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Cattle as technological interventions: The gender effects of water demand in dairy production in Uganda

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Abstract

Smallholder dairy production dominates the country of Uganda, with over 90% of the national herd owned by smallholders. To reduce hunger, malnutrition, and raise families out of poverty agricultural development, interventions in Uganda have focused on increasing milk production through the introduction of improved dairy cow breeds. Development actors, such as the East Africa Dairy Development (EADD) program in Uganda, see crossbreed dairy cows as a key technological intervention for improving production. Drawing on a multi-method study (spatial analysis, surveys, and qualitative interviews) of dairy smallholders, our paper examines the gendered effects of the introduction of crossbreed dairy cows. To ensure peak performance, improved breeds require more inputs (e.g., water, feed, and medicine), which are labor and time intensive with specific gendered outcomes. Our findings reveal that both men and women identify fetching water as one of the greatest challenges in maintaining dairy cows, but women and children disproportionately fetch the water and women have higher reported rates of time poverty. Water quality is also an issue, with smallholders struggling to provide clean water to cows, and our basic water testing reveals water sources with high nitrate levels that can be harmful for children and dairy cows.

Key words: water, development, gender, dairy, cattle

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Introduction

Smallholder production dominates the country of Uganda. In the case of dairy production, over 90% of the national herd is owned by smallholders (Balikowa 2011). The focus on improving smallholder production in Uganda fits within a broader framework of increasing food production to not only reduce hunger and malnutrition, but also as a mechanism to raise individuals and families out of poverty by increasing incomes (Kabunga 2014). As such, both the national government and public and private development interventions have sought to increase milk production in Uganda both for home consumption and through the development of dairy value chains. The introduction of improved dairy cow crossbreeds is viewed by development actors such as the East Africa Dairy Development (EADD) program in Uganda, as a key technological intervention for improving production.

EADD was started in 2008 in Kenya, Uganda, and Rwanda with a grant of $42.8 million USD from the Bill & Melinda Gates Foundation, and it is one of the leading market-oriented development initiatives in eastern Africa. The program implementation is led by Heifer International in partnership with the International Livestock Research Institute (ILRI), TechnoServe, the World Agroforestry Centre (ICRAF), and the African Breeders Service Total Cattle Management (ABSTCM). Phase I ran from 2008 to 2013. Now in phase II (2014–2018) in Kenya, Uganda, and Tanzania, EADD aims to boost the milk yields and incomes of small-scale farmers and their access to markets to improve food security and nutrition, and create sustainable livelihoods. EADD has targeted smallholder farmers, including women, to improve their livestock assets, especially dairy cows (Quisumbing and Roy 2014). Our paper examines the gendered effects of the introduction of crossbreed dairy cows. To ensure peak performance, improved breeds require more inputs (e.g., water, feed, and medicine) than traditional breeds that are labor and time intensive with specific gendered outcomes.

Through a mixed methods approach (spatial analysis, surveys, and qualitative interviews), this paper identifies key gender dimensions for improving dairy production in smallholder production. In analyzing efforts to improve food security through improving dairy production, our paper draws on literature located within science and technology studies as well as gender and development.

Technologies are not socially neutral (Nally 2016). In this paper, we conceptualize crossbreed cows as a technology. Although technologies are often associated with non-living entities such as robots or cars, scholars have increasingly focused on scientific practices of manipulating living organisms for human purposes, and this includes animal breeding (Haraway 2002; Holloway and Morris 2012; Jiang 2017). More accurately, dairy cattle breeds are an example of what science and technology scholars refer to as technoscience. Technoscience reflects the fact that science and technology are completely integrated in today's society, and the concept is used to justify "society's fix on technological innovation and efficiency" (Haraway 1997, p. 50).

In the naïve approach to using technology to promote development and solve food insecurity, there is the assumption that "new technologies can be developed in one context and then transplanted into another" (Nally 2016, p. 564). In our example, the technology is the importation of semen from exotic breeds, usually breeds located in the US and Europe, which are then bred with local breeds to create "crossbreed" dairy cattle. These "new" dairy breeds in Uganda are intended to increase milk production among smallholders.

