) | NR |
| 4 | 2007 | Rebekah J. Kent | 3transmission seasons and covered a wet year-drought year-wet year cycle | Southern Province of Zambia | Effects of droughts on the genetic structure of Anopheles arabiensis mosquitoes causing Malaria | Observational | - Neither predictable annual dry seasons nor unexpected extended drought periods appear to have an appreciable effect on the genetic diversity of this arid-adapted mosquito.<br>- extended drought conditions appeared to have little observable impact on the regional genetic diversity of An. Arabiensis and malaria transmission in the following season despite greatly reduced mosquito numbers. | NR |
| 5 | 2005 | Michael A Sattler | March 1 to May 29, 2003 | Central Dar es Salaam, Tanzania | Habitat characterization of Anopheles sp. Mosquito in an extended dry period. | Descriptive<br><br>(Open mosquito breeding sites searched.. Ecologic | -Of the 327 sites that contained water, 62% were productive for Anopheles sp. and 57% were productive for Culicine mosquitoes.(Malaria)<br>- The 202 sites productive for Anopheles sp. were made up of 69% low larvae density sites and 31% high larvae density.<br>- Large drains, swamps and puddles were much less likely to contain Anopheles sp. larvae than other habitats. Very turbid water diminished the | NR |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | parameters, mosquito larvaedensity and geographic location were recorded ) | chance that Anopheles sp. larvae were present. Breeding sites with a size of less than one meter were more likely to contain Anopheles sp. Larvae.<br>- Turbid water was clearly associated with the presence of Culicines. Breeding sites with pH values of 7.6 or less were also more likely to contain Culicine larvae. | |
| 6 | 1985 | Donald L. Unger | 14 day period including the day of the sandstorm( 26th March 1984) | Southern California desert | Sandstorms increases asthma and other respiratory problems | Cross sectional Survey of Emergency rooms in hospitals | - Study confirms the absence of increased respiratory problems during and immediately after the sandstorm. –(Differences between rainstorm and desert sandstorms are the humidity and the pollen counts which are higher in a rainstorm) Asthma is not provoked and the absence of symptoms is because of patients are not primed as the usual spring carpet of desert weeds and wildflowers are absent so patients were below their threshold.<br>- Drops in barometric pressure and high winds do not relate to respiratory problems. | Age |
| 7 | 1985 | M. A. Awad El Karim | May 1979-December 1982 | Port Sudan, Red Sea Province and South Kordofan Province | Water shortage and public health implications in a semi arid region. | Cross sectional study | -The reported prevalence of eye communicable diseases was 17 and 14 % among populations drawing water from unrectified and rectified hafirs respectively. For skin diseases it was 13% for unrectified and 11% for rectified hafirs.<br>-The prevalence in both communities is significantly high when compared with the national average which is 2 9% for eye communicable and 1% for skin diseases. The highest prevalence of diarrhoeal diseases was recorded among Port Sudan children (15.5%), followed by children where people draw water from Unrectified hafirs (13.5 %) and finally children where water is drawn from rectified hafirs ( 6.1 %) | NR |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 8 | 2003 | Ian Small | 1960 - 1980 (not clearly defined) | The Aral sea region - Uzbekistan & Kazakhstan | Impacts of water depletion aggravated by droughts.(Socio economic drought) | Descriptive | (a) Direct health effects;<br>1 diarrhea disease due to coli forms in drinking water 2.hepatitis, 3.malnutrition 4. Inhalation of pesticides.<br>(b) Indirect;<br>1.Living in conflict areas | Socio economic |
| 9 | 2006 | Sarah Polacka | August and September 2003 | Village of Shimbi Mashiriki Rombo District, Northern Tanzania | Relationship between active trachoma in children and detailed measures of water(water shortage) | Cross sectional | -The prevalence of active trachoma in the children examined was 18.4% (95% CI 15.9—20.9).<br>- Active trachoma prevalence increased with increasing water collection time (OR 2.25; 95% CI 1.13—4.46) but was unrelated to the amount of water collected.<br>- Crowding within beds (defined as number of people per bed) was associated with the prevalence of trachoma (OR 1.71; 95% CI 1.00—2.93), though crowding within rooms was not.<br>- Prevalence of active trachoma increased when more cattle, goats and sheep were kept in the household (P for trend <0.01) and when cattle were kept in the same room as people overnight (OR 2.31; 95% CI 1.32—4.05).<br>- Active trachoma prevalence decreased with reported frequency of clothes washing (P for trend <0.05)<br>- Active trachoma prevalence was substantially lower in children from households where more water was used for personal hygiene (P for trend ≤0.01), independent of the total amount of water used. | NR |
| 10 | 2001 | Scheman n, J | March 1996 to | Mali, | Trachoma in overcrowded and lack of personal | Cross sectional | -The prevalence of active trachoma (follicular [TF] or intense trachoma [TI]) was 34.9% (95% CI: 32.3-37.6) and the prevalence of TI was 4.2% (95% CI: 3.5-5.0). | Socioeconomic and environmental |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | June 1997 | African region | hygiene | | - Aridity/environmental dryness appears to be a risk factor<br>-Small villages had considerably higher trachoma prevalence than their larger neighbors.<br>- The proximity of a medical centre and the existence of social organizations such as a women's association were associated with lower levels of trachoma.<br>- Crowded living conditions increased the risk with a linear inverse relation between wealth and trachoma prevalence i.e. presence of a dirty face was strongly associated with trachoma (odds ratio [OR] = 3.67) as was the presence of flies on the child's face (OR = 3.62).<br>- Increase with distance to water source | information |
| 11 | 2007 | A Abdou | Not mentioned | Maradi, Niger | Association of personal and household risk factors for trachoma and ocular Chlamydia trachomatis infection | Cross sectional | -The prevalence of trachoma was 43% (95% confidence interval (CI) 39% to 47%) and of infection was 21% (95% CI 18% to 24%).<br>- Children aged 3–5 years had a stronger<br>association of clinical signs with infection, compared with those aged 1–2 years.<br>-Those with unclean faces were three times more likely to have clinical trachoma or ocular C trachomatis infection, compared with those with clean faces (OR 3.1 (95% CI 1.6 to 6.2) and 3.0 (95% CI 1.4 to 6.3), respectively).<br>- 75% of compounds were within 30 min of a water source. -Flies on the face were a risk factor for trachoma but not for C trachomatis infection. | NR |
| 12 | 1992 | James D. Arthur | May and October 1989 | Thai-Cambodian | Etiology of diarrhea in refugee camps due to | Cross sectional | -Rotavirus - 24 % of 487 children with diarrhea less than 5 years of age<br>-Campylobacter and ETEC - Of 107 Campylobacter strains isolated from 487 children with diarrhea, 54 % were C. jejuni, 26 % were C. upsaliensis, 14 | Age |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | border, Cambodian children camp Surin,Thailand. | overcrowding. | | % were C. coli, and 6 % were atypical Campylobacter.<br>-Shigella was isolated from 7 %. E.Coli -3<br>- Children with prolonged diarrhea were not infected with a single bacterial pathogen. Repeated episodes of diarrhea were caused by different agents, acquired because of crowding in the camp.<br>-Children in the feeding center were found to be infected by person-to-person contact. | |
| 13 | 2001 | Abraham Hodgson | Not mentioned | Kassena-Nankana district (KND), Northern Ghana | Risk factors for meningitis (over crowding ) | Case-control study | -Close contact with a case: more cases of meningitis (16%) than controls (9%) were sharing the same bedroom with that case (OR 2.18. CI 1.43-3.40. P < 0.001)<br>-Exposure to smoke from cooking fires; In 480 (95%) of 505 cases and 465 (92%) of 505controls, cooking was carried out in kitchens rather than outside (OR 1.83, CI 1.00-3.46, P < 0.05). 40 % of both cases and controls were exposed to smoke from cooking fires. | Age, sex, |
| 14 | 1977 | R. Mansell Prothero | Not mentioned | Over all | Health effects of Migration | Descriptive case study | (1) Exposure to diseases from movements through different ecological zones (e.g. malaria, trypanosomiasis, schistosomiasis, onchocerriasis)<br>(2) Exposure to diseases from movements involving contacts between different groups of people (e.g. smallpox, poliomyelitis)<br>(3) Physical stress (e.g. fatigue, under nutrition /malnutrition)<br>(4) Psychological stress-problems of adjustment | NR |
| 15 | 1994 | Sally E. Findley | 1982 (pre drought) 83-85(drought | The Upper Senegal river | Do droughts increase | Cross sectional | 1.Family depended on migration for their food<br>2.Other depended on remittance from prior migrants | Sex ,Socio economic |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | years | valley stretching from Matam, Senegal to Diamou, Mali | migration? | | 3.Others sent out other new migrants<br>4.During the drought there were no rise in migration maybe due to presence of already outmigrants supporting them, food relief sufficient or maybe the migration threshold had reached maximum in the pre-drought period.<br>5.Doubled short cycle or circulation migrations which involved higher level of movement involving 2 moves per migration. They are described as economically motivated and involves people from poorer families(poverty related)<br>The level of migration did not rise during the drought of 1983-1985. However, there was a dramatic increase in the migration of women and children during the severe 1983-1985 drought. Along with this increase in migration by women and children, there was a shift to short-cycle circulation, with 64 percent of the migrants adopting circular patterns | |
| 16 | 1993 | Bemt Lindtjgm | 2 years,1989-1991 (The population in Dubluk experienced drought and famine between 1983 and 1985 and in Elka the drought lasted from 1984 to | Pastoralist Boran community of Dubluk and in the agricultural community of Elka, Southern Ethiopia | Patterns of Migration of nomads in areas affected by droughts | Cross sectional | -The population structure was similar to that of Ethiopia at large~(ETHIOPIA, 1984)where the age pyramid reflects high fertility and declining mortality<br>-The under-representation of males in the above 15 years age group in Dubluk may reflect high rates of outward migration or increased mortality among males<br>-The high mortality rates in the Elka during 1988 and 1989 may partly have been a consequence of the long period of food shortage during the 1980s.<br>- The 'villagization' programme, initiated by the Ethiopian government in 1985, changed the demographic characteristics in Elka from a scattered society to higher levels of crowding and may thus have favoured the spread of, e.g., meningitis and malaria. | Age and sex, |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | 1988) | | | | -Outward migration was seasonal and associated with periods of food scarcity. | |
| 17 | 1986 | Appleton, C. C | February to September 1984 | North eastern South Africa | Resumption of Schistosomiasis after a drought followed by flood | Observational | -Two of the snails in the 11-12 mm size class (6.1 % of the sample) were shown to be shedding a pharyngeal, brevifurcous cercariae which were infected by male and female Schistosoma haematobium .<br>- It is likely that infection took place late in February or March, within five weeks of human contact with the river being resumed after a long period of drought then a consequent flood on January 1984.<br>= In a prolonged drought followed by a severe flood , B.globusus (snail species) can colonize newly formed water bodies and the S. haematobium transmission cycle can start within few weeks of human contact being resumed | NR |
| 18 | 2002 | Jeffrey Shaman | 1986 through 1991I | Indian River County, Florida | rise of vector borne ds. due to drought | Experimental ( modelling and scenario analysis) | -Virus transmission followed periods of modelled drought (specifically low WTDs 12 to 17 weeks before virus transmission, followed by a rising of the water table 1 to 2 weeks before virus transmission)<br>-Further evidence from collections of Culex nigripalpus (the major mosquito vector of SLEV in Florida) suggests that during extended spring droughts vector mosquitoes and nestling, juvenile, and adult wild birds congregate in selected refuges, facilitating epizootic amplification of SLEV.<br>-When the drought ends and habitat availability increases, the SLEV-infected Cx. nigripalpus and wild birds disperse, initiating an SLEV transmission cycle.(Saint Louis encephalitis virus) | NR |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 19 | 2007 | Annika Nordstrand | March 2002 through September 2004 | northern dry savannah and the southern tropical high plateau of Togo | Vector borne diseases in drought areas | Cross sectional | - RF(relapsing fever) caused by B. crocidurae is spreading to new areas because of the sub-Saharan drought, which might allow vector ticks to colonize new areas in the savannas of West Africa<br>- All patients from northern Togo were children (age range <1–14 years). For children <4 years of age, 6 (10%)of 60 were seropositive. Of these children, 5 had a fever and 4 had an active Borrelia infection detected by PCR.<br>DNA sequence analysis showed that 3 children were infected with B. crocidurae and 1 with B. duttonii.<br>- In southern Togo, 1 (9.1%) of 11 children <1–4 years of age were sero positive.<br>- The overall male-to-female ratio among study patients was 1.3:1.<br>-No difference in by sex, ethnic background, or profession, with the exception of cow herders who had a sero positivity 62.5% (5/8) compared with 12.2% (11/90) among those in other professions ($p<0.05$);<br>-More Borrelia-infected patients lived in houses made of mud rather than cement than persons without RF infection ($p = 0.008$)<br>–7 (4.5%) of 154 patients were co infected with malaria parasites and Borrelia. In the youngest children (<4 years of age), 4 of 5 Borrelia-infected children also had malaria | Age, sex, , socio economic |

