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Vulnerability of indigenous health to climate change: A case study of Uganda's Batwa Pygmies

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ABSTRACT

The potential impacts of climate change on human health in sub-Saharan Africa are wide-ranging, complex, and largely adverse. The region's Indigenous peoples are considered to be at heightened risk given their relatively poor health outcomes, marginal social status, and resource-based livelihoods; however, little attention has been given to these most vulnerable of the vulnerable. This paper contributes to addressing this gap by taking a bottom-up approach to assessing health vulnerabilities to climate change in two Batwa Pygmy communities in rural Uganda. Rapid Rural Appraisal and PhotoVoice field methods complemented by qualitative data analysis were used to identify key climate-sensitive, community-identified health outcomes, describe determinants of sensitivity at multiple scales, and characterize adaptive capacity of Batwa health systems. The findings stress the importance of human drivers of vulnerability and adaptive capacity and the need to address social determinants of health in order to reduce the potential disease burden of climate change.

Introduction

The potential impacts of climate change on human health are wide-ranging, complex, and largely adverse (Costello et al., 2009). These impacts may be immediate, such as through modifications to the magnitude and frequency of extreme events, or may manifest through more distal pathways such as a change in food security or the distribution of disease vectors (Haines & Patz, 2004; McMichael, Woodward, & Hales, 2006). Those regions of the world where poor health status is met with a limited capacity to adapt will be the most severely affected (Apuuli, Wright, Elias, & Burton, 2000; Confalonieri et al., 2007; Fussel, 2010). For this reason, sub-Saharan Africa has been identified as one of the world's most vulnerable regions (Davidson et al., 2003; Ramin & McMichael, 2009; Sokona & Denton, 2001; Tschakert, 2007). The Intergovernmental Panel on Climate Change (IPCC) predicts with high confidence that climate change, among other stresses, will reduce agricultural yields, aggravate water stress and alter the ecology of infectious disease vectors in the region through alterations in temperature and precipitation patterns (Boko et al., 2007). The health effects arising from these changes are expected to increase the region's burden of disease and exacerbate the existing burden in already fragile health systems.

Uganda is highly susceptible to these impacts due to economic underdevelopment and limited healthcare resources (Namanya, 2009; Wandiga et al., 2010). While a lack of scientific monitoring and information at the national and local levels makes it difficult to accurately predict how climate change will manifest in Uganda, the consensus of climate models, relevant literature and community-based research is that the foremost impacts will be more variable and intense rainfall, warming temperatures, and increased frequency of extreme weather events (Christensen et al., 2007; Hepworth, 2010, p. 65; Magrath, 2008, p. 56; National Water Development Report (NWDR), 2005; Republic of Uganda, 2007). Given that more than 80% of Uganda's population is dependent upon rain-fed agriculture for their livelihood, these environmental changes will have implications for economic well-being which in turn will aggravate potential health impacts (Orlove, Rancoli,

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Kabugo, & Majugu, 2010; World Bank, 2011). Malaria, diarrhoeal and waterborne diseases, augmented by poor hygiene and sanitation and decreased food security have emerged as public health concerns (Apuuli et al., 2000; Magrath, 2008, p. 56; Namanya, 2009; Orlove et al., 2010; Republic of Uganda, 2007; Wandiga et al., 2010). Strained under insufficient resources and a heavy burden of disease, healthcare in Uganda – including health policy and provision at the national, district, and local scales – has a limited ability to cope with increased disease outbreaks or adapt to changes in the composition of health determinants. In this context, Uganda is highly vulnerable to the negative health impacts of climate change.

This vulnerability, however, is not evenly distributed (Republic of Uganda, 2007). Marked differences exist between groups when it comes to how severely their health systems may be affected by climate change. One group widely considered to be at heightened risk are Indigenous peoples. In general, Indigenous populations globally experience significant disparities in health burden; in Canada, New Zealand, Australia and the United States, Indigenous peoples in many cases experience health statistics comparable to middle or low income nations (Cooke, Mitrou, Lawrence, Guimond, & Beavon, 2007; Green, King, & Morrison, 2009; Smylie & Anderson, 2006; Smylie, Anderson, Ratima, Crengle, & Anderson, 2006; Stephens, Porter, Nettleton, & Willis, 2006). In sub-Saharan Africa, Indigenous peoples experience poorer than average health outcomes, marginal social status, and are especially sensitive to environmental change due to their resource-based livelihoods and traditional health systems (Ohenjo et al., 2006). However, little attention has been given to these most vulnerable of the vulnerable. Ford, Berrang-Ford, King, and Furgal (2010a) and Ford, Vanderbilt, and Berrang-Ford (in press) refer to this as an Indigenous peoples 'vulnerability deficit' and identify it as a major gap in climate change research.

Within this context, we contribute towards addressing this gap by taking a bottom–up approach to assessing health vulnerability to climate change in highly marginalized Indigenous communities in Uganda. We do so by presenting a case study of the Batwa Pygmies, an Indigenous people inhabiting the southwest highlands of Uganda. We characterize this vulnerability through participatory qualitative research in two communities, with the following objectives: 1) Identify key climate-sensitive, community-identified health outcomes, 2) Describe and characterize determinants of sensitivity at the individual, community and regional levels, and 3) Assess the adaptive capacity of Batwa health systems.

