# Assessing Long-Term Climatic Change on Mortality Patterns in Marginal Communities in Gansu China

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## Abstract

China has been the fastest growing economy for the past two decades, and is routinely criticized about how this economic prowess comes at the cost of the health and well-being of its populace. Yet, while NGOs and other nations scrutinize how China's rapid industrialization leads to detrimental environmental degradation for the rest of the world, very little attention has been given to understanding how long-term changes in environmental conditions jeopardizes the lives of vulnerable people living in marginalized areas in China's poor interior provinces. In this study, We assess how long-term climatic change (drought) impacted mortality for 30 years in communities in China's interior province of Gansu.

We find that cold temperature, hot temperature, low humidity, high humidity and high diurnal temperature range are related to increased mortality. Expectantly, young and elderly age groups are adversely impacted by long-term climatic changes. However, our results indicate that women's mortality patterns are much more susceptible to cold and high humidity, suggesting that research is needed to identify mechanisms and biases that compromise women's well-being in vulnerable communities.

## Methods

We combined three meteorological measures of mean temperature ($T_{mean}$), diurnal temperature range (DTR) and relative humidity (RH) collected daily between Jan 1 1970 to Dec 31 2009 and death records from Jan 1 2004 to Dec 31 2009 to highlight how climate change impacted mortality patterns among vulnerable people living in Baiyin (sub-arid), Minqin (arid), and Tianshui (sub-humid) counties in Gansu.

Using analytic methods such as distributed lag nonlinear model (DLNM) combined with generalized additive model (GAM), a natural cubic spline-natural cubic spline, a double threshold-natural cubic spline, and a high threshold-natural cubic spline to assess non-linear and delayed effects of $T_{mean}$, DTR and RH, we assess the impact of these factors across non-external mortality ($D_{all}$), age-specific non-external mortality (<65 ($D_{0-64}$), 65-74 ($D_{65-74}$), and >75 years ($D_{75+}$)), on gender-specific mortality, and cause-specific mortality (circulatory disease ($D_c$) and respiratory disease ($D_r$)).

## Research Setting: China -- Gansu Study Sites

- Drought is a serious issue in China, with over half of the land mass composed of arid and sub-arid areas
- Over 80% of arid land in China is located in the northwest; most of this region is classified as historic dry areas with low levels of precipitation
- Drought causes extensive problems. About 60% of the loss of grain is attributed to climatic causes, with 58% of this damage due to drought
- Gansu is in northwest China. It is connected to the Qinghai-Tibet and Inner Mongolia Plateaus. Much of Gansu is composed of plateaus and mountains ranging over 1000 meters in elevation. The Badain and Tengger deserts form Gansu's northern border
- In recent years, excessive exploitation of groundwater, desertification of the grassland, water loss and soil erosion, grassland deterioration and water interception have exacerbated the direness of historical climatic conditions and local environment
- These climatic changes and the effects of human activities combine to detrimentally impact human health through economic, physical, and psychological stress and increased disease burden