**(B) Methodology of epidemiological studies;**

The methodology that was used in the studies listed out in table 4 are as follows;

**4** articles were **descriptive** in nature , (a)nutrition and health needs in drought stricken Africa were listed based on observation during the drought period (Dondero, 1985),(b) habitat characterisation of the Anopheles Species mosquito by open mosquito breeding sites, ecological parameters, mosquito larvae density and geographic location recordings (Carnell and Guyon, 1990),(c) listing of health effects of a socio economic drought in the region of the Aral sea (Small et al., 2003)(d)listing health effects of migration through various exposure factors (Prothero, 1977).

**10** of the studies were **cross sectional studies** with comparison between exposed and unexposed, the exposure outcome was determined in the same population in the same time. The results of each article were reported or presented in various ways in relevance to the study objectives e.g. in a study by Carnell. M. , et al in Mali, they measured the prevalence of malnutrion by weight for height index and the data was then presented using the standard deviation score based on the NCHS reference population and checked for significance (Carnell and Guyon, 1990) , 3 studies presented the prevalence of Trachoma using odds ratio with a 95% CI range (Polack et al., 2006),

(Schemann et al., 2002),(Arthur et al., 1992). The results will be discussed in detail under the discussion part of the study.

A prospective **cohort study** was done by (Gitau et al., 2005)to determine the growth retardation of infants borne to pregnant women with decreased maternal plasma vitamin A during pregnancy and vitamin E post partum and presented with p-value significance and 95% CI.

**Two observational studies** on the resumption of Schistosomiasis (Appleton, 1986) and the effects of droughts on the Anopheles arabiensis mosquito responsible for transmitting Malaria (Kent et al., 2007a) and an **experimental** (modelling and scenario analysis) study ( Shaman,2002) to find evidence of virus transmission following periods of modelled drought[4].

A **case control study** article to study the risk factors for Meningitis (Hodgson et al., 2001) in Northern Ghana and data presented using Odds ratio,95% CI and p value for significance results

**(C) Health effects:**

With reference to Table 4 which is a summary of main results relevant to the health impacts of droughts we observed the following health effects.

[4] Modeled drought defined as specifically low water table depth 12 to 17 weeks before virus transmission, followed by a rising of water table 1 to 2 weeks before virus transmission.

(1) **Malnutrition** ; **3** articles discussed about Nutrition related health effects as a result of Agricultural droughts, 2 articles in African regions and 1 in the Eastern Mediterranean region. 1 on the overall nutrition problems like Protein Energy Malnutrition and Vitamin A deficiency and the indirect effects like increase susceptibility to infectious diseases e.g. measles, another looks into the deficiency of Vitamin A in pregnant women leading to growth retardation of infants borne of these women. The other article on the identification of degree of malnourished in a drought stricken area.

The form of malnutrition that seems to be most frequent in areas in the African region and in Sudan is protein energy malnutrition (PEM) which is <80% of the reference median weight-for-height. Malnutrition affects 25 to 52% in Sudan,8 to 67 % in Chad and 8-18% in the Sahel regions(Dondero, 1985). Acute malnutrition leading to an increase in infectious diseases and fundamentally to death. The other malnutrition form mentioned is the Vitamin A deficiency that have led to permanent blindness when provoked by infectious diseases like measles (Dondero, 1985) and growth retardation in children( Infant length at time of collection and birth P= 0.051 ,6 weeks P=0.051 but decreased to P=0.026 at 16 weeks) borne to pregnant women with a decrease in the maternal plasma of Vitamin A(P = 0.028) during pregnancy and Vitamin E post partum (P= 0.042)(Gitau et al., 2005). The low intake of maize by pregnant women in Zambia is due to the hike in price of maize, which is a staple food in this region. The hike in

price is brought on by the drought which lowered production but post drought the production increased but so did the prices(Gitau et al., 2005).

(2) **Vector borne diseases**; **5** articles discussed about Vector borne diseases in relation to drought conditions. 2 articles on Malaria, 1 article on Saint Louis encephalitis in North America, 1 article on Relapsing Fever in Africa and an article on Schistosomiasis in South Africa

Malaria: A study carried out on the spatial and temporal genetic structure of the Anopheles arabiensis mosquito. It was observed that there were neither annual dry seasons nor extended drought period that appear to effect the genetic diversity of the mosquito and there is no effect on the malaria transmission in the wet year drought year wet year season despite great reduction in mosquito numbers(Kent et al., 2007b). In Tanzania , a study done on habitat characterization of the Anopheles sp. mosquito during an extended dry period also proved that breeding sites with a size less than one meter were likely to contain the mosquito larvae than large drains , swamps and puddles (Sattler et al., 2005) which only proves that malaria is a continuous threat in these areas.

Saint Louis encephalitis: In the Indian river county, Florida an area epidemic for the Saint Louis Encephalitis virus (SLEV) an observational study was done to check the association between

droughts and SLEV transmission(Shaman J.,2002). It was seen that periods of modeled drought led to virus transmission along with more evidence from collections of Culex Nigripalpus (mosquito vector) that suggested that during drought vector mosquitoes and wild birds congregate in certain places to facilitate the epizootic amplification of SLEV. When the drought ended and the habitat availability increased the SLEV-infected Culex N. mosquito and wild birds disperse initiating an SLEV transmission (Shaman, 2002) to humans.

Relapsing fever: The article by Nordstrand 2007 describes a tick borne relapsing fever that was caused by Borrelia crocidurae which spread to the northern dry savannahs and the southern tropical high plateau of Togo, Africa, due to the sub-Saharan drought. In the cross sectional study carried out during the drought period it was found that children (1-<14 years) presenting with fever in northern Togo (10%) and southern Togo (9.1%) were sero positive when tested for B. crocidurae.

Schistosomiasis: After prolonged drought followed by severe flood, it was observed that snails were shown to be shedding pharyngeal, brevifurcous cercariae which were infected by male and female Schistosoma haematobium. B.globusus can then colonize in the newly formed water bodies beginning the Schistosoma haematobium transmission cycle within a few weeks of human contact causing Schistosomiasis (Appleton, 1986). Human contact occurred when the

water from the snail infested pool was collected and used for washing purposes.