In contrast, we argue that the extent to which technologies such as crossbreed dairy cows benefit smallholders, especially women, depends on the relationship between these technologies and the social, environmental, economic, and institutional factors such as local agro-ecologies, production systems, the availability of markets for credit, and the governance and policy frameworks, in which they are embedded (Vercillo et al. 2015; also see Yamaguchi 2016; Jiang 2017). Crossbreed dairy cows demand new types of labor and social relations especially regarding the demand for more water. In this sense, crossbreed dairy cows are better thought of as technoscience, whereby human and nonhuman actors "are brought into alliance by the material, social, and semiotic technologies" and what counts "as nature and as matters of fact get constituted for and by millions of people" (Haraway 1997, p. 50). The EADD program aims to enhance gender equity and women's empowerment by incorporating women into the ownership and management of dairy cows. However, a part of EADD programming, and development programs more generally, relies upon asset transfer programs—in this instance semen for artificial insemination (AI), which is used to create crossbreed dairy cattle. However, these crossbreed cows are water intensive, and their adoption encouraged in a space that is periodically water scarce and (or) lacking safe water, which potentially increases gender inequity and women's disempowerment by ignoring the gendered nature of cattle related tasks such as fetching water.

Materials

Context of this study

In livestock asset transfer programs,[1] livestock are seen as playing an important role in providing a "pathway out of poverty and malnutrition" (Rawlins et al. 2014, p. 203; also Alary et al. 2011; Jodlowski et al. 2016), and livestock are, therefore, commonly given to the poor as part of asset-based poverty alleviation development programs (Krishna et al. 2012; Rawlins et al. 2014; Kim and Sumberg 2015). Although several studies have focused on the impact of animal ownership on various animal health and nutritional outcomes, only recently have studies begun to focus on the impact of livestock donations, or livestock asset transfer programs, and their impact on human nutrition and health (Rawlins et al. 2014; Jodlowski et al. 2016). In both types of studies (i.e., animal ownership and livestock donations), the findings generally support the view that there is a positive relationship between animal ownership and household and child nutrition.

As asset transfer programs have become more popular among development agencies, studies have begun to assess their utility for enhancing household food security and economic well-being (Rawlins et al. 2014; Jodlowski et al. 2016). However, few studies have examined the gendered dimensions of asset transfer programs. Studies that have focused on gender have focused on gendered impacts in terms of asset ownership and decision-making in the household, as well as time allocation. Das et al. (2013) found in Bangladesh that livestock transfers significantly increased the well-being of households and increased the amount of decision-making women had over some dimensions of women's empowerment such as important household assets and women's perceived sole ownership of cash. However, they also found several dimensions of women's empowerment where women's roles were reduced, including control over their own earnings and purchases, and their study found a disproportionate increase in men's assets compared with women's increases in cases of joint ownership or sole ownership of assets. Among these studies, one key finding has been that the increased feed and health needs of crossbreed and exotic livestock increase demands on both men and women's time (Johnson et al. 2016 citing Quisumbing et al. 2015). Our paper builds on these studies by including an analysis of crossbreed cow's demand for water and its implications for men, women, and children's time.

The introduction of crossbreeds to Uganda has a long history, with the Ugandan government having introduced AI programs back in 1953 (Balikowa 2011). Renewed efforts to increase the use of AI began with the introduction of liberalization policies in the dairy industry in the 1990s, with a sizeable influence of non-governmental organizations (NGOs), including Heifer, promoting AI in the 2000s (Balikowa 2011; Mbowa et al. 2012). Despite such a long history, improved dairy cattle are found less among poor smallholders because crosses are more susceptible to disease and have higher management costs (Balikowa 2011). However, with the combined effort of the government, NGOs, and the private sector, there has been an increase in crosses in the dairy herd composition, with the most growth having occurred in the central and eastern regions in the past decade (although the highest concentration of crosses remains in the western region at approximately 40%) (Mbowa et al. 2012). Despite the increase, estimates of crosses remain quite low, with crosses estimated as only 18% of all dairy cattle in the eastern region, where our study is based (Mbowa et al. 2012).