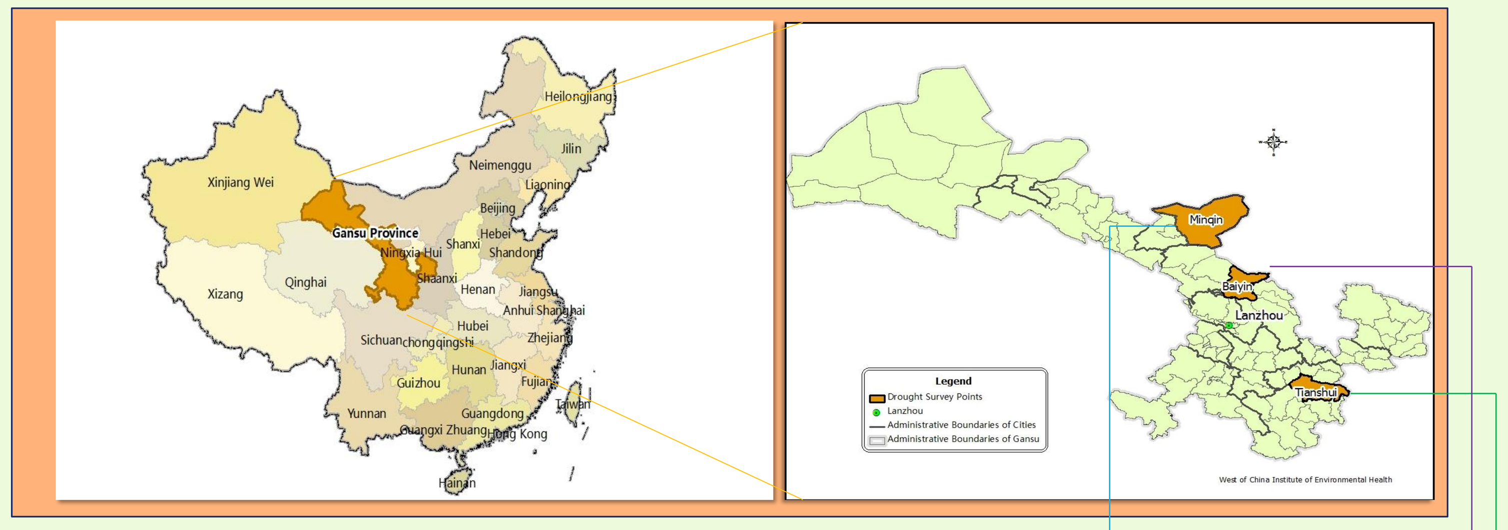
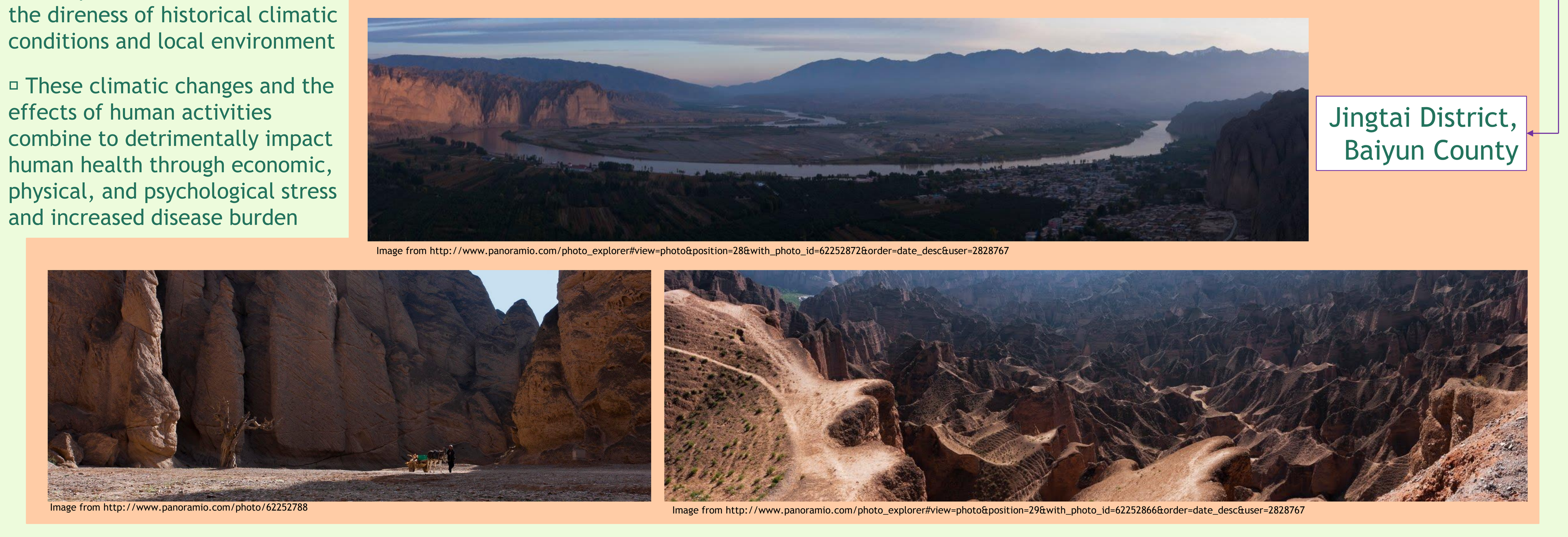



Image from http://www.treehugger.com/clean-technology/chinas-green-walls-losing-the-battle-against-encroaching-deserts.html

Minqin County

Images from http://www.colorsmagazine.com/stories/magazine/84/story/living-off-the-sand