Methods

The vulnerability framework

We draw upon the vulnerability framework of Ford, Berrang-Ford, King, and Furgal (2010b), Ford and Smit (2004) and Ford, Smit, and Wandel (2006) to structure our study. This model of vulnerability has emerged from climate change scholarship, and conceptualizes vulnerability as a function of exposure and sensitivity to climate change and adaptive capacity (Adger, 2006; Ebi, Kovats, & Menne, 2006; Fussel, 2008; Fussel & Klein, 2006; Parry, Canziani, Palutikof, van der Linden, & Hanson, 2007; Smit & Wandel, 2006). Vulnerability is a measure of the susceptibility to harm in a *system* in response to a *stimulus* or *stimuli*, and can essentially be thought of as the 'capacity to be wounded.' In a health context, *exposure* refers to the nature of climatic risks which affect (directly or indirectly) health outcomes. *Sensitivity* concerns the organization and structure of health systems relative to the climate-related health outcomes and determines the degree of severity at which exposures manifest. *Adaptive capacity* reflects the ability of health systems to address, plan for, or adapt to adverse climate-related health outcomes and take advantage of new opportunities and benefits. It incorporates attributes including resilience, resistance, flexibility etc that underpin the ability of human systems to manage change Ford & Smit, 2004; Smithers & Smit, 1997). Recognition of adaptive capacity and sensitivity is important as it directs attention to health systems themselves, as well as to the non-climactic factors that determine how climate change will be experienced and responded to.

Study area

The Batwa, also known as the Abayanda or Twa, represent the easternmost group of Central Africa's Pygmy population. Uganda's 6700 Batwa are concentrated in three rural districts in the southwest of the country (Uganda Population Secretariat, 2008). In the early 1990s, conservation projects led to the Batwa in Uganda being evicted from the forest, removing their access to traditional food, shelter and medicinal resources (Zaninka, 2001). This dislocation and subsequent adjustment to life outside of the forest has led to a significant and relatively unsuccessful cultural and socio-economic transition (Jackson, 2003, p. 40; Namara, 2007). Notwithstanding, the Batwa have achieved significant improvements in wellbeing over the past decade, in large part through the aid of development organizations, and many have transitioned to an agricultural livelihood in sedentary communities (Balenger, Coppenger, Fried, & Kanchev, 2005, p. 71). However, they remain with a very low socioeconomic and health status relative to the majority population in their own region and Uganda generally (Table 1).

This research was conducted with two Batwa communities – Kihembe and Mukongoro – in Kanungu District, adjacent to the Bwindi Impenetrable Forest National Park ("Bwindi") from June to August 2010 (Fig. 1, Table 2). Approximately 900 Batwa live in Kanungu, representing < 0.1% of the district's population (Bwindi Community Hospital, 2010). The majority ethnic group in the district is the Bakiga, whose principal livelihoods include agriculture, industrial tea and coffee production, and tourism services. The communities of Mukongoro and Kihembe were invited to participate after preliminary visits to several communities in the district.

Table 1
Selected development indicators.

	Batwa	Southwest Uganda[a]	Uganda
Health			
Life expectancy at birth (years)	28[b]	n/a	53[c]
Child mortality (% under 5)	41.0%[d]	18.1%[e]	13.7%[e]
Prevalence of malnourishment (% underweight children under 5)[f]	n/a	19.3%[g]	15.9%[g]
Education			
Adult literacy rate (% literate aged 15–49 years)	<10%[h]	Women: 67.6% Men: 84.1%[i]	Women: 56.3% Men: 82.8%[i]
Income			
GDP per capita (constant 2000 $US)	$97[j]	n/a	$366[k]

[a] Consists of ten districts: Kiruhura, Isingiro, Mbarara, Ibanda, Bushenyi, Ntungamo, Rukungiri, Kabale, Kisoro and Kanungu.
[b] As of 2003 (BDP, 2011).
[c] As of 2008 (World Bank, 2010).
[d] As of 2000 (EMMF, 2000).
[e] Average between 2000 and 2005 (UBOS/Macro Intl., 2007).
[f] As measured by the proportion of children age 0–59 months who are below −2 standard deviations from the median of the WHO Child Growth Standards in weight-for-age.
[g] As of 2006 (UBOS/Macro Intl., 2007).
[h] Estimate based on author's research.
[i] As of 2006 (UBOS/Macro Intl., 2007).
[j] Hodosi, 2010.
[k] As of 2009 (World Bank, 2010).

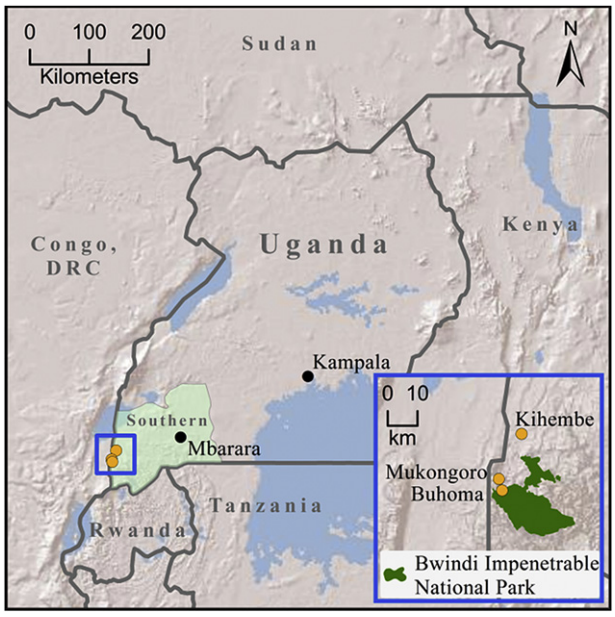

Fig. 1. Location of case-study communities (Source: Adam Bonnycastle, 2010).

The study presented here formed the basis of pilot research to inform proposal development for a 5-year health research and intervention project; if funded, communities would thus potentially benefit from investment in health intervention projects and local employment opportunities. The communities share a similar history of forest eviction and agricultural resettlement, but reflect differing livelihood transition dynamics and current proximity to the forest and its associated services, two factors with significant implications for health outcomes.

Data collection

Community-wide meetings facilitated by local development organizations were conducted in each community to present the research and collaboratively develop a research schedule involving Rapid Rural Appraisal ("RRA") and PhotoVoice methods. All community members were invited to participate following these meetings, with a majority of households electing to participate. All participants were compensated with lunch, photographs and a t-shirt, in accordance with local customs for compensation. Recognizing both the potential for bias due to media discourse on climate change and the distal mechanisms by which climate affects health, we avoided the use of the term "climate change" in this research, rather articulating questions to inquire how the Batwa perceive the environment to affect their health. The fieldwork was conducted in the local language of Rukiga with simultaneous English translation. Data collection took place from June–August 2010.