To accommodate the needs of crossbreeds, households participating in EADD are encouraged to modify their production practices by rearing these cattle in intensive production systems (i.e., in stalls) rather than extensive production (i.e., grazing on pasture) to increase milk production (Ooko 2013). Intensively reared cows can be raised even when there is a shortage of land and are more

[1]For livestock asset transfer programs, we include programs that provide exotic semen to create crossbreeds.

productive than grazed cows, producing milk yields up to 30 times higher than those of grazed cows (Rice 2008; TechnoServe Uganda 2008; Gachuiri et al. 2012). However, intensive production is more labor intensive and time consuming than extensive production. When cows are confined, fodder and water must be brought to the cows (Gachuiri et al. 2012; Ooko 2013), and waste must be manually removed from the enclosure daily to keep the animal comfortable and productive (TechnoServe Uganda 2008).

Water requirements of a lactating cow are closely related to milk production, moisture content in the feed, and environmental factors such as air, temperature, and humidity. Dairy cattle require varying amounts of water depending on how much milk the cattle produce, in addition to other conditions such as humidity and moisture of livestock feed as mentioned above (Njarui et al. 2014). Cattle given inadequate drinking water produce less milk (Njarui et al. 2014).

Water availability in rural Uganda

In 2015, the main water source for 92% of rural Ugandans was located outside of their compound (i.e., a cluster of homes representing a family unit usually, though not always, demarcated by an enclosure), meaning they had to walk or bike to their primary water source (Afrobarometer 2015). Although 56% of rural Ugandans reported never going without a clean water source, 44% reported going without clean water in the previous year, and 30% reported regularly going without clean water (Afrobarometer 2015).

In rural Uganda, there are several types of water sources used by smallholder households including ponds and open wells (considered unsafe), and improved water sources, which include boreholes (hand-pumped water supply), covered wells, protected springs, and rainwater collection. Much of the literature attributes the continued scarcity of water supplies to poor water governance (Fonjong and Fokum 2017; Naiga et al. 2017). Water governance is defined as the range of political, social, economic, and administrative systems that are in place to regulate the development and management of water resources and the provision of water services. As "men and women are seen as having distinct responsibilities in using and managing water systems," gender is relevant to addressing sustainable water resource management globally (Naiga et al. 2017, p. 506).

Gendered dimensions of water access

The labor associated with water, particularly water collection, poses unique challenges for women and children across much of rural Africa, including Uganda. In a study of 24 sub-Saharan African countries, Graham et al. (2016) analyzed the gendered labor of water collection, focusing on water collection that took 30 min or longer to complete. Consistent with similar studies, they found that women and girls were the primary collectors of water.

Research has established that time poverty is gendered in Uganda, in that women overwhelmingly feel like they have too much work and not enough leisure (Bergman Lodin et al. 2012; Malapit et al. 2014; Bain et al. 2016). Tasks such as water collection contribute to time poverty. In Uganda, women and children have been identified as the primary collectors of water for household use (Asaba et al. 2013; Magala et al. 2015; Naiga et al. 2017), whereas men are willing to collect water for commercial purposes, such as brick making, and for their animals (Naiga et al. 2017). Asaba et al.'s (2013) study in Makondo, Uganda, focused on the time and distance associated with water collection, along with the health implications of such activities. The results revealed the disproportionate burden of water collection for women and children (particularly girls) (Asaba et al. 2013). Water collection is considered "shameful" and "unmanly" for men, meaning that women and children are the primary water collectors. Water collection, especially the amount of time and energy it requires, strongly and often negatively affects women and children's lives (Asaba et al. 2013). First, there are health risks associated with water collection. The physical wear and tear that is involved can be hard on one's body, especially if children are sent at too early an age (Asaba et al. 2013). In Uganda, women and girls are much more likely to carry water by hand or on their heads, whereas men and boys are more likely to have access to a bicycle—an asset more often controlled by men—to carry water, which reduces the physical strain of the task (Asaba et al. 2013; and see Njarui et al. 2014 for similar results in Kenya). Second, the time spent collecting water takes away from the time available for women or children to engage in other activities such as education or earning income.