Jingtai District, Baiyun County

Maiji District, Tianshui County

## Comparisons of Research Site Characteristics

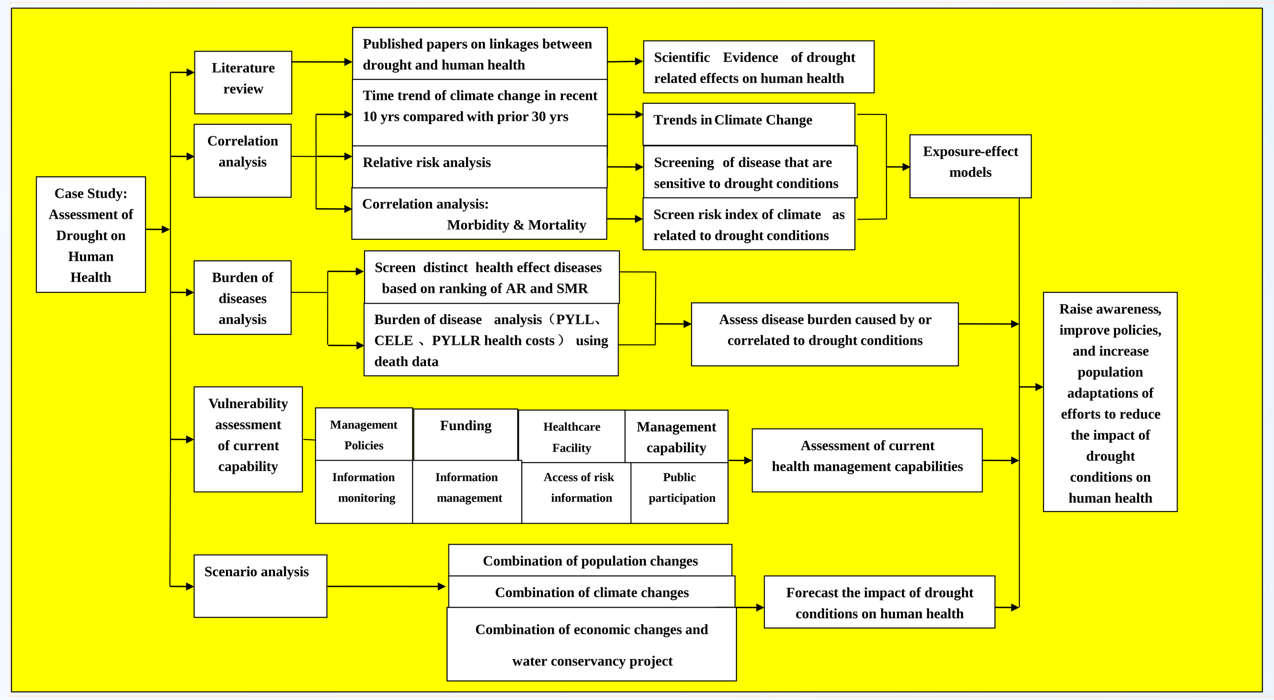
Geographic Characteristics of Three Study Sites

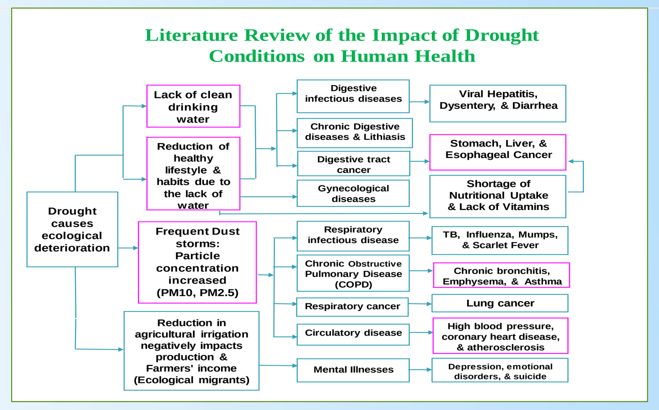
| Characteristics | Minqin County | Jingtai District, Baiyun County | Maiji District, Tianshui County |
|---|---|---|---|
| Location | Northeast of Hexi corridor, in the Shiyanghe River area | Middle of Gansu, east of the Yellow River, connected to the Hexi Corridor | Southwest Gansu |
| Climate Belts | Arid | Sub-Arid | Sub-Humid |
| Average Annual Temperature (°C) | 7.8 | 9.1 | 11.6 |
| Average Annual Precipitation (mm) | 110 | 186 | 600 |
| Average Evaporation (mm) | 2644 | 1723 | 1300 |
| Evaporation/Precipitation | 24.0 > 3 | 9.3 > 3 | 2.2 < 3 |