(**3) <u>Water related</u>**: 6 articles discussed about water availability in drought conditions and its consequence health effects. 2 articles on the health effects found due to water shortage, 1 article on prevalence of eye communicable diseases and skin diseases from water collected from two sources in Eastern Mediterranean region, 1 article on health effects like diarrhoea, hepatitis, malnutrition, respiratory problems, and effects of living in conflict area of the Aral sea in Europe, 3 articles on Trachoma and water availability and its use in the African region.

Diseases can be caused through various pathways in relation to water. It could be through (a) water sources in situation when there is water scarcity (b) water availability and its use.

(a) Water source- In a comparative study done by Awad El Karim in 1972 in Port Sudan, comparing two provinces that in prolonged dry period depend on hafirs[5] as water sources. The health effects seen were eye communicable, diarrhoeal and skin diseases (Table 5). The prevalence of eye communicable diseases was 17 and 14%, skin diseases it was 13 and 11%, among population drawing water from unrectified and rectified hafirs respectively, and the highest prevalence(13.5 and 6.1% from unrectified and rectified hafirs) of

[5] Hafir is a mechanically excavated pond where rain water could be collected during the rainy season and to be utilized during the dry season. Hafirs are always located in low depressions, where clay soil formation of more than 5 m deep exists to minimize losses by seepage.

diarrhoeal diseases among port Sudan children(15.5%)(Awad el Karim et al., 1985). The specific type or commonest type of these communicable diseases was however not listed.

| Area | No. investigated | No. of cases with | | |
|---|---|---|---|---|
| | | Skin | Eye comm. | Diarrhoea |
| With unrectified hafirs | 1330 | 49 (3.68 %) | 64 (4.81 %) | 203 (15.26 %) |
| With rectified hafirs | 1450 | 50 (3.45 %) | 63 (4.34 %) | 189 (13.03 %) |
| Port Sudan | 1106 | 30 (2.71 %) | 114 (10.31 %) | 214 (19.34 %) |

Table 5: Prevalence of diarrhoeal, eye communicable and skin diseases among Port Sudan and South Kordofan Province population (Awad, 1985)

The Aral sea area with increasing water depletion due to intensive irrigation, the failure of snowmelt in the feeder mountain ranges and transboundary political disputes over sharing of water between the Central Asian states caused the two river beds to dry up have lead to health effects like diarrhoeal diseases, and hepatitis(Small et al., 2003) increasing the proportion of infant death to 29.1% compared to the regional rate of 16%. These were due to the presence of and excess amount of coli forms in the supplied water (Binnie, 1996).

(b) Water availability and its use – Trachoma is an eye disease caused by Chlamydia trachomatis responsible for approximately 1.3 million cases of blindness worldwide, representing 3.6%of the global burden of blindness (Resnikoff et al., 2004) was seen to be associated to presence of a dirty face( OR = 3.67)(Schemann et al., 2002) in comparison to children with clean faces[unclean faces =OR 3.1 (95% CI 1.6 to 6.2) and clean faces 3.0 (95% CI 1.4 to 6.3)] (Abdou et al., 2007).

(4) Diseases related to migration: **3** studies discussed about migration in drought affected regions and the health effects related to it. 1 article on the overall health effect related to migration and 2 articles on the patterns of migration in Africa.

The potential heath effects of migration was chalked out into 4 categories (1) exposure to diseases from movements through different ecological zones ( e.g. malaria, trypanosomiasis, schistosomiasis, onchocerriasis); (2) exposure to disease from movements involving contacts between different groups of people (e.g. tuberculosis); (3) physical stress (e.g. fatigue, under nutrition/malnutrition) and (4) psychological stress- problems of adjustment(Prothero, 1977).

In a drought stricken area there is an assumption that the migration pattern increases but in a study by Findley, 1994 it was observed that the level of migration did not rise during the drought period of 1983-85 in the area of the Upper Senegal River valley. This could be due to presence of out migrants supporting them, food relief sufficient or maybe a threshold of migration has been reached. In Southern Ethiopia, however, it was observed that outward migration was seasonal and associated with periods of food scarcity (Lindtjorn et al., 1993).

(5) Diseases related to overcrowding: **2** articles discussed overcrowding and health effect. 1 on Diarrhoea in South East Asia and the other on Meningitis in Africa.

In a case control study in a refugee camp in Thailand children with prolonged diarrhea were not infected by a single bacterial pathogen but repeated episodes were caused by different agents, acquired because of crowding in camp, and the common feeding centre was the source of transmission(Arthur et al., 1992). Trachoma seem to also be on the increase in crowded living conditions (Schemann et al., 2002) crowding within beds (Polack et al., 2006). Meningitis was seen to increase when people shared a room in a case control study done in Northern Ghana in which cases (16%) as compared to controls (9%) (OR 2.18 CI 1.43-3.40. $P < 0.001$) were in close contact with a case (Hodgson et al., 2001). Infectious diseases like measles in crowded conditions have led to 40% mortality in the Sudan refugee camp (Dondero,1985) along with the prevalence of other diseases like diarrhoeal diseases, respiratory diseases like whopping cough and pneumonia, meningitis, and typhus (Dondero,1985).

(6) Dust related disease: An article however discussed on respiratory problems aggravating in a sandstorm in the Southern Californian desert in America. It was observed by Unger (1985), that even in a violent sandstorm[6] that the high wind does not seem to cause any

[6] A sandstorm/dust storm typically occurs in arid or semi-arid regions if high wind speeds cause the transportation of small particles like sand or fine clastic sediment by saltation and/or suspension

statistically significant immediate effects on asthma and other respiratory problems present as pre disposing factors.

**(D) Determinants that came from Table 4;**

**(1) Age = 3** articles discussed the effects on the various age groups. The identification of malnourished children in the drought affected area was done by comparing two different clusters of children from different socio economic background. Children between 12-23 months (Table 6) were significantly more affected by malnutrition (44% were less than-2SD of the NCHS median weight –for-height and 12% were less than -3SD of the NCHS median) in the Timbuktu region of Mali (Carnell, 1990). In Port Sudan children had the highest prevalence of diarrhoeal diseases (15.5%) (Awad, 1985). The study population in a majority of the articles was children (Dondero, 1985) (Carnell, 1990) (Polacka, 2006) (Arthur, 1992) (Nordstrand, 2007) which suggest that majority of health issues in drought affected regions is more severe in children.

*Prevalence of wasting among children 'under 5 years' by estimated age groups,* Timbuktu Region, May 1985*

| Age (height) | Total N | Median weight-for-height < −2 SD n | (%) | < −3 SD n | (%) |
|---|---|---|---|---|---|
| 0–5 months (49–66 cm) | 227 | 23 | (10)† | 0 | (0) |
| 6–11 months (67–75 cm) | 248 | 79 | (32) | 17 | (7) |
| 12–23 months (76–85 cm) | 369 | 162 | (44)† | 44 | (12) |
| 24–59 months (86–118 cm) | 955 | 239 | (25) | 29 | (3) |

* Age estimated by height.[2]
† Chi-square significant at $P < 0.001$.

**Table 6: Prevalence of wasting among children in Timbuktu region (Carnell,1990)**

**(2) Sex = 3** articles discussed the severity of health effects according to sex. In 2 articles it appeared that males were more susceptible to being malnourished and has a higher incidence of infectious diseases than females. In the migration pattern study(Findley, 1994) it was noticed that males migrated more often than females though in another study (Lindtjorn et al., 1993) the amount of females and children migration increased during the severe drought period of 1983-85 in the Sahel region.

**(3) Socio economic =** In an article comparing the nutrition status of two communities it was seen that nomad children were more vulnerable than their sedentary (Table 7)counterparts was higher in

the Bella and Tamashek ethnic group in comparison with the other groups (Table 8) (Carnell and Guyon, 1990).

*Prevalence of wasting among children 'under 5 years' in nomad and sedentary populations, Timbuktu region, May 1985*

| | Total | Median weight-for-height | | | |
|---|---|---|---|---|---|
| | | < −2 SD* | | < −3 SD† | |
| | N | n | (%) | n | (%) |
| Nomad | 240 | 103 | (43) | 24 | (10) |
| Sedentary | 1558 | 312 | (20) | 78 | (5) |

* Chi-square significant at $P < 0.001$.
† Chi-square significant at $P < 0.005$.

**Table 7: Prevalence of wasting among 2 type of population group(Carnell,1990).**

*Prevalence of wasting among children 'under 5 years', by ethnic group, Timbuktu region, May 1985*

| | Total | Median weight-for-height | | | |
|---|---|---|---|---|---|
| | | < −2 SD* | | < −3 SD | |
| Ethnic group | N | n | (%) | n | (%) |
| Sonrhai | 1011 | 258 | (26) | 45 | (4) |
| Bella | 331 | 126 | (38) | 31 | (9) |
| Tamashek | 164 | 62 | (38) | 11 | (7) |
| Peulh | 147 | 30 | (20) | 7 | (5) |
| Others | 140 | 28 | (19) | 2 | (1) |

* Chi-square significant at $P < 0.001$ (df = 4).

**Table 8 : Prevalence of wasting among ethnic groups(Carnell,1990)**

In another article(Lindtjorn et al., 1993) it was described that the pastoralists community had an increase in migration rate and mortality than the agricultural community but the latter being more vulnerable to higher levels of overcrowding and favouring the spread of malaria , and meningitis. They seem to be more prevalent of

trachoma (P<0.05) in cow herders who had 62.5% sero positivity as compared to other professions 12.2% and in patients living in mud houses rather than cement (P=0.008). The presence of a medical centre and a social organization in the village was associated with a lower level of trachoma (Scheman, 2001). In the comparative study of pastoralist (Dubluk) and agricultural (Elka) community it was seen that the high mortality rates in the latter was due to food shortage while in the former was more related to outward migration among males. The Elka community had a higher level of overcrowding and may have favored the spread of e.g., meningitis and malaria (Lindtjorn, 1993).