Gender division in water collection is not the only way in which gender matters. In the regions of our study, the bulk of households rely on boreholes for water; however, there is a problem of boreholes breaking down for a variety of reasons including technical parts failing and vandalism (DWD 2016). Naiga et al. (2017) found that men and women agreed that women are important contributors to maintaining collective water provisioning in rural communities, as they are more likely to contribute to water user fees (for replacement parts) and labor (cleaning the water point and clearing plants) to ensure maintenance. Yet men were much less likely to support women serving in formal positions on local water committees that oversee borehole maintenance, as a woman holding a public position was perceived as an "impossible woman" by men (Naiga et al. 2017, p. 517). Thus, the literature suggests that gender inequality not only in households, but also in communities, contributes to a double burden for women in Uganda as it relates to water. Women must collect the water (either doing so themselves or organizing someone else, such as children, to do it for them), but they are not empowered to ensure the maintenance of boreholes, thereby contributing to longer distances traveled for household members to collect water when boreholes break down. Moreover, if protected water sources like boreholes break down, women are responsible for either ensuring the water used by the household is made safe (by boiling or filtering) or caring for sick family members (Naiga et al. 2017) and, specific to our study, sick animals, as a result of waterborne diseases.

Water quality in rural Uganda

When boreholes break access to clean water declines, and if it is the dry season, there is also an increase in water scarcity. In a study located in a semi-arid portion of Kenya, when water became scarce farmers used a more diverse method of providing water for dairy cattle (Njarui et al. 2014). In Njarui et al.'s (2014) study, it was found that 57% of farmers surveyed obtained water from more than one source, including a mixture of shallow wells, valley bottoms, rooftops, boreholes, water pans, and piped water.

Nitrate contamination is a serious water quality problem that affects both human and animal health. Nitrate levels > 10 mg/L are a threat to pregnant women and infants because excessive nitrate levels can cause methemoglobinemia, also known as "blue baby syndrome," as blood is less able to absorb oxygen, making it difficult for an infant to breathe (Knobeloch et al. 2000). The presence of nitrates in drinking water for livestock is also known to influence animal health (Sallenave 2017). Water is an essential component of livestock health, and nitrate contamination in livestock drinking water has demonstrated health effects, particularly for reproduction and milk production.

Surface water or shallow ground water sources can become contaminated with nitrates through various means such as from manure, causing nitrate poisoning (Linn and Raeth-Knight 2010). This can result in labored breathing, convulsions, and even death in dairy cows (Linn and Raeth-Knight 2010). Nitrates in drinking water can also affect dairy cow reproduction. For example, dairy cows in herds that drank water with the highest nitrate concentrations had the longest calving intervals (Beede 2006). In sum, water provisions, in terms of quality and access, not only affect the animals but also the livestock owners. Households must balance water usage between agriculture, livestock, and household needs, recognizing that inadequate amounts of quality water for dairy cows can reduce the production of animal products (Wilson 2007).

Methods

We used a mixed methods approach, which included household and individual surveys of farmers, GPS coordinates and tracks, and in-depth interviews with a subset of 15 farmers. For the survey data, we collected a total of 172 household surveys in May and June of 2016 from three villages, two of which had just begun working with EADD, phase II programming. All the villages were located in the eastern region of Uganda. In addition, we collected 318 individual surveys. The data presented here are part of a larger, multi-year study that uses the Women's Empowerment in Agriculture Index (WEAI) survey.[2]

The two EADD locations were selected based on consultation with Heifer Uganda, the lead implementing partner of EADD. Although both locations were new to EADD programming, one was chosen for its already high performing dairy cooperative (HH IDs 400s), which was regularly collecting milk from farmer members to send to the market, and producing yogurt and ghee. The other location was low performing (HH IDs 500s), in that there was extremely limited milk collection and no value-added products such as yogurt being made by the cooperative. In the two EADD villages, a list of dairy cooperative members was provided to us, which provided our sampling frame. Cooperative members who were selected for the surveys were largely based on convenience. For households headed by a man, we required that both the husband and wife (or wives) be present before the surveys were conducted. Farmer households in non-EADD (HH IDs 600s) sites were identified through extension workers familiar with the dairy farmers in the area.

All households participating in our study were required to own or have owned a dairy cow, either crossbreed or indigenous, within the past year. Two of our sites had a majority of crossbreed dairy cattle (i.e., the high performing EADD site (400s) and the non-EADD site (600s)), whereas the low performing EADD site (500s) only had 11% crossbreed dairy cows, with the rest (89%) being indigenous/local dairy cows (see **Table 1**).

