



Public Health and Rural Livelihoods under Water Scarcity in the Ruaha Landscape, Tanzania

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A combination of irrigated agriculture, uncontrolled water diversions, and intensive livestock grazing of wetlands has resulted in dramatic decreases in both water quantity and quality in Tanzania's vast Ruaha Landscape. This has directly impacted human livelihoods and wildlife populations that depend on the multitude of ecosystem services provided by the Ruaha River watershed, and has indirectly influenced the transmission of disease between humans, livestock, and wildlife. This study assesses the socioeconomic and environmental factors influencing human and livestock health. Results show that reported wealth, cattle sickness, consumption of raw cow blood, and limited accessibility to surface water sources increased the probability of reported chronic diseases in the household. Household wealth and walking distance to surface water were also found to affect cattle health. These findings remind us that health issues should not only be seen in relation to health services, but as being intimately connected to the state of: 1) ecosystems and the services they provide; 2) social institutions for land use planning, settlement and social services; and 3) culture and traditions (diet, nutrition and husbandry practices).

Background

Accessibility to water and land resources for agriculture and grazing areas are key factors for sustainable agriculture development and sustainability of rural livelihoods in Africa, particularly in the arid and semi-arid regions of Africa characterized by widespread food insecurity exacerbated by persistent droughts, erratic rainfall, and increasing human populations. Adaptations of pastoralists and agro-pastoralists in arid zones include keeping diverse species of livestock, movements of species-specific and production-specific livestock herds over large areas, emigration out of the pastoral system until perturbations pass, economic diversity, and seasonal and drought-induced nutritional stress allocation among community members. However, the potential for movement between and access to alternative seasonal pastures is increasingly limited. While pastoral and agricultural populations throughout Africa have grown, pastoralists have been unable to expand livestock holdings due to factors such as disease epidemics, recurring droughts, and intertribal raiding. In addition, traditional dry season ranges with water access have been lost to intensive agriculture (both colonial and African agriculturalists), to game parks, and to conservation areas.

A consequence of these changes in pastoralist communities is the enhancement of disease vectors at the human-livestock-wildlife interface. In particular, loss of access to water sources has forced pastoralists and their livestock to move further seasonally and to be more concentrated during the dry season. The combination of greater migration and concentration can contribute

to the transmission of diseases among livestock herds, as well as between humans, livestock, and wildlife as they are forced to share dwindling water sources. More than 75% of human diseases are zoonotic – shared between human and other animal species – with links to wild and domestic animals. In East Africa, zoonotic diseases are presenting significant simultaneous threats to human health, livestock productivity, and wildlife conservation, and can no longer be addressed as separate problems within isolated disciplines. An investigation of the underlying drivers of zoonotic disease under increasing water scarcity, with emphasis on bovine tuberculosis, has been the focus of the Health for Animals and Livelihood Improvement (HALI) project of the Ruaha Landscape, Tanzania.

This brief reports on household survey research of the HALI project aimed at addressing the impact of increasing water scarcity in the Ruaha Landscape on household and livestock health. This study was conducted in the villages of the Idodi and Pawaga divisions adjacent to the Pawaga-Idodi Wildlife Management Area (WMA), an area recently transitioning out of grazing land to a village-controlled hunting range adjacent to the south-eastern border of the Ruaha National Park in southwest Tanzania. In other research briefs the HALI team has described the underlying causes of the recent seasonal drying of the Great Ruaha, evaluation of disease risk, the design of our socioeconomic studies, landscape factors behind livestock disease loss, and gender roles in pastoralist households (See Further Reading). Here we report on the analysis of the household survey data.

Findings

To assess socioeconomic and environmental factors influencing human and livestock health, as measured by reported chronic disease in the household and sickness in both cattle and small stock (goats and sheep), we estimated logistic regression models. The explanatory variables used to explain a household's health included: wealth class (determined by Tropical Livestock units (TLUs) and land), reported livestock sickness in the herd, reported household drinking of raw blood (a custom prevalent amongst traditional pastoralists), reported household treating of drinking water, walking distance to surface water sources, access to piped water for drinking and cooking, age of the household head (or the respondent), and walking distance to the nearest village health care center. Table 1 shows the results of the regression model for reported household health. In this model, many explanatory variables have the expected effects on household health. Not surprisingly, wealth was among the factors explaining variation in reported household health in this region. Households in the poor category were two times more likely to report chronic diseases than households in the wealthy category, when holding other variables constant, suggesting that wealthier families are more likely to invest more in health prevention.