**(4) Environmental factors =**The prevalence of trachoma is low in children from households where water use is more for personal hygiene and with frequent clothes washing (P <0.05) independent of the amount used but increases if the distance for water collection takes more time (OR 2.25,95% CI 1.13-4.46) unrelated to amount of water collected. Trachoma risk is increased when livestock were kept with people overnight in the same room (OR 2.31;95% CI 1.32-4.05) (Polack et al., 2006). It was seen that breeding sites with a size of even less than one meter is enough for the Anopheles to breed causing malaria irrespective of the season (Sattler, 2005). The mosquito is semi arid adapted so the disease is continuous despite the greatly reduced mosquito numbers (Kent, 2007). Very turbid water decreases the chances of Anopheles mosquito larvae but Culicine larvae can

breed in turbid water with a pH of 7.6 or less (Sattler, 2005). The reported prevalence of eye communicable and skin diseases was higher among populations drawing water from unrectified hafirs than from rectified hafirs (Awad, 1985).

**Other abstracts;**

Of the other 19 articles that were only available as abstracts inspite of every possible effort by the reviewer to get the full text. 6 articles discussed on nutrition related conditions such as PEM. 4 articles discussed on overcrowding situations and the increase of health effects like diarrhoea, respiratory infections, tuberculosis, and intestinal parasites. Another article spoke on the effect of drought on the condition of women. Another article discussed the increase of nitrate and cyanide in the animal forage causing mortality of livestock and increase poverty level. These are however just some of the information extracted from the abstract and they were not reviewed in this study.

## Key messages:

**Overview:** Total numbers of articles selected were 19, ranging from 1977 to 2007 in published years. Majority of articles being cross sectional studies, a few descriptive studies, a cohort study and a case

control study. Most of the studies were being conducted in Southern Africa where drought is a natural hazard and a few in the Eastern Mediterranean region mainly Sudan .There was however no articles that took climate change into account with relation to the health impacts of drought.

**A) Drought defined:** Overall a more meteorological type of drought is seen in majority of studies.

**(B) Health effects**:

(a) During the drought period;

- Nutrition related –Malnutrition i.e. protein energy malnutrition & vitamin A deficiency in Sudan and Mali , vitamin A & E deficiency in pregnant women leading to growth retardation in infants born to them
- Vector borne disease – Relapsing fever caused by ticks in Togo (Africa), usually co-infected with malaria.
- Water related – (a) from water source – eye communicable diseases, skin diseases in Sudan (Eastern Mediterranean), (b) water shortage – diarrhea due to the presence of coli forms in the water, hepatitis in the region Aral Sea (Central Asia),(c) water availability and its use – trachoma in Mali, Niger and Tanzania ( Africa)
- Dust related – no increase effect of dust on Asthma or other Respiratory Tract Infection in Southern California( North America)

Indirect effects:

- Migration - no increase in migration pattern in drought stricken areas of the upper Senegal River valley (Africa) in comparison to the usual pattern of migration. Comparison between 2 communities showed that the pastoralists had better health status than the agricultural community in Southern Ethiopia( Africa)
- Overcrowding - overcrowded household increases the incidence of Meningitis in Northern Ghana (Africa) Measles, Diarrhea and Respiratory diseases also prevalent in a refugee camp in Sudan (Eastern Mediterranean). Trachoma however is not related to overcrowding in houses but only when sharing a bed in Tanzania (Africa)

(b) Post drought followed by flood;

Direct effects:

- Malaria – drought had no effect on the genetic structure of the Anopheles A. mosquito and they are still capable of breeding and causing Malaria in Zambia (Africa).
- Schistosomiasis - snails can colonize in newly formed water bodies and the schistosoma haematobium cycle can start in South Africa.
- Saint Louis Encephalitis – due to virus transmission by the mosquito vector post drought in Florida ( North America)

**C) Determinants**;

- Malnutrition seen to be more severe in males than in females.

- Children more affected by nutritional deficiencies
- Sedentary community seems to be more affected than a nomad population even though malnutrition degree was higher in nomad children.

Household conditions increase the severity of certain problems like trachoma.

**D) Knowledge gaps;**

- Limited literature available on the health impacts of droughts
- Limited studies being done in Central Asia and South East Asia as they are areas where the impact of climate change will be high.
- Limited knowledge on the mechanism of meteorological droughts

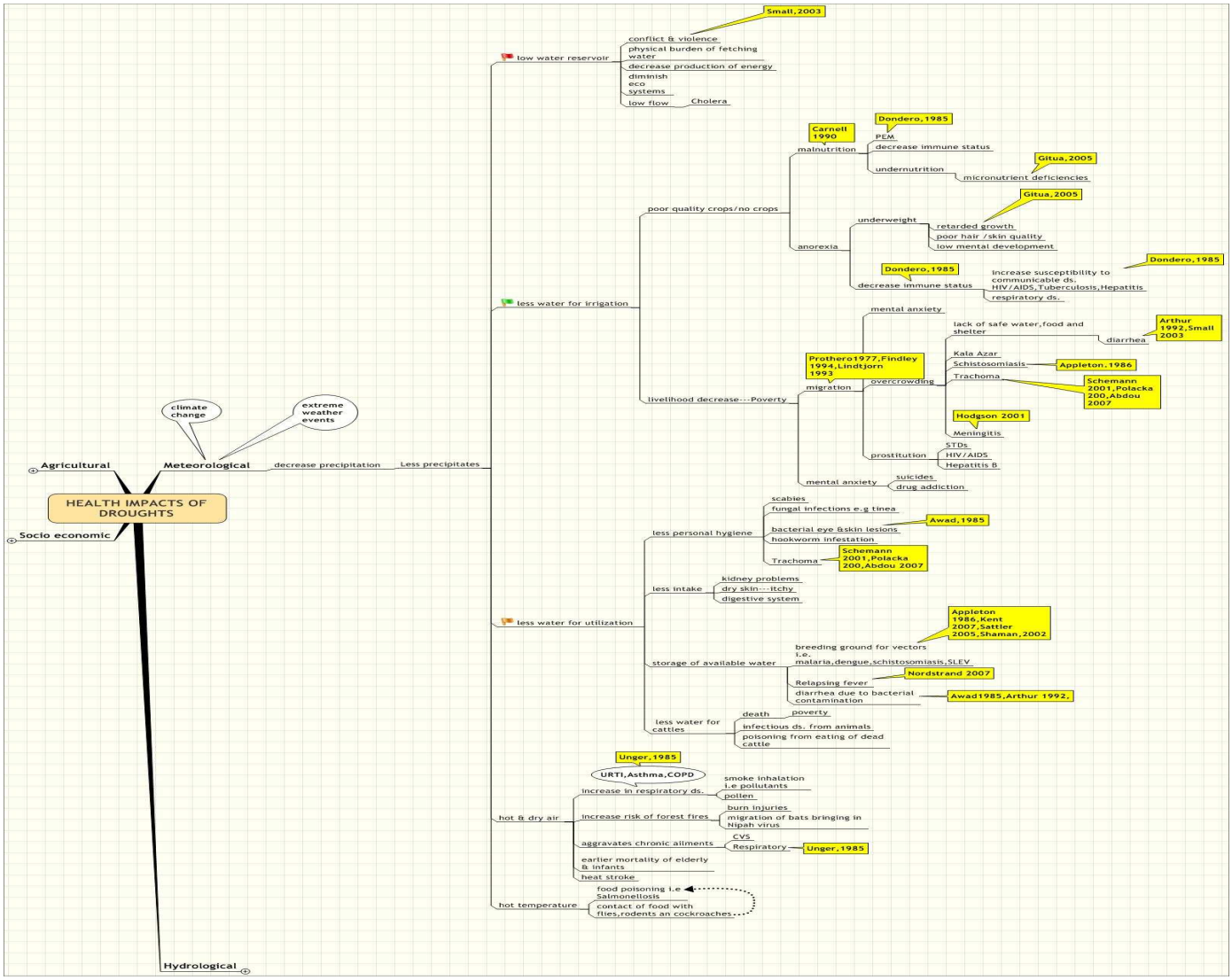



Figure 6: Available studies supporting the assumptions of possible health effects of droughts.

Filling these results into the previously designed mind map (Figure 6) we can see that the retrieved articles correspond to health effects of malnutrition, trachoma, malaria, schistosomiasis, and diarrhoeal diseases. However we could not find studies done on fire related injuries, mental effects, skin conditions, food contamination, and tuberculosis.

## 6. Discussion

Overall, the search yielded 38 articles which were linked to droughts but only 19 could be accessed. The results extracted from these 19 articles will be discussed according to the key messages extracted from the results section , in the following manner; (1) type of drought defined; (2) the health impacts discussed; (3) the determinants that played a role in the severity of the health impacts and (4) the limitations

**(A) Defining droughts**;

In the majority of the articles, droughts mostly start as meteorological droughts due to reduced rainfall in that area followed in sequence by an agricultural drought and crop failure leading to food shortage. In the Sahel region in 1983 to 1985 the drought which hit this region was the most severe leading to a famine (Carnell and Guyon, 1990). Rainfall was 30% below the fifty year average in the upper Senegal river valley during the year 1983-85 leading to low agriculture production of millet and also of forage for livestock(Findley, 1994). In the area of the Aral Sea however the drought seem to be more socio economic in nature due to intensive irrigation, the failure of snowmelt in the feeder mountain ranges and transboundary political disputes over sharing of water between the Central Asian states caused the two river beds to dry up (Small et al., 2003).

