“Survival is the ability to swim in strange water.”

Frank Herbert, *Dune*
The Road to Arrakis: *Dune* and a sustainable future

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Drylands include all terrestrial regions where the production of crops, forage, wood and other ecosystem services are limited by water. Formally, the definition encompasses all lands where the climate is classified as dry subhumid, semiarid, arid or hyper-arid. This classification is based on Aridity Index values.<sup>1</sup>

The long-term mean of the ratio of an area’s mean annual precipitation to its mean annual potential evapotranspiration is the Aridity Index (AI).

Notes: The map is based on data from UNEP Geo Data Portal (http://geodata.grid.unep.ch/). Global area based on Digital Chart of the World data (147,573,196.6 square km); Data presented in the graph are from the MA core database for the year 2000.
Drying areas

- Over 40% of the earth’s area is drylands
- Over 35% of the population live in these areas
- Of these two billion people, 90% live in developing countries and over 75% have inadequate water and sanitation

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Implications of increasing dryness

• Workload and resources
  – Children’s skills and knowledge

• Health
  – Cost of purification
  – Hygiene
  – Concentration of pathogens
The Study Community

• Multi-ethnic community
  – Bugakhoe, | |anikhoe, Wayeyi, Gciriku, Hambukushu

• Mixed subsistence economy
  – Farming, herding, fishing, hunting, gathering

• 500 people

• School attendance less than 20%
Figure 6. 5 year running averages of Okavango River discharges at Mohembo, observed and simulated, 20th, 50th and 80th percentile of inter-GCM range

Mmopelwa et al. 2011
Figure 7. Thamalakane River flows observed and 20\textsuperscript{th}, 50\textsuperscript{th} and 80\textsuperscript{th} percentile of ensemble simulations driven by GCM data for 20\textsuperscript{th} and 21\textsuperscript{st} century

Mmopelwa et al. 2011
Okavango River In-flow

Input at Mohembo (Mm3/year)

Year

1950 2000 2050 2100
Domestic Garden Animal husbandry Grain process Food process Childcare Craftwork Fishing Collecting wild food

7-12 13-18 19-24 25-49 50+
• Burden of collecting and carrying water falls mainly on children and women
• Lowest skill activity
• Increased time spent in this low skill activity reduces time children can spend acquiring other skills
  – Traditional crafts and practices
  – Formal education
The weight of water carrying

- **Boudinar, Morocco**
  - Girls collect approximately 100 liters (100 kg or 220 lbs) total water per day in three round trips taking one hour each way
    - Malika Abdelali-Martini and Aden Aw-Hassan 2013

- The average US child’s backpack is 18 lbs.
Water quality and infectious disease

• Waterborne disease accounts for 90% of all infectious disease in developing countries
• Scarcity of fresh water has also been directly linked to negative human health outcomes including increased exposure to waterborne disease and diarrhea
• Diarrheal disease ranks 4th in the global burden of disease
  – Greatest proportion occurring in sub-Saharan Africa
  – Children under five years of age are most affected, with an estimated loss of 800,000 children each year
The Study Communities

• Multi-ethnic
  – Tshua, Subiya,
  – Batawana, Kalanga, Nandjwa

• Mixed subsistence economy
  – Farming, herding, fishing, hunting, gathering, wage labor

• 2500 people in 18 communities
Research on water quality and health

• Water scarcity affects water quality
• Climate change will continue to increase water scarcity
  – CNH-Ex: Water Quality and Environmental Health in Botswana: Coupled Dynamics in a Water-Scarce Environment (2011-2014)
    • PI: Kathleen Alexander, DVM, PhD, Virginia Tech
    • NSF Awards #1114953 #1518486
The setting
Collecting water quality data
Preliminary results

• Does water scarcity due to climate change affect the incidence and prevalence of infectious disease?
Knowledge, attitudes, and behavior

• Most respondents identified dirty drinking water as the cause of diarrhea (88%) and 100% noted sediment occurring in drinking water

• Knowledge among respondents of the benefits of boiling water in preventing diarrheal disease was widely acknowledged, only 24% reported using this intervention even though access to fire for heating water for laundry, dishes, and cooking

• These results were similar to a previous study by Alexander and colleagues where surveyed diarrhea patients reported 30-40% boiling of water
Latrines

- Often seen as crucial public health intervention to avoid water source contamination by *E coli* and other human pathogens
- Long campaign in study area by government to build latrines
- Government and NGO health workers encourage graywater disposal in latrines
- Results in dispersal of fecal bacteria
Latrines

• In a study of three villages and 90 households during the 2012 dry season diarrheal outbreak it was found that
• The majority of respondents among the three villages had a pit latrine form of sanitation (69%) but 29% of these were full and unavailable for use
• Open-air defecation differed significantly by village with 45% of the respondents in a more remote community engaging in this practice in contrast to only 15% from a large town
• Full latrines lead to contamination of water supplies from both graywater disposal and open-air defecation
Increasing contact with wildlife

• Wildlife and people sharing scarcer water resources

• More potential contamination of drinking water with wildlife fecal pathogens
Continuing research objectives

- Further exploring linkages between knowledge, attitudes, and behaviors
- Why does information about climate change and health have limited impact on behavioral change?
- Mmopelwa and colleagues (2011) have shown that a majority of people in this area believe that climate change will have major impacts on their households
- Cultural models of health
  - Religious beliefs and practices
  - Customs and traditions
- Individual cost/benefit analysis
  - Cost of time and fuel
- How is the health, growth, and development of children affected by water scarcity
Cultural beliefs and practices

• Religious or cultural practices may have different hygienic viewpoints than biomedicine approach promulgated by public health workers

• Even when information about pathogens is available, an alternative belief model incorporating supernatural explanations of health conditions may be prioritized
Individual cost/benefit analysis

- Fuel is costly in the settings described
- Collecting firewood takes time away from other activities that might be perceived as more important
- Kerosene is an expensive luxury for most used only for lights
- If the risk of contracting diarrheal disease is perceived as low, the cost of boiling water may be viewed as too high given the risk of diarrhea
Time preference

- Preferred schedule of consumption
- People tend to prefer immediate consumption to delayed consumption
Discount rate

• Rate at which delayed benefits are devalued and measured in terms of present value
• Some probability that future benefits will not be realized
• Current benefits are compounded
Tragedy of the commons

- Hardin 1968
- Situations in which open-access (communal or cooperatively-held) resources are destroyed or depleted because of individual self-interest
Collective action problem

• Individuals are unlikely to provide a public good by altruistically sacrificing their own harvest if others who have not necessarily sacrificed anything are free to share the benefits

• Water
  – Open-access resource
  – Hard to defend
What will we learn?

• We need to account for cultural beliefs and practices in planning for the effects of climate change.
• We also need to understand that individuals act in their perceived benefit, which is often in the short-term and is not concerned with larger groups or longer time frames.
• A large proportion of the world’s population live in dry areas that will become even dryer and these people have limited access to technological, health, and financial resources.
• To mitigate the effects of climate change communities must be involved in decision-making.
“Any road followed precisely to its end leads precisely nowhere. Climb the mountain just a little bit to test that it's a mountain. From the top of the mountain, you cannot see the mountain.” Frank Herbert, *Dune*
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Tuesday, October 20
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