Rapid Rural Appraisal

Rapid Rural Appraisal (RRA) techniques are used to address a need for systematic qualitative and comprehensive field surveying in rural development research; RRA is methodologically characterized by small, multi-disciplinary research teams who employ a range of tools targeted at gathering information in an intensive, iterative, and expeditious manner (Chambers, 1981; Food and Agriculture Organization (FAO), 1997). In consultation with communities, we employed five RRA techniques to inform the research.

1. Semi-structured household interviews were guided by predefined research questions (Electronic Appendix I available only with the online version of the paper) and implemented with a flexible structure to allow the interviewee's voice and perspectives to guide the interview. Interviews were conducted on a household basis. A total of twenty-one household

Table 2
Characteristics of case study communities.

Characteristic	Mukongoro	Kihembe
Social		
Population	12 households (approx. 24 adults) Average number children per household: 5 Total (est.): 84	15 households (approx. 45 adults) Average number children per household: 3 Total (est.): 90
Settlement history	Established in 2000, land purchased for Batwa by development organizations	Established in 2001, land purchased for Batwa by development organization
Immigration	Households arrived from the DRC (fleeing conflict), and nearby Ugandan Batwa and Bakiga communities (many as squatters in the latter)	Generally, similar to Mukongoro; however, less immigration from the DRC and more from other Batwa and Bakiga communities
Social relations	Congenial, individuals exhibit a great willingness to work together	Contentious, history of conflict over land and social relationships
Political organization	Village chairman elected by community, serves as representative to development organizations	Village council elected by community; representatives (often on council but not necessarily) nominated to development organizations
Relationship w/development organizations	Low dependence; relationship appears mutually beneficial and is long-standing with frequent contact between parties	Greater dependency; relationship has a history of tension, though appears to be improving now with house-building project
Economic		
Principal livelihoods	Agriculture; small amounts of hired labour, handicraft making, and tourist performances	Split evenly between agriculture and hired labour; small amounts of handicraft making, and brick making
Crops grown	Bananas, maize, beans, cassava, sorghum, millet, jackfruit	Maize, beans, sorghum, cassava, millet, jackfruit
Housing	Development organization in process of building mud houses for all community members, most are complete	Development organization in process of building mud huts for all, approximately half are complete; remaining households live in grass huts, one relatively wealthy household lives in self-built brick huts
Land	Small, steeply sloping plots of similar size are evenly divided between households	Gently sloping plots in range of sizes are unevenly divided between households
Biophysical		
Relative climate	In Bwindi park microclimate, wet and cool	Distanced from park forest, hot and dry
Environment	Narrow valley of steep, terraced hills	Broad expanse of low, cultivated hills
Distance from Bwindi park; access	3 km; 45 min walk on trails	40 km; 1 h drive on dirt road

interviews (50 adults), were conducted in the two communities: ten in Mukongoro and eleven in Kihembe. Interviews ranged from 30 min to 1 h.

2. Key informant interviews targeted individuals with a highly specialized knowledge of Batwa health. Interviews (2) were conducted within the communities with the chairman or highest-standing political representative of each community, as well as externally with individuals (7) from non-profit, government, church, and academic institutions. These interviews were guided by an outline of contextual topics related to health (Electronic Appendix II, available only with the online version of the paper). On average, interviews lasted one-and-a-half hours.
3. Future storylines were conducted as an exercise whereby respondents were posed a hypothetical future scenario to gauge their responses in a particular context. The primary aim of the storylines was to inform assessment of adaptive capacity at the community level. Three questions related to future environmental scenarios identified through local climate change projections were posed: "How will your health be affected if: 1) The rains change and your crops fail more often? 2) The water source dries up more often? 3) There are more mosquitoes?" Health was not pre-defined for respondents so as not to introduce *a priori* bias of how health is defined within communities; responses reflected individual interpretations and may include physical, mental, social, spiritual, or economic perspectives on health. Each individual question was followed up with the query of "How will you adapt?" In both communities, future storylines were conducted on a community-wide basis during final group meetings that were held at the end of the research schedule in each community.
4. Biographies sought to scale-down assessments of vulnerability to the individual level, and thereby evoke the unique sensitivities of every individual relative to their historical experiences and contextualize climate change and the environment. Life narratives were constructed through biographical interviews following a standard guide of questions. Biographies were not exhaustive: questions focused on asking respondents to identify key events in their pasts which they feel have shaped their health. They lasted approximately half an hour and were conducted with two members of each community who were selected by the researchers in consultation with key informants near the end of the research period as individuals who represent the historical experiences of the Batwa.

PhotoVoice

PhotoVoice, defined by Wang and Burris (1997) as "a process by which people can identify, represent, and enhance their community through a specific photographic technique," is an emerging methodology in the social sciences field in general and climate change in particular (Healey et al., 2011; Lardeau, Healey, & Ford, 2011). By passing over agency to the subject of study and allowing them to dictate what is important, PhotoVoice helps to facilitate a contextual understanding of vulnerability that is vital to climate change research. PhotoVoice in the two communities was conducted in three stages. The first involved recruiting volunteers for participation. After each semi-structured household interview, all adult members of the household were invited to participate; oral consent was acquired from all participants. Those who consented then attended a half hour training session conducted by the researchers in which participants were taught how to use the cameras and conveyed the objectives of the activity. Participants were presented with the guiding question, "How does the environment affect your health?" and asked to respond to it using photography. In total, twenty-three adults participated in PhotoVoice, consisting of six females and nine males in Mukongoro and six females and two males in Kihembe. Following training, community members had two to 5 h with their assigned cameras to complete the activity. After the cameras and photographs were returned, participants were invited to take part in a discussion group to speak about the photographs they took and the motivations behind them.