The other articles were conducted in semi arid areas i.e. Sudan, where drought is a natural hazard and is meteorological in nature followed by either an agricultural drought or a hydrological drought. These areas usually follow wet year drought year wet year cycle(Kent et al., 2007a). In South Africa the rains came late in late 2001 leading to insufficient maize production (Gitau et al., 2005) . Sudan is a semi arid area where water scarcity follows lack of rain in the dry season in the desert area. In Tanzania (Dar es Salaam) even though the climate is hot and humid there are times when - in spite the rainy season - the rainfall was less than half the average and short periods of rainfall fails leading to an extended drought period (Sattler et al., 2005).

From the following, we identify that the sequence of a drought event follows the sequence (Figure 1) discussed earlier in the introduction section that drought begins with a decrease in rainfall (meteorological drought) and with time goes on to the other types of droughts whether agricultural or hydrological in nature. In the majority of the articles, droughts mostly start as meteorological droughts due to reduced rainfall in that area followed in sequence by an agricultural drought and crop failure leading to food shortage. In the Sahel region in 1983 to 1985 the drought which hit this region was the most severe leading to a famine (Carnell and Guyon, 1990). Rainfall was 30% below the fifty year average in the upper Senegal river valley during the year 1983-85 leading to low agriculture production of millet and also of forage for livestock(Findley, 1994). In the area of the Aral Sea

however the drought seem to be more socio economic in nature due to intensive irrigation, the failure of snowmelt in the feeder mountain ranges and transboundary political disputes over sharing of water between the Central Asian states caused the two river beds to dry up (Small et al., 2003).

The other articles were conducted in semi arid areas i.e. Sudan, where drought is a natural hazard and is meteorological in nature followed by either an agricultural drought or a hydrological drought. These areas usually follow wet year drought year wet year cycle(Kent et al., 2007a). In South Africa the rains came late in late 2001 leading to insufficient maize production (Gitau et al., 2005) . Sudan is a semi arid area where water scarcity follows lack of rain in the dry season in the desert area. In Tanzania (Dar es Salaam) even though the climate is hot and humid there are times when - in spite the rainy season - the rainfall was less than half the average and short periods of rainfall fails leading to an extended drought period (Sattler et al., 2005).

From the following, we identify that the sequence of a drought event follows the sequence (Figure 1) discussed earlier in the introduction section that drought begins with a decrease in rainfall (meteorological drought) and with time goes on to the other types of droughts whether agricultural or hydrological in nature. More information on the mechanism of a type of drought e.g. socio economic, that affects a particular geographic region like the Central Asia region or in South

East Asia would be beneficial . The region of Central and South East Asia has been projected to have further increase episodes of drought events due to climate change (IPCC, 2007).

**(B) Health impacts**;

The selected studies were mainly conducted in the African region and the Eastern Mediterranean region specifically in Sudan, mostly in a rural setting so the health impacts described would differ in other geographical areas and in a rural or urban setting Health impacts can happen during the drought period and also post drought. Post drought when the rain comes and the ground cannot absorb the water due to the hardening of the earth‘s crust , often leading to flooding and water being accumulated in areas which are breeding grounds for vectors like the Anopheles Arabiensis and the Culex Nigripalpus mosquitoes.

1) During the drought period;

- **Direct effects**: (i) **Malnutrition**- As outlined earlier that most droughts are meteorological in nature affecting regions deficient of rainfall leading to agricultural droughts in which the soil moisture is insufficient for growing of crops leading to poor or low crop production and food shortage. Food shortage leads to insufficient intake followed by the consequence of malnutrition.

Malnutrition affects all age groups across life span (Table 9) from growth development defects of the fetus as apparent from the Gitua 2005 study of Vitamin A & E deficiency in pregnant women. Increase susceptibility to infectious diseases (Dondero, 1985) in infants and young children. Protein energy malnutrition leads to an increase risk of infection and death in infants and retarded intellectual development and stunted height in adolescent (WHO, 1999) Vitamin A deficiency when aggravated with infectious diseases like measles causes permanent blindness (Dondero, 1985).

Table 9: Malnutrition across life span, by disorder and consequences (WHO, 1999)

| Life Stage | Common Nutritional Disorders | Main Consequences |
|---|---|---|
| Embryo/fetus | Intrauterine growth retardation (IUGR); Iodine deficiency disorders (IDD); Folate deficiency | Low birth weight ; Brain damage; Neural tube defects; Stillbirths |
| Neonate | Low birth weight ; IDD | Growth retardation; Developmental retardation; Brain damage; Early anaemia |
| Infant and young child | Protein-energy malnutrition (PEM) ; IDD ; Vitamin A deficiency (VAD); Iron deficiency anaemia (IDA) | Continuing malnutrition; Developmental retardation ; Increased risk of infection; High risk of death; Blindness ; Anaemia |
| Adolescent | PEM, IDD, IDA ; Folate deficiency ; Calcium deficiency | Delayed growth spurt ; Stunted height; Delayed/retarded intellectual development; Increased risk of infection; Blindness; Anaemia; Inadequate bone mineralization |
| Pregnant and lactating women | PEM, IDD, BAD, IDA; Folate deficiency; Calcium deficiency | Insufficient weight gain in pregnancy; Maternal anaemia; Maternal mortality; Increased risk of infection; Night blindness; Low birth weight/high-risk death rate for fetus |

*Source: WHO, 1999*

It is apparent that malnutrition is a common health effect in drought conditions, and should be addressed primarily. In such events in the past relief food camps have been set up which have their rate of success in reducing malnutrition (Carnell, 1990) and should be

encouraged. Relief food camps could bring about a marked difference in the nutrition status of the affected people as they would be receiving fortified food with required calorie needs and essential vitamins and minerals like Iron and Zinc.

(ii) **Vector borne diseases**-No article mentioned vector borne diseases during the drought period but mostly occur post drought due to torrential rain creating a flood situation in these prior dry areas. The article by Nordstrand however described a Tick borne Relapsing fever that was caused by Borrelia crocidurae which spread to the northern dry savannahs and the southern tropical high plateau of Togo Africa due to the sub-Saharan drought. The diagnosis for relapsing fever was however missed because 7(4.5%) of the 154 patients especially in children (4 of 5 Borrelia-infected) were co infected with malarial parasites (Nordstrand A., 2007). There seems to a shift in vector borne diseases from drought areas as vectors spread to neighbouring areas to colonize and breed.

Malaria- Speculations that maybe a drought season would wipe out the population of Anopheles Arabiensis mosquito and thereby decrease the transmission season of malaria has been put to rest by a study done on the spatial and temporal genetic structure of the Anopheles mosquito and the habitat characterization study in Tanzania shows us that they can breed in anyplace no mater now small in diameter. During droughts mosquito activities reduces

increasing the amount of non immune persons that when the drought breaks there is a larger population who are susceptible thus increasing transmission rates (Bouma, 1997) post drought. Other drought related factors that may result in an increase in the risk of malaria stagnation and contamination of drainage canals and small rivers which serve as breeding ground for this vector.

(iii) **Water related**- Diseases can be caused through various pathways in relation to water. It could be through (a) water sources in situation when there is water scarcity (b) water availability and its use.

(a) Water source- Most of the epidemics of water-related diseases are usually associated with unforeseen pollution of safe supplies, the use of polluted supplies without treatment, failure of treatment processes and secondary pollution of the water distributed (Feachem,1977). As seen from the Awad 1985, study that unprotected sources as a hotbed of infectious agent. Chlorination of water source or protection by proper barriers, regular monitoring of distribution channels and education of how to draw water from public source could reduce the bacterial content of the water resources.

(b) Water availability and its use – Trachoma is an eye disease caused by Chlamydia trachomatis responsible for approximately 1.3 million cases of blindness worldwide, representing 3.6%of the global burden of blindness (Resnikoff et al., 2004) which is mainly increased in children with dirty faces, sharing the bed, living with animals in the

same room and the presence of flies on the face as risk factors seen from the studies.

Trachoma has been targeted by the WHO for elimination by the year 2020 (WHO, 1998) and has endorsed the SAFE strategy for trachoma control. SAFE stands for Surgery (for trichiasis), Antibiotics (for active trachoma), Face washing (to decrease transmission) and Environmental change (to interrupt transmission). In drought affected regions due to water shortage face washing could prove to be a difficult strategy to pursue unless intense health education is provided to communities. Face washing independent of the amount of water use could help reduce the incidence of trachoma in these communities.

(iv) **Dust related**- Drought usually is accompanied by hot, dry, dust storms (Perez, E., 1996) but no article was found on the health effects related to them. However it was observed by Unger 2005, that even in a violent sandstorm[7] that the high wind does not seem to cause any statistically significant immediate effects on asthma and other respiratory problems present as pre disposing factors.

This does not however conclude that there is no health effects related to inhalation of aerosols or any respirable particles but merely the absence of relevant literature. More research should be done on

[7] A sandstorm/dust storm typically occurs in arid or semi-arid regions if high wind speeds cause the transportation of small particles like sand or fine clastic sediment by saltation and/or suspension

respiratory diseases in relation to dust or sand storms in drought events.

- **Indirect effects:** (i) Mobility and disease- In a natural disaster, displacement is a primary concern as the risk for communicable disease transmission is associated with the size and character of the polpulation displaced, proximity to safe water and latrines, the nutritional status and the level of immunity to vaccine preventable diseases like measles (Noji E, 1997).

  Migration on its own has many classification distinguished by its duration of stay termed as long cycle or short cycle pattern (Prothero, 1985), of which will not be discussed in detail here. The patterns of migration does not change in a drought situation which could be due to presence of out migrants supporting the families that remained, food relief sufficient or maybe a threshold of migration has been reached. We cannot conclude that migration is an indirect effect of drought but it would be worthwhile to do more research on the association of migration to droughts. Also individual studies would be needed to assess which health effects are more frequent in migrants depending on geographical location.