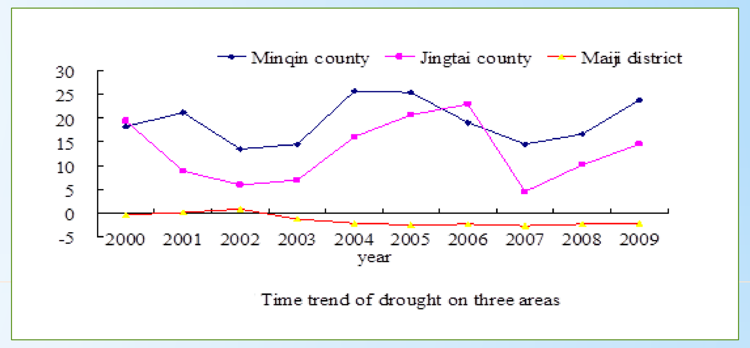
Comparison of Health Services and Economic Development (in 2007)

| Indicators | Minqin County | Jingtai District, Baiyun County | Maiji District, Tianshui County |
|---|---|---|---|
| Overall Population (x10,000) | 31.3 | 23.36 | 59.26 |
| Agricultural Population (x10,000) | 23.98 | 18.7 | 30.61 |
| Percentage of Population Agricultural | 76.6 | 80.1 | 51.7 |
| GDP per person (Yuan) | 8,476 | 9,735 | 8,878 |
| Average number of health technicians (per 1000 people) | 2.2 | 2.68 | 3.14 |
| Average number of hospital beds (per 1000 people) | 1.88 | 1.92 | 3.08 |

## Results

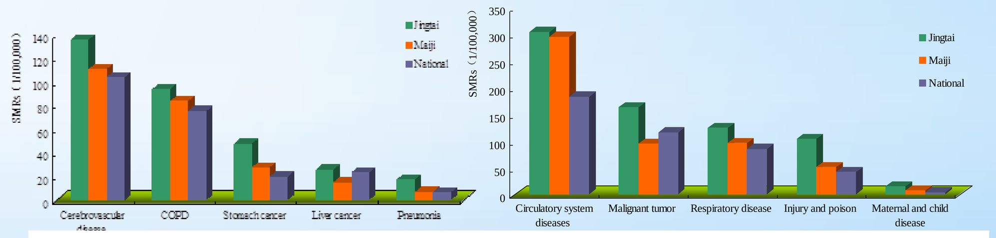





### Analytic Data Sources

- Death surveillance data from local CDC (2004-2010)
- Infectious surveillance data from local CDC (2005-2010 )
- Health service data from the Health Yellow Book
- Social economic data from the Statistical Yearbook
- Climatic data: meteorological reports for Gansu (1970-2009)




Comparison of Standardized Mortality Rates between Jingtai, Maiji, and across the rest of China

Comparison of Incidence Rate, Standardized Incidence Rate, and Attributable Rate Rank (1/100,000) between Minqin and Maiji for Digestive Infectious Diseases

| Diseases | Minqin County | | Maiji District | | National | Comparison of Minqin To Maiji on SIRs | | Comparison of Minqin To National SIRs | |
|---|---|---|---|---|---|---|---|---|---|
| | IR | SIRs | IR | SIRs | SIRs | RR | AR | RR | AR |
| Hepatitis Not Typing | 9.10 | 9.77 | 2.49 | 2.58 | 4.69 | 3.79 | 7.19 | 2.08 | 5.08 |
| Hepatitis C | 4.14 | 4.58 | 11.70 | 11.50 | 6.93 | 0.40 | -6.92 | 0.66 | -2.35 |
| Bacillary Dysentery | 17.16 | 16.89 | 42.70 | 41.39 | 27.87 | 0.41 | -24.50 | 0.61 | -10.98 |
| Hepatitis A | 15.45 | 16.39 | 44.05 | 46.82 | 4.85 | 0.35 | -30.43 | 3.38 | 11.54 |
| Other Infectious Diarrhea | 4.03 | 3.73 | 37.18 | 35.38 | — | 0.11 | -31.65 | — | — |