Data analysis

Qualitative data and photographs were transcribed and digitally stored. Content analysis framed by the vulnerability framework was performed to identify themes relating to health outcomes, exposures, sensitivity, and adaptive capacity. For descriptive purposes, basic quantitative analysis was conducted, including counts of participants mentioning particular themes. The resulting typology of themes was used in a qualitative matrix analysis to examine causation and association pathways, with health outcomes as the starting point for analysis. Data analysis was complemented with a review of peer reviewed and grey literature on climate change, health, Uganda, and the Batwa, noting that peer reviewed scholarship is limited with regards to the Batwa. Ethics approval was obtained from McGill University's Research Ethics Board, which is guided by the Canadian Tri-council Policy Statement on research involving human subjects, and includes special oversight for research working with Indigenous peoples; the research was further guided by best practice frameworks for working with Indigenous communities in climate change research (Pearce, Ford, Caron, & Kudlak, in press; Pearce et al., 2009). Oral consent was sought for all interviews, PhotoVoice participation, and the use of quotations and photographs for publication.

Implications of data collection strategy

The methods aimed to reflect community member perspectives and priorities related to environmental determinants of health and related coping mechanisms; biases associated with the positionality of the researchers may, however, shape the results and interpretation of the research. The research team included researchers from Canada, Peru, and Uganda. The data collection was predominantly conducted by two white, western females in their 20s with no previous experience in Batwa communities. The data collection was guided by two non-Indigenous Ugandan researchers in their 40s, one of whom works for the Ugandan Ministry of Health. A history of marginalization and ethnic prejudice of Batwa in the region meant that community participants were often deferential to non-indigenous visitors, including Ugandan researchers and regional partners. As articulated by Baxter and Eyles (1997), this positionality is likely to introduce bias into the interpretation of collection data and the results presented. The research was thus designed to integrate source, method, and investigation triangulation, as well as peer debriefing among western and Ugandan researchers and partners to improve the rigour of interpretations and minimize bias.

Results

We present results using a vulnerability framework, beginning with a characterization of the determinants of exposure and sensitivity to climate drivers in the research communities. Here, we first summarize the climate-sensitive health outcomes identified as priority concerns or contributors to health burden, including malaria, malnutrition, respiratory disease, and stomach disorders. This is followed by characterization of the pathways of biophysical

exposure to climate-sensitive health outcomes: water, food security, infectious disease vectors, and weather events. Discussion of human drivers of sensitivity at the individual, community, and regional scales provides a context for socio-economic and demographic determinants of vulnerability. Finally, we present key mechanisms and opportunities for adaptive capacity identified by communities, including traditional medicine, healthcare provision, and community collective action.

Exposure-sensitivity

Climate-sensitive health outcomes

Community members identified a consistently poor health status as one of their greatest challenges. Healthcare professionals concurred that despite recent improvements, the Batwa face a significantly higher burden of disease than that of the rest of the district. There is limited literature available on historical trends; however, it was asserted by key informants and community members that Batwa health declined dramatically following their removal from the forest as a result of livelihood dislocation, the introduction of new communicable diseases and the loss of traditional diet of forest products (Ohenjo et al., 2006).

The earliest available statistics on Batwa health in Kanungu are those taken as part of a study of the population in 1996 by Kabananukye and Wily (1996), which documented that 87% of Batwa women had lost at least one child, 60% of those before the age of two. Dominant causes of reported deaths included measles, kwashiorkor, diarrhoea and malaria. Approximately ten years ago, separate studies by two local development organizations found child mortality rates (<5 years old) for the Batwa of close to 40%, more than double both the regional and Ugandan averages (Batwa Development Program (BDP), 2011; Episcopla Medical Mission Foundation, 2000).

An influx of development aid, originating mainly from foreign NGOs and missionaries, has targeted Batwa health in the past decade (Balenger et al., 2005, p. 71). Key informants concurred that increased education, access to Western medicine and overall economic developments have led to significant improvements in health status. Notwithstanding optimism by healthcare officials that health outcomes will converge with regional averages in the next decade, there remain significant gradients in health. A 2009 household survey in two sub-counties of Kanungu conducted by the local hospital concluded that the Batwa suffer poorer health outcomes and access fewer health services relative to Bakiga communities (Bwindi Community Hospital, 2010). Specifically, the Batwa are less likely to use mosquito nets, access safe delivery during birth or use family planning, and are more likely to have tuberculosis or be malnourished (Bwindi Community Hospital, 2010).

During interviews and PhotoVoice discussions, community members were asked to specify their major health problems, a measure meant to encompass both frequency and severity of disease. Four of the five major problems identified were climate-sensitive: malaria, malnutrition, stomach disorders, and respiratory disease (Table 3). The fifth, HIV/AIDS, does not yet have a significant burden in the community, but was frequently noted by community members and represents a major future health concern. The diseases identified are consistent with the morbidity profile of the region's majority population, suggesting that the Batwa suffer from the same diseases as the general population, but to a more severe degree (Jackson, 2003, p. 40).

All households identified malaria as a leading health concern. Healthcare and NGO officials report that the prevalence of malaria is increasing as a function of warming temperatures and higher frequency of the disease in local mosquitoes. Key informants attributed the higher concentration of malaria in the local mosquito population to the increasing mobility of the local population to and from endemic malarial areas as well as the large numbers of visitors arriving from these areas. The *Anopheles gambiae* S.L mosquito is the dominant malarial vector in southwest Uganda. Observed increases in its density during the El Niño year of 1998, where abnormally high temperature and precipitation caused a malaria epidemic in the region, are consistent with local reports that gradually warming temperatures may be contributing to increased prevalence of clinical malaria (Alonso, Bouma, & Pascual, 2011; Kilian, Langi, Talisuna, & Kabagambe, 1999; Lindblade, Walker, Onapa, Katungu, & Wilson, 1999; Peterson, 2009; Zhou, Minakawa, Githeko, & Yan, 2004). Households reported that cases of malaria are most common at the beginning of each dry and rainy season because of the presence of stagnant water at these times of transition. Community members explained that at the beginning of the rainy season, rainfall is not heavy enough to wash away stagnant pools of water, while at the beginning of the dry season pools of water have not yet completely dried up. Estimates of clinical malaria prevalence are confounded by the use of syndromic definitions in malaria self-reporting within the communities; locally, the word for malaria is used for a range of feverish symptoms that are likely to include malaria infection as well as other diseases with similar non-specific symptomology (e.g. typhoid) (Kengeya-Kayondo et al., 1994). Healthcare resources in the region are insufficient to confirm clinical incidence; local hospital officials note, however, that malaria rates reported by the Batwa are not disproportionate relative to district and national levels.