Our household surveys contained questions to assess the socio-economic status of households and of individuals in the household. One measure that is statistically significant for indicating differences in wealth is flooring material, with mud floors indicating lower socio-economic status. Approximately, half of all households in our sample had mud floors in their dwelling (48%), whereas concrete floors made up the other half (50%) of the survey population (see **Table 1**). Occupationally, the vast majority of primary household respondents identified working on one's own farm or raising livestock as their primary occupation (89%).

For this paper, we use the household survey question "who usually goes to the water source to fetch the water?" Many households responded that multiple household members fetch the water and that which person from the household fetches the water depends on the time of day. Therefore, for the purposes of our analysis, we selected the first household member that was reported in those cases

[2]The WEAI was created to measure the empowerment, agency, and inclusion of women in the agriculture sector in an effort to identify ways to overcome obstacles and constraints. The index measures the roles and extent of women's engagement in the agriculture sector in five domains (referred to as 5DE, as follows: (1) decisions about agricultural production, (2) access to and decision-making power over productive resources, (3) control over the use of income, (4) leadership in the community, and (5) time use. It also measures women's empowerment relative to men within their households. The WEAI is considered a useful tool for tracking progress toward gender equality and for allowing women and men to work toward autonomy and decision-making in key domains (Alkire et al. 2013).

Table 1. Demographic information of households surveyed.

	EADD 400s (high performing)		EADD 500s (low performing)		Non-EADD 600s		
	No.	%	No.	%	No.	%	Total for all HHs
HH surveys	75	43.60	46	26.70	51	29.70	100%
Woman-headed households	14	18.70	4	8.70	8	15.70	15%
Average household size (number of individuals)	8	—	8.6	—	7.2	—	7.9
Working own farm/raising livestock[a]	60	82	41	91	46	96	89%
Percentage of HH with crossbreed dairy cows	—	65	—	11	—	59	48%
Primary flooring							99%
Earth/mud floor[b]	40	53	24	53	19	37	49%
Concrete/cement[b]	34	45	21	47	31	61	50%
Primary cooking fuel							
Firewood[b]	72	96	44	98	50	98	97%
Primary light source							82%
Lanterns/candles[b]	29	39	15	33	37	73	47%
Solar[b]	30	70	20	44	10	20	35%

Note: HH, household; EADD, East Africa Dairy Development.
[a]Out of a subset of 166 of the total sample of 172 due to individuals who did not identify an occupation due to illness or old age.
[b]Out of 45HH in EADD Eastern.

where households reported more than one member who fetches water. We recognize that our results may not fully capture the dynamics of who in a household is responsible for water collection and how that varies at different time periods, but rather is intended as a snapshot in time.

We also collected water tracks using handheld GPS units for a subsample of 35 households among those surveyed (approximately 25%). These tracks followed the path that someone in the household took from the house to the water source, and were intended to measure the distance to the source, and if relevant, the elevation. The selection of households for which we recorded GPS tracks was based on convenience sampling in the field, which was largely contingent on our sending all four of our survey teams to designated households before we then took a water track. Basic water quality testing was done at the water source for all 35 water tracks collected, which included nitrate levels. We used litmus pH test strips, which were inserted directly into the flowing water for the amount of time directed, with pH, nitrate, and nitrite levels recorded.

Finally, we drew upon in-depth follow-up interviews with 15 EADD farmers (10 women and 5 men) who had completed our surveys. Interviews were conducted in person and in the local language. All interviews were recorded and then transcribed and translated into English. The interview data were coded to identify what men and women perceived as the primary benefits, challenges, and trade-offs of owning dairy cows.

Our study was reviewed and approved by the institutional review boards at Iowa State University and the University of Richmond. All participants in our study provided informed consent, which included the participants understanding that participation in the study was voluntary and that their identities in reporting of results would remain confidential. Informed consent was translated into the local languages.

Findings

Among all the studied households, the average number of times water was fetched was three times per day. Among households for which we collected water tracks ($n = 35$), we found that those households who had to travel the farthest to the water source made comparatively fewer trips in a day, with the exception of one outlier. Once the outlier was removed from our analysis, there was a clear downward trajectory for the total number of trips made based on the distance to the water source. A regression line drawn on a scatterplot of the two variables (number of times fetching water and distance to source) showed a negative relationship; with every additional 334 m between the household and the water source the household made 50% fewer visits to the water source. Figure 1 provides an overview of water tracks recorded relative to households surveyed, with water distances ranging from 3 to 1145 m, and a median distance of 412 m from the house to the water source.