Also, households reporting sick cattle were three times more likely to report chronic diseases than households without sick cattle. Similarly, there was a positive correlation between reported blood consumption, a zoonotic disease transmission risk factor, and the probability of reporting chronic diseases in the household. Households reporting drinking raw blood were found to be at least four times more likely to report chronic diseases than households who do not. There was a significant difference between ethnic groups in terms of raw blood consumption with a higher proportion of Maasai households reporting drinking blood than the Barabaig and Sukuma. These results suggest a key linkage to the livestock sampling portion of the HALI project. For households who reported cattle sickness in their herds and for whom livestock were tested for possible brucella and bovine tuberculosis (BTB), 15% of cattle tested positive for BTB and 8% were suspected to be positive, while 46% tested positive for brucella. These results are suggestive of a critical link between human and livestock health and the transmission of zoonotic diseases.

The variable walking time to surface water was found to be positively correlated to household health, suggesting that households farther away from surface water sources have greater reported health problems. This result suggests that limited access to surface water sources due to distances and time involved in water collection result in use of volumes inadequate to support basic personal hygiene and marginally adequate for human consumption.

Similarly, factors determining livestock health were assessed. Results demonstrated that wealth positively correlated to cattle sickness suggesting that wealthy households are associated with sick cattle. The probability of reporting sick cattle was two times greater for wealthy households than for the poor. For pastoralists and agro-pastoralists, wealth is measured in part by the number of animals owned; thus having a large herd size may increase the probability of reporting sick cattle in the herd. Livestock health is also dependent upon access to adequate water for consumption. The results indicate the odds of households reporting cattle sickness in the herd increase by a factor of 1.7 for every additional hour walked to surface water sources. This demonstrates that lack of livestock watering sources caused by drought and exacerbated by drying of rivers and streams affects the health of cattle, and therefore may contribute to the decline of their productivity.

Reporting of the presence of wildlife in the same water sources used by livestock (a zoonotic disease risk) had no effect on reported health of cattle. However, identification of pathogens in water samples taken from a variety of water sources used by humans only, livestock and humans, or livestock, humans, and wildlife within the HALI project will allow for a more unbiased investigation of these potential pathways.

Finally, a comparison between wet and dry seasons revealed that households consumed less meat per week in the dry season than in the wet season, and that there were more reported human and livestock health problems in the wet season than the dry season. In particular, reported cases of diarrhea and fever were significantly higher in the wet season. For diarrhea, the main water quality risk is the microbial load (e.g. *E. Coli* and total coliform) from human and animal excreta. Water quantity plays a role because more water allows for increases in washing of hands, food, and clothes and in many situations allows for more effective removal of waste via drainage and sewers, all leading to decreases in diarrhea and lower rates of mortality. However, too much water leading to flooding can also be a problem for water-related diseases such as diarrhea. For villages in the Ruaha region, only 1% of households surveyed reported using improved latrines, while 43% used traditional pit and 56% used the bush as a toilet facility. Thus, it is not surprising to record more reported cases of diarrhea in the wet season. Similarly, households surveyed reported significantly more malaria cases in the wet season. Malaria is a water-related disease which is spread through insect vectors, especially *Anopheles gambiae* in East Africa that breeds in water. The risk of a malaria epidemic is associated with anomalous temperatures in the months preceding and during the rainy season. Rainfall, in general, affects the availability and suitability of disease habitats, while temperature affects the rate of vector and pathogen development. For livestock health, there were also

Table 1. Estimated coefficients and odds ratios for the logistic regression household model.

Parameter	Estimate	Standard Error	Wald Chi-Square	Odds ratio
Intercept	0.1559	0.7686	0.0411	1.169
Wealth	-0.7434*	0.4333	2.9439	0.475
Sick cattle	0.9800**	0.4355	5.0636	2.665
Sick shoats	0.2849	0.4393	0.4204	1.330
Blood consumption	1.3783***	0.4381	9.8974	3.968
Water treatment	-0.2231	0.4200	0.2822	0.800
Walking time to surface water	0.4641**	0.2400	3.7401	1.591
Distance to health center	-0.2521	0.2225	1.2839	0.777
Piped water sources	0.3642	0.6022	0.3659	1.439

Asterisks (*) denote the level of significance: * $p < 0.10$, ** $p < 0.05$, and *** $p < 0.01$.

significantly more reported sickness and death of cattle, goats, and sheep in the wet season. The reported sickness and death of livestock (especially goats) can be attributed to the outbreak of Rift Valley Fever (RVF) which is in general associated with heavy rainfall and localized flooding (Wilson, 2003).

Practical Implications

A combination of irrigated agriculture, uncontrolled water diversions, and intensive livestock grazing of wetlands has resulted in dramatic decreases in both water quantity and quality of Tanzania's vast Ruaha Landscape. This has impacted human livelihoods, livestock productivity, and wildlife populations that depend on the surface water and associated ecosystem services of the Greater Ruaha River. Understanding the dynamics of zoonotic disease agents in human, livestock and wildlife populations and how they relate to land use change and environmental management is critical to developing mitigation strategies at multiple scales, including the often overlooked landscape scale.