Malnutrition was only explicitly mentioned by a few households as a health concern, yet sixty-five per cent (thirteen of twenty households in semi-structured household interviews where the issue was raised) of families reported that they did not have enough food to satisfy their needs on a daily basis. All households reported that food was not of sufficient nutritional quality. The diet of the Batwa consists principally of locally-grown foods such as banana, cassava, maize, millet, beans, and greens sourced from their own farms or bought at the local market; subsistence crop production is seasonal and climate-dependent. Some households lamented the loss of traditional foods from inside the forest and linked the loss to present malnutrition. For example, honey from traditional forest apiculture, wild meat sources, and traditional wild fruits and vegetables are no longer readily available.

Dehydration – associated with limited availability of water and poor water quality, particularly during the dry season – was also noted as an important health concern, leading to general weakness and stomach disorders. Diarrhoea was noted by most households as a common, yet not serious, problem. Healthcare officials reported a high rate of parasitic worms in both communities; however, only in Mukongoro did community members offer worms as an ailment, referring to them as "stomach itching". Kihembe community members did not report "stomach itching" until they were specifically asked about it by the researchers. The fact that "stomach itching" is not perceived as a health abnormality in Kihembe could be a reflection of how commonplace worms and other stomach disorders are or the limited amount of Western health sensitization and education received by Kihembe relative to other communities like Mukongoro which are located closer to the local hospital.

The opposite reporting trend occurred for respiratory diseases, as Kihembe noted a higher prevalence than Mukongoro. Healthcare officials suggested that this may be due to the dry climate in Kihembe. Community members voiced numerous complaints about high dust levels, particularly with reference to prevalence of coughing while working in the fields. Pneumonia was reported in both communities, with respondents living in grass huts in Kihembe reporting the highest incidence.

Table 3
Key community-identified, climate-sensitive health outcomes.

Health outcome	Community description	Representative quotes	PhotoVoice results
Malaria	Feverish symptoms including any combination of headache, high temperature, common flu, physical weakness, loss of appetite, dizziness	"Malaria is rampant here and all the time we are going to Kihembe clinic [for treatment]" "Malaria is the most common disease. It has always been a problem." "With malaria, you feel weak, [your] temperature increases, and you have a headache"	
Malnutrition	Insufficient nutrition to meet basic needs; characterized by length of time without food, types of food consumed, and visible physical symptoms (e.g. circumference of upper arm, bloated stomach)	"It is a common problem that the children will not have enough food" "When we don't get all of our harvest, having enough food is a problem." "We continuously dig on the same land, so it gets exhausted…We have small portions of land and the crops don't grow very well."	
Stomach disorders	Diarrhoea, parasitic worms, ulcers, hernias, holistically referred to locally as "stomach itching'"	"Worms are caused by eating badly" "We have no clean water. We use the stagnant water that kids play and bathe in. Every dry season it dries up and we must go somewhere else to fetch water…When that dries up, we go even further."	
Respiratory disease	Common cough, tuberculosis, pneumonia	"Digging in hot temperatures makes dust come into the nose, and then flu comes" "Old women who sleep without something to cover them at night get coldness and fevers."	

Pathways of biophysical exposure

The main biophysical exposures through which the Batwa come to experience negative climate-sensitive health outcomes are summarized in Table 4. In both interviews and PhotoVoice, water emerged as the primary response to the question of how environment affects health. Healthcare officials reported that poor water is responsible for a high degree of morbidity, causing numerous stomach disorders and other types of waterborne disease. The principal water sources in both communities are small ponds. Community members reported that access to the sources is relatively easy in both communities as the sources are within 15 min walking distance from the respective centres of each. Community members

Table 4
Health exposures.

Exposure pathway	Exposures			Key climate-sensitive health outcomes
	Both communities	Mukongoro	Kihembe	
Water	■ Insufficient amounts ■ Polluted water sources	■ Alternative sources 2 and 7 km away, respectively (poor water quality for both)	■ Alternative source is 2 km away (Ikankoko river) (higher water quality but difficult physical access)	■ Stomach disorders
Food security	■ Quantity ■ Quality	■ Small agricultural plot size ■ Over-cultivation	■ Poor quality of soils ■ Pests attacking crops	■ Malnutrition
Infectious disease vectors	■ Large vector population ■ Breeding opportunities in stagnant water ■ Low levels of antibodies in population	■ Attractive climate for vectors due to high precipitation	■ Attractive climate for vectors due to high temperatures	■ Malaria
Weather events	■ Extreme weather events ■ Extreme temperatures	■ n/a	■ High temperatures ■ Relative lack of precipitation	■ Respiratory disease

consistently referred to their respective water sources as “dirty”, “infected”, or “full of disease”. Despite being aware of these dangers, there is lack of accessible, preferred alternatives. However, the principal sources in both communities run out of water during the dry season for upwards of two months, forcing community members to seek out alternative sources. Treatment of the water, principally through boiling, was a common but not unanimous activity in both communities. Some households expressed a desire to treat their water but lacked necessary resources (e.g. saucepans).