In terms of who in the household fetches water, within our total sample ($n = 160$),[3] overall, women fetched water 54% of the time. If we only include women 18 years and over, the percentage of women collecting water increases to 66% ($n = 65$). Adopting Asaba et al. (2013) age categories,

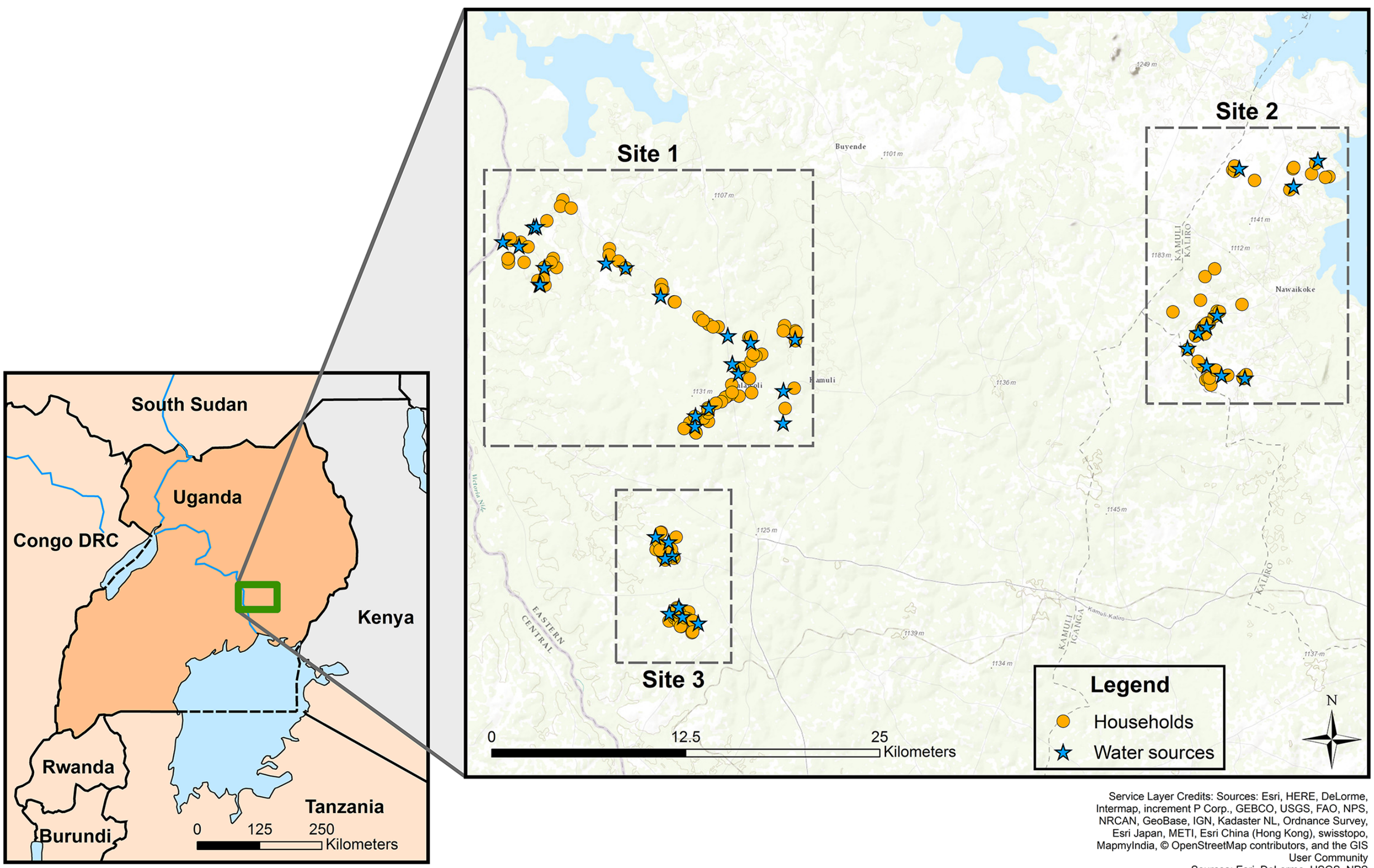

Fig. 1. Map of households surveyed and water tracks recorded.