These findings highlight some of the most important issues identified by focus group meetings at local and district levels during this study, including lack of health care infrastructure, limited access to clean and safe drinking water, insufficient watering points for livestock, and traditional husbandry practices as important problems at the local level. To assist local communities to break poverty cycles and reduce risks of disease contamination, there are key areas that need particular attention. These include improving accessibility to water sources for livestock and domestic consumption, investing in human health and veterinary care facilities and their personnel, developing an outreach program on hygiene and sanitation to address cultural barriers, and increasing accessibility to the market for agricultural and livestock products.

The findings also suggest that pressure to utilize land and water resources to expand economic development through increased agriculture production is in conflict with the health of pastoralist and agro-pastoralist households and their livestock. Efforts to address water scarcity and its impact on pastoral and agro-pastoral communities' health and livelihoods should be coordinated at the watershed scale and evaluated against other landscape level goals such as irrigation, ecotourism, and hydroelectricity production. There is a need for an integrated sectoral collaboration between government agencies, and coherence in inter-sectoral policies. Rural development programs should not only pay attention to the increased production of food but also to an integrated approach to management of rangelands, wetlands, and other habitats.

Lastly, these findings remind us that health issues should not only be seen in relation to health services, but as being intimately connected to the state of: 1) ecosystems and the services they provide; 2) social institutions for land use planning, settlement and social services; and 3) culture and traditions (diet, nutrition and husbandry practices). While these preliminary results point to the relationship between water scarcity in the Ruaha Landscape and health and livelihoods of pastoral and agropastoral communities, data from disease sampling of wildlife and livestock, and pathogen prevalence in water samples are needed to better understand the dynamics of zoonotic diseases, to confirm our findings, and to draw some policy implications. The HALI project with its integrated approach provides a novel platform to understand these dynamics. However, long term transdisciplinary research partnerships and diagnostic capacity building need to be forged to enhance our ability to understand how human actions affect land use and land cover, along with the consequences of these changes on human, livestock, and wildlife health.

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Wilson, R.T. 2003. "Animal health and disease control in the Usangu wetland of southwestern Tanzania." *Tropical Animal Health and Production* 35(1): 47-67. Available online: <[*About the Authors:* Dr. Michel Masozera was a Jim Award Recipient 2006-2007, Norman E. Borlaug LEAP Fellow Fall 2007, and is currently the Director of Payment for Ecosystem Services at the Wildlife Conservation Society \(WCS\). He can be contacted by email at \[mmasozera@wcs.org\]\(mailto:mmasozera@wcs.org\). Dr. Jon Erickson is an Associate Professor in the Rubenstein School of Natural Resources and Environment at the University of Vermont. Email: \[jon.erickson@uvm.edu\]\(mailto:jon.erickson@uvm.edu\). Dr. Deana Clifford has been the HALI project Coordinator based at the Wildlife Health Center in the School of Veterinary Medicine, University of California, Davis and is currently a Veterinary Epidemiologist with the California Department of Fish & Game. Email: \[dclifford@ucdavis.edu\]\(mailto:dclifford@ucdavis.edu\). Dr. Peter Coppolillo is an Associate Conservation Ecologist and former Director of the Ruaha Landscape Program for the Wildlife Conservation Society \(WCS\). He is currently Coordinator for the WCS Yellowstone Program. Email: \[PCoppolillo@wcs.org\]\(mailto:PCoppolillo@wcs.org\). Dr. Rudovick Kazwala is a Professor in the Faculty of Veterinary Medicine, Sokoine University of Agriculture. Email: \[kazwala@suanet.ac.tz\]\(mailto:kazwala@suanet.ac.tz\). Dr. Harrison Sadiki is the HALI project Field Coordinator and Veterinarian at Sokoine University of Agriculture. Email: \[hsadily@yahoo.com\]\(mailto:hsadily@yahoo.com\). Dr. Jonna Mazet is Professor of Wildlife Health and Epidemiology and Co-Director of the Wildlife Health Center at the University of California Davis. Email: \[jkmazet@ucdavis.edu\]\(mailto:jkmazet@ucdavis.edu\).](http://www.springerlink.com/content/103008/?p=cc726d4c525e45c0a14e5242b324f426&pi=0>_/_/35:47-67/.</p></div><div data-bbox=)

The Health for Animals and Livelihood Improvement (HALI) project was established in 2006 and is a stakeholder-driven research and capacity-building program to assess the effects of zoonotic disease and water management on animal health, biodiversity, and livelihoods in the Ruaha ecosystem, Tanzania. The project is led by Dr. Jonna Mazet. She can be contacted via post at Wildlife Health Center, One Shields Ave., School of Veterinary Medicine, University of California, Davis, CA 95616, USA, or via email: jkmazet@ucdavis.edu.



The Global Livestock CRSP is comprised of multidisciplinary, collaborative projects focused on human nutrition, economic growth, environment and policy related to animal agriculture and linked by a global theme of risk in a changing environment. The program is active in East and West Africa, and Central Asia.

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