Food security is another pathway through which negative health exposures are manifest. Most Batwa source food from their own farm, from Bakiga farms as payment for their work, or from purchases at the local market. Charity and begging also remain major sources of food. According to community members, this paucity is due in large part to challenges associated with their own farming practices. Both communities experience frequent crop failure. In Mukongoro, steep valley environs limit plot sizes; population pressure, slope erosion, and poor farming practices contribute to over-cultivation and reduced productivity. Kihembe’s more arid climate is characterized by dry and infertile soils, and productivity is further compromised by crop pests. In recent years, cassava crops have failed community-wide due to locust attacks. There is limited research globally on whether climate change may contribute to increased locust outbreaks, though notably, researchers in China have found that locust outbreaks are more likely to occur in warmer, drier weather (Qui, 2009).

Infectious disease vectors present a third pathway of climate-sensitive health exposures. The vector of primary concern is *A. gambiae*, which carries the malarial parasite *Plasmodium falciparum*, the leading cause of morbidity and mortality in both communities. The environment of each community provides a suitably attractive habitat for the vectors. Additionally, there are sizeable pools of stagnant water in both communities that can serve as breeding grounds for the mosquitoes. Once exposed to a vector, the Batwa are particularly susceptible to contracting malaria due to the population’s relatively weak immunity to the disease. The *A. gambiae* prefers an open habitat and has vastly reduced survival rates under forest canopy (Tuno, Okeka, Minakawa, Takagi, & Yan, 2005). Given that vector density is thus much lower inside of the forest where the Batwa have historically lived, the Batwa have had minimal pathogen exposure to *P. falciparum* and as a result, have a lower current immunity to the parasite.

Human drivers of sensitivity

While exposures dictate the environmental mechanisms through which Batwa health may be affected by climate change, the severity of these impacts is determined by socioeconomic sensitivity. These sensitivities are manifest at individual, household, community and regional levels and stem from multiple sources (Table 5).

At the individual level, children and pregnant women are most sensitive to the adverse health effects of climate change given their already high morbidity and specific health and nutrition requirements. Up to the age of seven when they begin schooling, children bear the highest burden of disease in both communities. Parents report that children tend to be sick most severely as well as most frequently, some requiring hospital visits up to four times a month. The morbidity profile of children is similar to that of the broader community, with malaria the primary reason for ill health (Jackson, 2003, p. 40). According to hospital officials, sensitivity is high from birth: many Batwa children are born with low birth weights and are underfed and malnourished during infant years.

Sensitivities that raise Batwa vulnerability relative to the rest of the population are most pronounced at the community scale. The low socioeconomic status of the Batwa is documented in grey literature, by key informants, and by community members themselves. While exact income figures are difficult to estimate, development organizations confirm that most Batwa live well below the World Bank’s US$1.25 per day poverty line (Batwa Development Program (BDP), 2011).

The most significant and frequently reported socioeconomic concern was land security and tenure. Despite the purchase of land plots by development organizations, land titles were not transferred to the Batwa, limiting land security and investment. Additionally, population growth and immigration have led to plots of insufficient size and productivity to support household subsistence. The Batwa, with limited financial resources and low socioeconomic status, have been unable to access local land or credit markets – traditional, informal, or microfinance – in order to acquire larger plots. Households in many cases report being unable to afford basic household goods, such as pots, plates, utensils, mats, and bedding. In their absence, community members reported being unable to engage in health-promoting practices such as sleeping under a blanket at night, boiling their drinking water, or cooking on a stove without substantial smoke. The provision and maintenance of proper sanitation facilities is also largely absent; in Mukongoro, only a handful of households have constructed permanent latrines while in Kihembe, there are none. For waste disposal other than latrines, small holes are dug in the ground and covered in soil when full. Accumulation of waste can contaminate water sources, particularly during heavy rainfall events.

The majority of Batwa income goes towards food. According to health professionals, the diet of the Batwa since their departure from the forest is generally lacking in nutrients and minerals formerly sourced from forest fruits and vegetables (Kabananukye & Wily, 1996). A number of interviewees highlighted the importance of a nutritious diet, but cited a lack of financial resources to purchase food from the local market. While prices are lower at larger markets in more central trading centres, the Batwa cannot

Table 5
Health sensitivities.

Scale	Sensitivity pathway		Sensitivity
Individual	Demographics	Children and women	■ Children under seven years of age ■ Pregnant women
Community	Low socioeconomic status	Inability to afford basic quality and/or quantity of livelihood assets	■ Lack of land ownership, tenure insecurity ■ Poor housing ■ Lack of household goods ■ Poor nutrition ■ Poor sanitation
	Social and political marginalization	Social prejudice and discrimination Political	■ Inability to fully engage in local society ■ Lack of political representation ■ Limited government assistance ■ Traditional rights unrecognized in statutory law
	Livelihood transition	Loss of traditional livelihood	■ Loss of socio-cultural integrity ■ Limited access to forest resources
		Adjustment to new livelihood	■ Lack of compensation ■ Need to acquire agricultural knowledge ■ Introduction to local market competition ■ Dependence upon external sources of income and aid
Regional	Demographics	Population	■ High population growth
	Economy	Major revenue sources	■ Potentially volatile tourist industry ■ Climate-sensitive industrial agriculture, coffee and tea production
	Conflict	Instability	■ History of extreme conflict ■ Close proximity to conflict in DRC
		Population	■ Forced migration ■ Large refugee population

physically access these markets because of high transportation costs. The provision of sufficient calories takes precedence over the provision of nutritious calories.

Current and historical social and political marginalization contributes to community sensitivity. Historically, the Batwa were perceived as dirty, lazy, and backward due to their traditional hunter-gatherer lifestyle in the forest, and were commonly exploited in forced labour (Namara, 2007; Warrilow, 2008, p. 36; Woodburn, 1997). Such perceptions manifest into minimal or no Batwa political representation, exclusion from local permits to access forest resources, refusal of service from some government healthcare facilities, and in general, a subservient relationship with the wider Kanungu community (Tumushabe & Musiime, 2006). In recent years, these perceptions have begun to change with sensitization by local human rights groups and an influx of international development activity. Instances of conspicuous, systemic forms of discrimination such as refusal of healthcare are now rare (Balenger et al., 2005, p. 71; Jackson, 2003, p. 40). Additionally, Batwa communities have begun to organize politically by forming an NGO, the United Organization for Batwa Development in Uganda (UOBDU), whose primary mission is to build representative capacity. Despite this progress, households report continued general prejudice.