  (ii) Overcrowding – Crowding is common in displaced populations by natural disasters and can facilitate the transmission of communicable diseases (Watson, 2007). Drought situations leading to famine are usually associated with famine relief camps. In these relief camps

susceptibility to communicable diseases is increased through malnutrition and risk of transmission rises through close contact, poor sanitation and movement of people between camps (Toole & Waldman 1988). Diarrheal diseases are frequent problems in crowded areas along with other disease like measles, trachoma, hepatitis, respiratory disease, meningitis, etc.

There are many other health effects that could be related to crowding for which we did not find literature on, for e.g tuberculosis and scabies that would be worthwhile to consider.

2) Post drought health effects:

Post drought when the rain comes and the ground cannot absorb the water in due to the hardening of the earth‘s crust , often leads to flooding and water being accumulated in areas which are breeding grounds for vectors like the Anopheles arabiensis and the Culex nigripalpus mosquitoes. Besides the common vectors a few studies have also revealed that Schistosomiasis resumes (Appleton,1986) and that droughts play role in the amplification of the Saint Louis Encephalitis Virus (SLEV) in Florida(Shaman,2002).

**Schistosomiasis;** Schistosomiasis is caused when people bathe or frequent the water in which the infected snails are present and get infected. These snails can colonize in newly formed water bodies which have been replenished when the rain comes. In an area that the

disease is frequent, warnings should be given to the population to not bathe in these pools.

**Saint Louis encephalitis virus;** -

The SLEV is transmitted through the bite of the Culex mosquitoe to a human and it was seen that a drought event restricts the mosquito's activities to other habitats where wild birds are found .This forced convergence of mosquito vectors and avian amplification hosts provides an ideal environment for the rapid epizootic amplification of SLEV. When the drought ends and water resources increase, infected mosquitoes and birds leave these habitats and begin an early transmission phase of the Florida SLEV.

Standing water caused by heavy rainfall or over flow of rivers post drought can create new breeding sites for vectors causing malaria, schistosomiasis, relapsing fever, etc. This situation can develop in an increase of vector population and potential disease transmission (Watson, 2007). By knowing about possible vectors prevalent in a geographical area, preventive measures that were going on in pre drought period should be continued so as to prevent new infection.

**(C) Determinants:**

In the articles there were a few studies that looked into determinant factors that influence the severity of a health impact on the affected population.

**1) Age**= In majority of the studies the study population were children and in some study it was only diseases prevalent in children like trachoma. Through this we observe that children are more susceptible to infectious diseases escpecially if they are malnourished and living under unhygenic conditions and over crowding.

**2) Sex =** Malnutrition seems to be more affected in males in comparison to females but the result was not statistically significant. The reason could be that males move around a lot more in comparison to females who are more home based. In the migration study too it was seen that there was a decrease in male members below the age of 15 which is due a more increase in migration patterns in males as they go and look for food and work.

**3) Socio economic =** Every community has different traditions and pratices. For the pastoralists they move around and are at risk to malnutrition as compared to their sedentary agriculture community who in turn are more at risk to developing infectious diseases like measles and meningitis due to over crowding in the villages**.**

**4**) **Environmental factors =** Environment conditions such as inadequate sanitation facilities favours the spread of infectious agents like the presence of coliforms in the public water supply which if not treated cause water borne problems. It was seen that the distance of water source increases the risk of a child developing trachoma irrespective of the amount of water used. Having a medical facility and a social organization in the village has reduced the number of cases as health care is accessible and also health education given to mothers on childcare.

**(D) Limitations of the study:**

There are many limitations to this literature review study. First and foremost the limited number of retrieved articles may partly be due to the choice and linkage of search terms. The search terms may have limited the search by looking in to articles that were specifically related to droughts and skipping the more general search of each key word. The literature articles included for the review (19 articles) were too little to come up with enough evidence of health impacts of droughts so further research into this area would be highly beneficial. Furthermore the selected articles did not discuss what the health impacts were but mention problems existent in a drought situation. The unavailability of full text articles caused a handicap for the reviewer to further review and summarizes findings. Review articles, letters and editorials without any empirical information were

excluded further limiting the source as the study only included evidence based findings. Considering the language non English, non French, non German, relevant studies may have been missed out. Not including studies with other Natural Disasters have also decreased literature availability. The research question itself created a very wide generalized concept to drought and its consequences. Knowledge gaps reveals that not many articles are published on the health effects of droughts specifically.

Even though we have the limitations of available articles, from this study we can gather the available evidences and give certain recommendations of what are the health impacts of droughts present in certain geographical regions.

# 7. Conclusions and Recommendations

**Summary of results:**

The main aim of this study is to compile the evidence for health impacts that accompany and follow a drought disaster. Despite the lack of literature, the included articles have highlighted some prominent health effects in different geographical locations. Malnutrition appears to be the most acute sequel in the African regions and in Sudan. The most frequent type of malnutrition is protein energy malnutrition (PEM) and vitamin A deficiency a condition leading to blindness. Growth retardation is seen in infants born to mothers who lack Vitamin A and Vitamin E in their plasma during pregnancy and post partum. Malaria can still pose a health risk despite the decrease in mosquito population during a drought season. Eye communicable diseases like Trachoma are frequent in crowded situations especially susceptible are children with unclean faces and presence of flies. Tick borne relapsing fever is present in Togo and similar regions but diagnosis is missed due to its co infection with malaria. Indirect effects of migration and crowding in relief camps like measles, diarrheal diseases, respiratory diseases, meningitis have been mentioned but there is no evidence to back up their presence and also there were too less studies to give conclusive certainty. The post drought effects of flood and the resumption of vectors to colonize in new breeding sites in host snails,

mosquito and wild birds gives rise to the Saint Louis encephalitis virus in Florida and the Schistosoma Haematobium in Southern Africa.

Migration does not seem to be much of a problem in drought stricken areas but when it does happen it is mostly the male members who move in search of food. There seem to be no statistically significant differences in infection incidence in both sexes but the health effects seem to be more severe in children. Environmental conditions like polluted water source, overcrowding, far distance to collect water, low water availability ,unclean surroundings , having cattle in the house have a more profound effect on the health effects and seem to exacerbate them.

**Conclusions:**

From the summary we can conclude that there are health effects of droughts that affect the morbidity and mortality of an affected population. Keeping in mind the geographical differences, environmental and socio economic factors, the effects will vary in frequency and severity. Even with limited evidence we can compile the health effects but more research into the health impacts of droughts should be encouraged.

With the projections of the IPCC on climate change and the increase in extreme weather events, droughts are likely to increase in areas like Central Asia and South East Asia. Research on the health impacts of

droughts on the two areas are highly recommended as there is limited studies being done there.

**Recommendations:**

Based on the summary and conclusions it can be recommended that (a) early warning systems could be developed for areas like Africa, Eastern Mediterrenean, Central Asia and South East Asia like the Drought monitoring system developed for North America (NDMC, university of lincoln- Nebraska) giving early warnings of approaching drought events (b) strenthening of health services by increasing disease surveillance and control, capacity building of healthcare professionals in the public and private sector, improvement of mother and child health and increasing immunization measures especially for measles (c) preparing disaster preparedness plans in areas at risk of droughts and to consider adaptative measures for risk reduction and management of health effects of droughts e.g nutrition (d) inter sectoral partnerships with sectors like agriculture, family welfare for food and health care by encourage famine relief camps. Collaborations with meteorological office for early warnings and (e) further research on the health impacts of droughts in the Central and Southeast Asian regions. Research on fire related, dust related and mental effects of droughts should be carried out. Adaptative measures to the health impacts are highly recommended so a disaster management plan can be chalked out for the affected regions.

This study have tried to increase the awareness of the health effects of droughts so policy makers can understand what is to be expected if such an event occurs. With the knowledge preparedness could be more precise and be more effecive in preventing morbidity and mortality in the affected population.

## Reference list:


ABDOU, A., NASSIROU, B., KADRI, B., MOUSSA, F., MUNOZ, B. E., OPONG, E. & WEST, S. K. (2007) Prevalence and risk factors for trachoma and ocular Chlamydia trachomatis infection in Niger. *Br J Ophthalmol,* 91**,** 13-7.

AHERN M, Kovats R. S, WILKINSON P, FEW R, and MATTHIES F: Global Health Impacts of Floods: Epidemiologic Evidence; 2005; Johns Hopkins Bloomberg School of Public Health

APPLETON, C. C. (1986) Resumption of Schistosoma haematobium transmission after drought and subsequent flood. *Ann Trop Med Parasitol,* 80**,** 367-8.

ARTHUR, J. D., BODHIDATTA, L., ECHEVERRIA, P., PHUPHAISAN, S. & PAUL, S. (1992) Diarrheal disease in Cambodian children at a camp in Thailand. *Am J Epidemiol,* 135**,** 541-51.

AWAD EL KARIM, M. A., EL HASSAN, B. M. & HUSSEIN, K. K. (1985) Social and public health implication of water supply in arid zones in the Sudan. *Soc Sci Med,* 20**,** 393-8.

BINNIE & Partners, (1996). Aral Sea Program 5, Project no. 1Uzbekistan Water Supply Sanitation and Health Project. Final Report Water quality and Treatment. Tashkent: State Committee on Forecasting and Statistic of the Cabinet of Ministers of the Republic of Uzbekistan / Binnie & Partners.

BOUMA MJ, KOVATS RS, GOUBET SA, COX JS, HAINES A. (1997),Global assessment of El Niño's disaster burden. Lancet; 350: 1435–38

BOUMA, M.andC.Dye, (1997): Cycles of Malaria associated with El nino in venezuela, J.Am.Med.Assoc, 278, 1772-174.

CARNELL, M. A. & GUYON, A. B. (1990) Nutritional status, migration, mortality, and measles vaccine coverage during the 1983-1985 drought period: Timbuktu, Mali. *J Trop Pediatr,* 36**,** 109-13.