Comparison of Incidence Rate, Standardized Incidence Rate, and Attributable Rate Rank (1/100,000) between Minqin and Maiji for Respiratory Infectious Diseases

| Diseases | Minqin County | | Maiji District | | National | Comparison of Minqin To Maiji on SIRs | | Comparison of Minqin To National SIRs | |
|---|---|---|---|---|---|---|---|---|---|
| | IR | SIRs | IR | SIRs | SIRs | RR | AR | RR | AR |
| TB | 203.64 | 227.37 | 106.00 | 104.26 | 88.14 | 2.18 | 123.11 | 2.58 | 104.26 |
| Rubella | 9.43 | 7.73 | 5.46 | 1.31 | — | 5.90 | 6.42 | — | — |
| Measles | 0.28 | 0.23 | 1.38 | 5.29 | 7.85 | 0.04 | -5.06 | 0.03 | 5.29 |
| Chickenpox | 7.39 | 5.94 | 14.15 | 13.61 | — | 0.44 | -7.67 | — | — |
| Mumps | 17.10 | 14.28 | 31.59 | 30.63 | — | 0.47 | -16.35 | — | — |
| Influenza | 2.59 | 2.68 | 66.37 | 64.00 | — | 0.04 | -61.33 | — | — |

Comparison of Disease Burden between Jingtai and Maiji

| Diseases | Jingtai | | | | Maiji | | | |
|---|---|---|---|---|---|---|---|---|
| | PYLL | CELE | ILL | PYLLR | PYLL | CELE | ILL | PYLLR |
| Circulatory system diseases | 2057 | 4.5 | 4.9 | 9.1 | 7644 | 7.2 | 6.2 | 14.1 |
| Malignant tumor | 2534 | 2.4 | 9.9 | 11.2 | 5235 | 1.8 | 12.0 | 9.6 |
| Injury and poison | 5918 | 2.2 | 29.4 | 26.1 | 7380 | 1.1 | 30.2 | 13.6 |
| Respiratory diseases | 852 | 1.4 | 5.1 | 3.8 | 1265 | 1.4 | 3.8 | 2.3 |
| Maternal and child diseases | 2341 | 0.8 | 63.3 | 10.3 | 3069 | 0.5 | 71.4 | 5.7 |
| Cerebrovascular disease | 623 | 1.5 | 3.5 | 2.7 | 2890 | 1.9 | 6.2 | 5.3 |
| Chronic Obstructive Pulmonary Disease (COPD) | 413 | 1.0 | 3.3 | 1.8 | 1066 | 1.3 | 3.3 | 2.0 |
| Stomach cancer | 558 | 0.6 | 7.8 | 2.5 | 1103 | 0.5 | 8.9 | 2.0 |
| Liver cancer | 491 | 0.4 | 11.7 | 2.2 | 961 | 0.3 | 13.9 | 1.8 |
| Pneumonia | 323 | 0.2 | 13.5 | 1.4 | 417 | 0.1 | 15.4 | 0.8 |

PYLL: Potential years of life lost; CELE: Cause eliminated of life expectancy; PYLLR: Potential years of life lost rate; ILL: Index of life lost

## Implications

- Based on Attributable Rate (AR) rankings, the top ten illnesses that most impact human health under drought conditions are malignant tumor, injury and poison, respiratory diseases, circulatory system diseases, maternal-and-child diseases, cerebrovascular disease, stomach cancer, pneumonia, liver cancer, and COPD. . This means that these five types of illness have higher impact on humans living in drought conditions and drought-prone environments.
- In comparing disease burden using PYLL, CELE, ILL, and PYLLR, our study found that the CELE of circulatory system diseases is the greatest. This diseases had the greatest impact on the expected life. PYLL is a direct measurement index of burden of disease, which measures the amount of life lost caused by diseases. PYLLR is the manifestation of per capita life expectancy loss years. However, it can not reflect the association between early death and diseases. ILL highlights the extent of the association between early death and diseases and whose variation is small. In other words, gender and region have smaller effect to ILL, and ILL is more affected by the core characteristics of diseases. ILL and PYLL reflected the different aspects of association between life lost and diseases.
- We conclude with a few policy suggestions for improving human health in drought conditions and drought-prone areas. We recommend that studies and policies aimed at understanding and improving human health enhance the development of chronic diseases surveillance systems and cancer surveillance systems, establish protocols for registering more health, morbidity, and mortality information. If possible, efforts should be made to expand the scope of registration to expand the monitoring scope of whole population to create an information database that more thoroughly captures morbidity, chronic diseases, and death. These initiatives would help clarify the responsibilities of medical organizations and personnel, allowing researchers and health care professionals assess and improve the quality of life and reduce chronic diseases and mortality.

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