At the community scale, removal and transition from forest to agricultural environs has meant that the Batwa's traditional knowledge is poorly matched to their current agricultural livelihoods. This has introduced a dual challenge. First, Batwa continue to lament lack of access to traditional forest resources such as medicinal herbs. Secondly, transition to new agricultural livelihoods has been problematic; the Batwa received neither financial compensation nor training or capacity development in agriculture following their eviction. Over the past two decades, the Batwa's knowledge of agriculture has matured considerably through learning from fellow Bakiga farmers; given an historical lag in the acquisition of this knowledge, however, Batwa are currently unable to compete in local agricultural markets compared to local Bakiga farmers who have been raised in communities and families with generations of experience in agriculture. Key informants affirmed that one of a number of reasons the Batwa face difficulties in selling their produce at market is price competition and their inability to produce at efficient scale economies relative to more experienced Bakiga farmers.

In terms of loss of socio-cultural identity, some community members shared sentiments such as "the forest is our life" and stressed the forest's dominant role in their spirituality and cultural practices. Sites of worship and traditional ceremonies for the Batwa are all located inside of the forest (Minority Rights Group International, 2008). The loss of these more intangible assets such as a sense of belonging and spiritual connection with their surrounding environment, while difficult to quantify, are vital to an understanding of the Batwa's current vulnerability.

Many Batwa seek alternate employment to supplement their income; selling labour on Bakiga farms is common, though ad hoc, irregular, and sensitive to seasonal availability. Tourist services, handicraft making and other local service-based livelihoods are present, but demand for workers in these sectors is not currently available on a scale that would accommodate a large portion of the Batwa population.

The Batwa have, to varying degrees, developed a dependency upon external aid. All households depend upon external development organizations for the provision of land, education, and healthcare, while approximately half of households report getting significant support in other areas such as housing, sanitation, and technical assistance in agriculture. Aid dependence is, however, subject to variability. For example, a healthcare program funded by a European international development organization for the Batwa in a nearby district which has provided free treatments and community health outreach services for communities over the past three years with prominent success at the time of writing. The funding for the program is scheduled to run out within a year and there is currently no forthcoming replacement for the donor.

At the broadest scale, the Batwa are exposed to region-wide health sensitivities. Demographically, Kanungu's high population growth of about 3% per year puts a strain on public resources ranging from healthcare services to environmental goods (Bernard, Egeru, Okello, & Mutuzo, 2010). The regional economy has come under pressure due to volatility in several of its major revenue sources, especially the tourism and coffee and tea production sectors. Tourism in Bwindi is based on revenue from gorilla trekking, with the industry contributing up to 70% of the national tourism authority's annual revenues (Tenywa, 2007). Additionally, the region is still recovering from a long and recent history of

extreme and violent conflict, including spillover effects from the 1994 Rwandan genocide and decades of civil war in the eastern Kivu provinces of the DRC, which border Uganda. Instability is still rife in areas of Kivu bordering Kanungu, and potential armed militia attacks continue to pose a threat to regional livelihoods.

Adaptive capacity

Current adaptive capacity in Batwa health systems is a function of complementary formal and informal institutions that manage health outcomes. Formal healthcare institutions include both Western healthcare and traditional medicine. Generally, community members will use traditional medicine as a first course of treatment before seeking out Western healthcare. There appears to be no apprehension or cultural opposition towards using the latter. While community members may prefer traditional herbal treatments, they concur that Western care is effective.

The Batwa are renowned for their traditional herbal medicines and studies have identified dozens of local medicinal plants used by the group, many of which contain active compounds against diseases such as malaria, diarrhoea and intestinal worms (Cunningham, 1996). There was discord among interviewees as to whether herbs were indeed available outside of the forest, though community members consistently reported that fewer community members are learning to use traditional medicine than in the past. Kihembe and Mukongoro each have one traditional herbalist, both of whom lamented that their knowledge was not being passed on to younger generations.

Government provision of Western healthcare services is limited, and community members report problems in access due to financial costs and discrimination. Both communities are dependent upon development organizations and their private facilities for the provision of Western healthcare. Recognizing the health challenges faced by the Batwa while visiting the area a decade ago, two American missionaries constructed a hospital in the nearest trading centre, Buhoma, specifically targeted at Batwa health. Bwindi Community Hospital (BCH) opened in 2003. The 62-bed hospital provides health services to more than 25,000 patients annually as well as community outreach programs to remote Batwa communities. Its services receive positive feedback from all participants, most of whom report dramatic improvements in their health since its opening. These observations are confirmed by a number of local studies which have documented the positive health impacts of BCH. In partnership with local development organizations, the hospital pays for all Batwa treatments; outreach services for health education and ambulatory services are also available. Through programs such as these, formal institutions of adaptive capacity connect with informal ones. Informal institutions that contribute to adaptive capacity of Batwa health systems include knowledge and education and community support networks.

Community support networks are defined here as a community's collective will to withstand disadvantageous circumstances and its facility to work together to do so. Community support networks are a key component of adaptive capacity. The two communities exhibited different degrees of community support. In Mukongoro, community members have a history of collaboration and were optimistic about their collective future. While some "quarrelling and laziness" were reported by community members, this sentiment was outweighed by the focus upon working hard and developing the community as a whole. In Kihembe, a history of social conflict divides the community and there remains opposition to engaging in mutually supportive activity. Reactions during interviews to such activities ranged from relative apathy to complete rejection. Community perceptions of external support networks also differed. Community members in Mukongoro appear to take greater responsibility for their own development and do not seek to rely upon it. Community members in Kihembe, in contrast, expressed less desire for self-sufficiency and point outwards for the solutions. For example, in responding to a question about how to address a lack of malaria nets, the most common response in Mukongoro was that one should work hard to earn enough money to go out and purchase a mosquito net. In Kihembe, the most common response was that the government or development organizations should provide all households with mosquito nets.