CHOUDHURY, A.Y and Bhuiya, A.,(1993): effects of biosocial variable on changes in nutritional status of rural Bangladeshi children, pre- and post-monsoon flooding. J.Biosoc.Sci. 351-357.

DONDERO, T. J., JR. (1985) Nutrition and health needs in drought-stricken Africa. *Public Health Rep,* 100**,** 634-8.

EM-DAT: The OFDA/CRED International Disaster Database, Jul-23-2008. - Data version: v12.07, accessed from www.em-dat.net - Université Catholique de Louvain - Brussels – Belgium

Feachem R. G., Burns E., Coiencoss A.. Cornin A., Cross P., Curtis D., Kmn. M. and Lamb 0. H. Water *Health and Development. An Interdisciplinary Etoluatiorl.* Tri-new Books, London, 1977.

FINDLEY, S. E. (1994) Does drought increase migration? A study of migration from rural Mali during the 1983-1985 droughts. *Int Migr Rev,* 28**,** 539-53.

GITAU, R., MAKASA, M., KASONKA, L., SINKALA, M., CHINTU, C., TOMKINS, A. & FILTEAU, S. (2005) Maternal micronutrient status and decreased growth of Zambian infants born during and after the maize price increases resulting from the southern African drought of 2001-2002. *Public Health Nutr,* 8**,** 837-43.

HODGSON, A., SMITH, T., GAGNEUX, S., ADJUIK, M., PLUSCHKE, G., MENSAH, N. K., BINKA, F. & GENTON, B. (2001) Risk factors for meningococcal meningitis in northern Ghana. *Trans R Soc Trop Med Hyg,* 95**,** 477-80.

IPCC Fourth Assessment report: Climate change 2007. Chapter12-Europe. Accessed from http://www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr.pdf on 27th July 2008

IPCC: Climate change 2007; Synthesis report, IPCC Fourth Assessment report, 2007. Page 65, Accessed from http://www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr.pdf on 10th July 2008.

KENT, R. J., MHARAKURWA, S. & NORRIS, D. E. (2007a) Spatial and temporal genetic structure of Anopheles arabiensis in Southern Zambia over consecutive wet and drought years. *Am J Trop Med Hyg,* 77**,** 316-23.

KENT, R. J., THUMA, P. E., MHARAKURWA, S. & NORRIS, D. E. (2007b) Seasonality, blood feeding behavior, and transmission of Plasmodium falciparum by Anopheles arabiensis after an extended drought in southern Zambia. *Am J Trop Med Hyg,* 76**,** 267-74.

LINDTJORN, B., ALEMU, T. & BJORVATN, B. (1993) Population growth, fertility, mortality and migration in drought prone areas in Ethiopia. *Trans R Soc Trop Med Hyg,* 87**,** 24-8.

MENNE, B and R BERTOLLINI, 2000: The health impacts of desertification and drought, Down to Earth, 4-6

NATALYA A., A.V. Pak,( 2008) Central Asian Research Hydro meteorological Institute, Tashkent, Republic of Uzbekistan, Forecasting of Drought in Central, Accessed from http://unfccc.int/files/meetings/workshops/other_meetings/application/pdf/uzbekistan.pdf on 4th August 2008

NATIONAL DROUGHT MITIGATION CENTRE, University of Nebraska-Lincoln, (2006), Understanding and defining droughts, Accessed from http://drought.unl.edu/whatis/concept.htm on 1st august 2008

NOJI E., Public health consequences of Disaters, New York,Oxford University press,(1997)

NORDSTRAND A., BUNISKI I., LARSSON C.,TSOGBE K., SCHWAN T.G.,NILLSON M.,BERGSTROM S.,(2007)Tick-borne Relapsing Fever Diagnosis Obscured by Malaria, Togo, Emerging Infectious Diseases • www.cdc.gov/eid • Vol. 13, No. 1, January 2007

PEREZ E., THOMPSON, P, Natural hazards: causes and effects. Lesson 7-Drought , Prehosp Disaster Med, 71-7; quiz 78-9

POLACK, S., KUPER, H., SOLOMON, A. W., MASSAE, P. A., ABUELO, C., CAMERON, E., VALDMANIS, V., MAHANDE, M., FOSTER, A. & MABEY, D. (2006) The relationship between prevalence of active trachoma, water availability and its use in a Tanzanian village. *Trans R Soc Trop Med Hyg,* 100**,** 1075-83.

PROTHERO R and M. CHAPMAN, eds (1985), Circulation in Third World countries. London: Routledge and Kegan Paul, 1985

PROTHERO, R. M. (1977) Disease and mobility: a neglected factor in epidemiology. *Int J Epidemiol,* 6**,** 259-67.

RESNIKOFF, S., PASCOLINI, D., ETYA'ALE, D., KOCUR, I., PARAJASEGARA, R., POKHAREL, G.P., MARRIOTI, S.P.,( 2002). Global data on visual impairment in the year. Bull. World Health Organ. 82, 844—851.

SATTLER, M. A., MTASIWA, D., KIAMA, M., PREMJI, Z., TANNER, M., KILLEEN, G. F. & LENGELER, C. (2005) Habitat characterization and spatial distribution of Anopheles sp. mosquito larvae in Dar es Salaam (Tanzania) during an extended dry period. *Malar J,* 4**,** 4.

SCHEMANN, J. F., SACKO, D., MALVY, D., MOMO, G., TRAORE, L., BORE, O., COULIBALY, S. & BANOU, A. (2002) Risk factors for trachoma in Mali. *Int J Epidemiol,* 31**,** 194-201.

SHAMAN J.,DAY J.F., and STIELITZ M., (2002) Drought-Induced Amplification of Saint Louis encephalitis virus, Florida. Emerging Infectious Diseases Vol. 8, No. 6.

SMALL, I., FALZON, D., VAN DER MEER, J. B. & FORD, N. (2003) Safe water for the Aral Sea Area: could it get any worse? *Eur J Public Health,* 13**,** 87-9.

TOOLE MJ & WALDMAN J (1988) An analysis of mortality trends among refugee populations in Somalia, Sudan and Thailand. Bulletin of the World Health Organization 66, 237–247.

UNGER, D. L. (1985) Immediate effects of a sandstorm on asthma and other respiratory problems. *Chest,* 87**,** 543-4.

WATSON J.,(2007) Epidemics after Natural Disasters,Emerging Infectious diseases.www.cdc.gov/eid.vol.13,No.1, January 2007.

WHITE,R.,(2003): Commentary: What can we make of an association between human immunodeficiency virus prevalence and population mobility? Int.J.epidemiology 753-754

WORLD METEROLOGICAL ORGANIZATION,( 2006), Drought monitoring and, early warning: concepts, progress and future challenges, WMO-No. 1006.

World Health Organization. 1998 Global elimination of blinding trachoma. World Health Organization 51st World Health Assembly Resolution 51.11. Geneva:,

ANNEX 1

Source: "EM-DAT: The OFDA/CRED International Disaster Database
www.em-dat.net - Université Catholique de Louvain - Brussels - Belgium"

**EM-DAT: Drought impacts by country from 1900 to 2007**

| Drought | Occurrence | Number of Affected | Damages ($US'000) |
|---|---|---|---|
| **Australia and New Zealand** | | | |
| Australia | 10 | 10 | 10573000 |
| New Zealand | 1 | 0 | 100000 |
| **Caribbean** | | | |
| Anguilla | 1 | 0 | 0 |
| Antigua and Barbuda | 1 | 75000 | 0 |
| Cuba | 6 | 820000 | 183139 |
| Dominican Rep | 1 | 240000 | 5000 |
| Haiti | 7 | 2305217 | 1000 |
| Jamaica | 3 | 100000 | 6500 |
| Puerto Rico | 1 | 0 | 2000 |
| **Central America** | | | |
| Costa Rica | 3 | 0 | 24000 |
| El Salvador | 4 | 400000 | 193400 |
| Guatemala | 3 | 186596 | 24000 |
| Honduras | 8 | 815625 | 17000 |
| Mexico | 6 | 65000 | 1610000 |
| Nicaragua | 4 | 553000 | 18000 |
| Panama | 1 | 81000 | 0 |
| **Central Asia** | | | |
| Tajikistan | 1 | 3000000 | 57000 |
| Uzbekistan | 1 | 600000 | 50000 |
| **Eastern Africa** | | | |
| Burundi | 3 | 2800000 | 0 |
| Comoros | 1 | 0 | 0 |
| Djibouti | 7 | 647750 | 0 |
| Eritrea | 2 | 3900000 | 0 |
| Ethiopia | 10 | 43636200 | 92600 |
| Kenya | 11 | 35352000 | 1500 |
| Madagascar | 5 | 2795290 | 0 |
| Malawi | 6 | 19678702 | 0 |
| Mauritius | 1 | 0 | 175000 |
| Mozambique | 10 | 16797500 | 50000 |
| Rwanda | 6 | 4156545 | 0 |
| Somalia | 10 | 2883500 | 0 |
| Tanzania Uni Rep | 8 | 8037483 | 0 |
| Uganda | 7 | 3206000 | 1800 |