Discussion

Results highlight the significance of social, political, economic, and institutional determinants in characterizing the vulnerability and adaptive capacity of Batwa health to climate change. While climate change may expose all individuals and communities to similar biophysical risks, it is the social determinants of high sensitivity and limited adaptive capacity that increase Batwa vulnerability. Furthermore, our work suggests that differential sensitivity and adaptive capacity of the two communities are strongly influenced by internal community dynamics catalyzed by external support. Notwithstanding common trends in vulnerability among Batwa, local or specific vulnerabilities largely associated with internal conditions of the unit exposed – whether individual, household or community – are important determinants of sensitivity. Herein, climate change vulnerability may be highly dependent upon socioeconomic determinants at the local scale.

The starting point for successful adaptation to climate change is thus predicated on addressing the social determinants of high sensitivity and limited adaptive capacity among the Batwa (Ford, In press). In particular, successful adaptation to past environmental change – the transition to life outside of the forest – will be necessary in order to reduce current sensitivities. The Batwa view climate change – as articulated through perceptions of environmental impacts on health – as a minor threat; climate change discourse has little resonance on the ground, where it is overshadowed by social and economic determinants of health. Consistent with existing vulnerability research, this study therefore suggests that adaptation to the potential health impacts of climate change is best approached in the present through addressing the Batwa's social determinants of health, primarily through the provision of sustainable livelihoods in which fundamental health and equity needs are met (Campbell-Lendrum & Woodruff, 2006; Costello et al., 2009; Ebi & Burton, 2008; Ford, Berrang-Ford, King, & Furgal, 2010c). Three potential entry points for adaptation figure prominently herein: land access and ownership, economic self-sufficiency, and new forms of traditional knowledge.

In general, Batwa households which have land tenure security through access and ownership experience better health outcomes and are more optimistic about their future than those lacking tenure security; the acquisition of land was also the most frequently cited strategy for health adaptation to climate change among community members. This observation of a link between land and wellbeing was observed in both communities, has been confirmed by quantitative studies in Batwa communities over the past two decades, and is supported by scientific and grey literature (Ohenjo et al., 2006) including studies on the mental health implications of climate change for Indigenous communities globally (Berry, Bowen, & Kjellstrom, 2010; Berry, Butler et al., 2010; Cunsolo-Willox et al., In press). A 2005 study, for example, found that child mortality (under five years of age) of the Batwa was 59% for households without land while only 18% for households with land (Balenger et al., 2005, p. 71). The significance of land tenure and ownership as a determinant of Batwa health and sensitivity cannot be overstated; interventions for improved adaptation that do not respond to land insecurity are less/unlikely to be successful.

Within the communities, the households who were most successful in generating their own wealth, independent from external sources, were generally healthier. Key informants were unanimously more optimistic about those of Mukongoro than Kihembe because of the community's relatively more active engagement towards an aim of self-sufficiency. The research suggests two possible reasons for this contrast between the communities. The first, related to settlement histories, indicates that because community members in Mukongoro for the most part have a shared history as refugees from the Congo and established themselves in Mukongoro with equal plots of land and opportunities, they have developed a more productive internal dynamic. In Kihembe, four original households were given all of the land by development organizations and asked to subsequently divide the land and distribute it to new families as they arrived. As Kihembe's population grew, there was discord in the parcelling of land to newly arriving families, fostering inequality and an antagonism that remains a salient issue in the community. A second reason for the differing degrees of effort put towards self-sufficiency by the two communities may be the relationship between the respective communities and external development organizations. In Mukongoro, the relationship has been largely positive and many of the development projects have explicitly focused on capacity building and fostering self-sufficiency through an iterative process. In Kihembe, the relationship has been far more contentious and focused on unilateral provision of aid.

Participants in this study consistently highlighted the role of traditional knowledge, particularly related to health and nutrition, as an important factor affecting present livelihoods. Batwa traditional knowledge is, to a large extent, poorly matched to current livelihoods outside of the forest. Whereas agricultural knowledge among the Batwa is already developing in Kanungu communities, provision of education and training in agriculture would contribute substantively to reducing sensitivity and increasing adaptive capacity. Increased knowledge, however, would need to be combined with financial resources to effectuate new skills. In some cases, Batwa have developed nuanced agricultural techniques, but lack resources to purchase seeds, tools, or land for implementation. Educational and financial support interventions would support improved transition and adaptation of Batwa to agricultural livelihoods.

Conclusion

Existing socio-economic and health disparities predispose the Batwa to experiencing the brunt of the higher disease burden that is expected to arise from climate change in this part of sub-Saharan Africa. Successful adaptation depends on the extent to which they can reduce their sensitivity to these negative health outcomes. Land tenure and security, economic self-sufficiency, and new forms of traditional knowledge are fundamental to this aim. As one of the many variables that determine future health outcomes for the Batwa, climate change impacts will be manifest through existing sensitivities.

This research contributes to a limited field of work assessing climate change and health vulnerability in a developing nation, providing a baseline for understanding vulnerability and identifying adaptation opportunities. Recent research has identified significant gaps in our understanding of the health dimensions of climate change vulnerability and adaptation, particularly among Indigenous populations and in developing country contexts (Costello et al., 2009; Ford, in press; Ford et al., in press, 2010c). One of the few areas of consistent consensus at recent Conferences of the Parties for the United Nations Framework Convention on Climate Change (UNFCCC) has been the establishment of adaptation funds for low income countries to respond to the effects of climate change. Access to, and implementation of such funds will require evidence-based adaptation plans. This research contributes to an emerging knowledge base to inform the identification of adaptation needs and opportunities in highly vulnerable Indigenous populations.

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Appendix A. Supplementary material

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.socscimed.2012.04.016.

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