| | | | |
|---|---|---|---|
| Zambia | 5 | 4173204 | 0 |
| Zimbabwe | 5 | 13855000 | 2550000 |
| **Eastern Asia** | | | |
| China P Rep | 29 | 386414000 | 19876420 |
| Hong Kong (China) | 7 | 0 | 0 |
| Japan | 1 | 0 | 0 |
| Korea Rep | 2 | 2800000 | 0 |
| Mongolia | 1 | 450000 | 0 |
| **Eastern Europe** | | | |
| Bulgaria | 2 | 0 | 0 |
| Hungary | 3 | 0 | 984000 |
| Moldova Rep | 2 | 210394 | 0 |
| Romania | 2 | 0 | 500000 |
| Russia | 3 | 1000000 | 0 |
| **Melanesia** | | | |
| Fiji | 2 | 294455 | 30000 |
| Papua New Guinea | 2 | 540000 | 0 |
| Solomon Is | 2 | 380 | 0 |
| **Micronesia** | | | |
| Kiribati | 1 | 84000 | 0 |
| Micronesia Fed States | 1 | 28800 | 0 |
| **Middle Africa** | | | |
| Angola | 6 | 2610000 | 0 |
| Cameroon | 4 | 586900 | 1500 |
| Central African Rep | 1 | 0 | 0 |
| Chad | 8 | 2356000 | 83000 |
| Congo | 1 | 0 | 0 |
| Sao Tome et Principe | 1 | 93000 | 0 |
| Zaire/Congo Dem Rep | 2 | 800000 | 0 |
| **Northern Africa** | | | |
| Algeria | 2 | 0 | 0 |
| Morocco | 5 | 412000 | 900100 |
| Sudan | 7 | 23210000 | 0 |
| Tunisia | 2 | 31400 | 0 |
| **Northern America** | | | |
| Canada | 5 | 55000 | 4810000 |
| United States | 9 | 0 | 6835000 |
| **Northern Europe** | | | |
| Denmark | 1 | 0 | 751700 |
| Lithuania | 2 | 0 | 278473 |
| **Russian Federation** | | | |
| Soviet Union | 1 | 5000000 | 0 |
| **South America** | | | |
| Argentina | 1 | 0 | 120000 |

| | | | |
|---|---|---|---|
| Bolivia | 8 | 3491209 | 965600 |
| Brazil | 15 | 47750000 | 4723100 |
| Chile | 2 | 120000 | 255000 |
| Colombia | 1 | 100000 | 0 |
| Ecuador | 2 | 634000 | 0 |
| Guyana | 2 | 607200 | 29000 |
| Paraguay | 4 | 106390 | 0 |
| Peru | 8 | 3606104 | 296000 |
| Uruguay | 1 | 0 | 250000 |
| **South-Eastern Asia** | | | |
| Cambodia | 5 | 6550000 | 138000 |
| East Timor | 1 | 0 | 0 |
| Indonesia | 9 | 4804220 | 160200 |
| Lao P Dem Rep | 5 | 4250000 | 1000 |
| Malaysia | 1 | 5000 | 0 |
| Philippines | 8 | 6553207 | 64453 |
| Thailand | 5 | 13500000 | 424300 |
| Viet Nam | 5 | 6110000 | 649120 |
| **Southern Africa** | | | |
| Botswana | 6 | 1344900 | 3000 |
| Lesotho | 5 | 2010500 | 1000 |
| Namibia | 6 | 783200 | 51000 |
| South Africa | 8 | 17475000 | 1000000 |
| Swaziland | 5 | 1630000 | 1739 |
| **Southern Asia** | | | |
| Afghanistan | 4 | 4528000 | 250 |
| Bangladesh | 6 | 25002000 | 0 |
| India | 13 | 1061841000 | 2441122 |
| Iran Islam Rep | 2 | 37625000 | 3300000 |
| Nepal | 5 | 4600000 | 10000 |
| Pakistan | 1 | 2200000 | 247000 |
| Sri Lanka | 8 | 6256000 | 0 |
| **Southern Europe** | | | |
| Albania | 1 | 3200000 | 0 |
| Bosnia-Hercegovenia | 2 | 62575 | 298000 |
| Croatia | 1 | 0 | 330000 |
| Greece | 1 | 0 | 1000000 |
| Italy | 2 | 0 | 800000 |
| Macedonia FRY | 1 | 10000 | 0 |
| Portugal | 3 | 0 | 1443136 |
| Spain | 4 | 6000000 | 10660000 |
| Yugoslavia | 1 | 0 | 1000000 |
| **Western Africa** | | | |
| Benin | 2 | 2215000 | 651 |

| | | | |
|---|---|---|---|
| Burkina Faso | 11 | 5563290 | 0 |
| Cape Verde Is | 10 | 40000 | 0 |
| Cote d'Ivoire | 1 | 0 | 0 |
| Gambia The | 7 | 830000 | 700 |
| Ghana | 3 | 12512000 | 100 |
| Guinea | 2 | 0 | 0 |
| Guinea Bissau | 6 | 132000 | 0 |
| Liberia | 1 | 0 | 0 |
| Mali | 9 | 2827000 | 0 |
| Mauritania | 10 | 5860907 | 59500 |
| Niger | 11 | 12755058 | 0 |
| Nigeria | 1 | 3000000 | 71103 |
| Senegal | 8 | 7549000 | 374800 |
| Togo | 3 | 550000 | 500 |
| **Western Asia** | | | |
| Armenia | 1 | 297000 | 100000 |
| Azerbaijan | 1 | 0 | 100000 |
| Cyprus | 2 | 0 | 0 |
| Georgia | 1 | 696000 | 200000 |
| Iraq | 2 | 500000 | 2000 |
| Israel | 1 | 0 | 75000 |
| Jordan | 2 | 330000 | 0 |
| Syrian Arab Rep | 1 | 329000 | 0 |
| Yemen Arab Rep | 2 | 2020000 | 10000 |
| Yemen P Dem Rep | 2 | 0 | 0 |
| **Western Europe** | | | |
| Belgium | 1 | 0 | 0 |
| France | 4 | 0 | 1610000 |
| | | | |
| Total = | **559** | **1928898711** | **82441506** |

ANNEX 2

**Data extracting format:**

1. Basic Information**;**
    - ID
    - Title of the article
    - Journal
    - Published date
    - Author
1. Eligibility;
    - Confirm eligibility for review(inclusive criteria)
    - Reason for exclusion
2. Background Description;
    - Type of study
    - Study objectives
    - Hypothesis
3. Method;
    - Study setting(geographical distribution)
    - Study population(size)
    - Study period ( affected years)
    - Case definition of droughts
    - Determinants of health discussed
    - Health effects caused (a) direct (b) indirect
    - Source of materials(natural disaster/ climate change)
    - Other remarks
4. Results;
    - Summary of main results
    - Other results
5. Conclusion and Miscellaneous;
    - Conclusion of the author/s
    - Miscellaneous comments of the author/s
    - Correspondence required
    - Conclusions of the reviewers[8]
6. Notes.

[8] Result of the Quality assessement

ANNEX 3

Data Extracted [Article No.3];

1. Basic Information

   - ID = Food prices effects
   - Title of the article= Maternal micronutrient status and decreased growth of Zambian infants born during and after the maize price increases resulting from the southern African drought of 2001–2002.
   - Journal = Public Health Nutrition
   - Published date = 11 April 2005
   - Author = R Gitau, M Makasa, L Kasonka, M Sinkala, C Chintu, A Tomkins and S Filteau

2. Eligibility;

   - Confirm eligibility for review(inclusive criteria) = Growth retardation due to droughts
   - Reason for exclusion= NR

3. Background Description;

   - Type of study= Longitudinal cohort study
   - Study objectives = To investigate the effects on maternal micronutrient status and infant growth of the increased maize prices that resulted from the southern African drought of 2001–2002.
   - Key words = Famine, Micronutrients, Pregnancy, Stunting

4. Method;

   - Study setting(geographical distribution) = A maternal and child health clinic in Lusaka, Zambia
   - Study population(size) = 429 women
   - Study period ( affected years)= June 2001 to December 2004
   - Case definition of droughts = ND
   - Determinants of health discussed= socio economic factor
   - Health effects caused (a) direct , micronutrient deficiencies in the plasma of pregnant women leads to growth retardation of the babies
   - (b) indirect
   - Other remarks

5. Results;

Summary of main results = Maize price increases were associated with decreased maternal plasma vitamin A during pregnancy (P ¼ 0.028) and vitamin E postpartum (P ¼ 0.042), with the lowest values among samples collected after May 2003 (vitamin A: 0.96 mmol l21, 95% confidence

interval (CI) 0.84–1.09, n ¼ 38; vitamin E: 30.8 mmol mmol21 triglycerides, 95% CI 27.2–34.8, n ¼ 64) compared with before January 2002 (vitamin A: 1.03 mmol l21, 95% CI 0.93–1.12, n ¼ 104; vitamin E: 38.9 mmolmmol21 triglycerides, 95% CI 34.5–43.8, n ¼ 47). There were no significant effects of sampling date on maternal weight, haemoglobin or acute-phase proteins and only marginal effects on infant weight. Infant length at 6 and 16 weeks of age decreased progressively throughout the study (P-values for time of data collection were 0.51 at birth, 0.051 at 6 weeks and 0.026 at 16 weeks)

- Other results

6. Conclusion and Miscellaneous;

- Conclusion of the author/s = The results show modest effects of the maize price increases on maternal micronutrient status. The most serious consequence of the price increases is likely to be the increased stunting among infants whose mothers experienced high maize prices while pregnant.
- Miscellaneous comments of the author/s =
  During periods of food shortages it might be advisable to provide micronutrient supplements even to those who are less food-insecure.

- Correspondence required =No

- Conclusions of the reviewers = 4/5

7. Notes.

The effect of maize price increases on maternal blood constituents was examine by dividing the samples according to the dates they were collected: before price increases, i.e. before January 2002, during high prices, i.e. January 2002–April 2003; and after prices decreased again, i.e. May 2003 to the end of the study.

Block SA, Kiess L, Webb P, Kosen S, Moench-Pfanner R, Bloem M, et al. Macro shocks and micro outcomes: child nutrition during Indonesia's crisis. Economics and Human

Biology 2004; 2: 21–44.