[3]Due to missing data, only 160 households reported fetching water by gender.

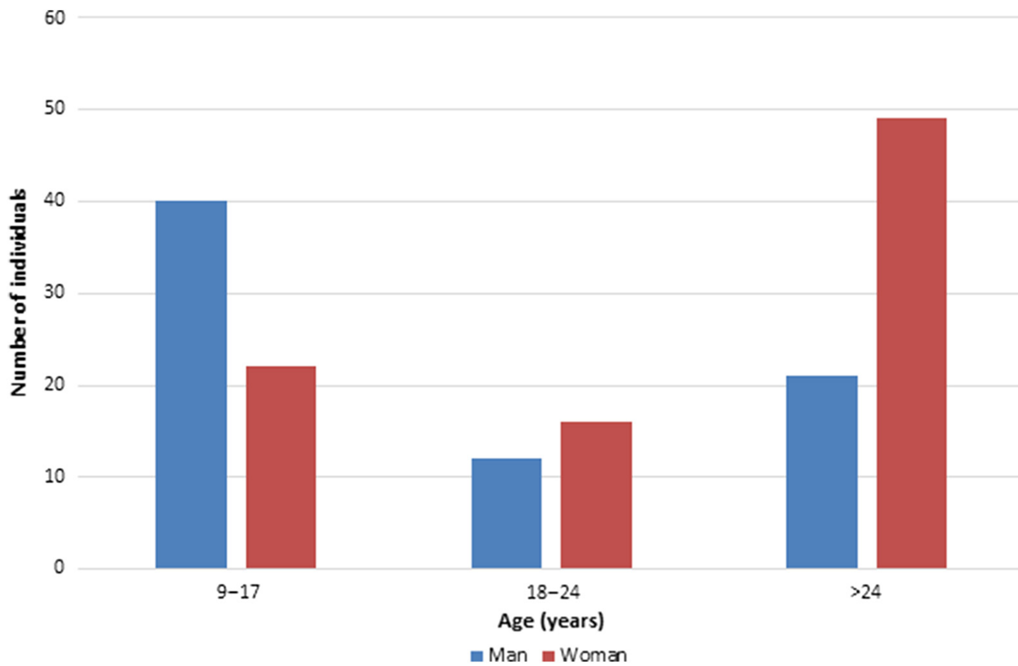

Fig. 2. Gender and age of primary person fetching water from source.

we found that boys were far more likely to fetch water than girls in the 9- to 17-year-old age category (see Fig. 2), whereas we found that in the other two age categories women were more likely to fetch water than men, with the largest difference occurring among the oldest age category (> 24 years). Overall, 9- to 17-year-old girls fetched water 37% of the time, whereas 18- to 24-year-old women and women 25 years and older fetched water 57% and 70% of the time, respectively. For the 35 tracks recorded, those that were 800 m or more from the household identified boys as the main water collectors, whereas there was no pattern based on gender or age for water collection under 800 m.

In our in-depth interviews, both men and women identified water—either fetching it for their cows, or having to move their cows to water—as one of the greatest challenges they faced in maintaining dairy cows, especially in the dry season. For men and women, ensuring cows have water is a time investment, with women often discussing the trade-offs in what activities they prioritize to ensure their cows have water. As one woman farmer stated:

> Taking the cows to drink water is the main challenge because we just take them. At such a time sometimes you have other things to do but when the cows are just there you have to take them to drink first. And after they have drunk water you can't just leave the cows. You feed them slowly and then return them. That is hard. (HH 524 woman)

Another woman farmer described her day as follows:

> Generally, when I wake up early in the morning for my housework duties I take the cows for grazing, then proceed to do other farm work. After farm work I come back home to prepare lunch, then I go back to check on my cows. I change them to another location and also give them water for drinking. Then come back to finalize with lunch preparations and then we eat. Later on I prepare supper alongside other home related chores. (HH 639 woman)

Men expressed similar frustration over the distance to water sources, although they rarely offered a sense of what trade-offs they were making in terms of their time (i.e., they did not elaborate on what other chores or jobs they needed to attend to rather than fetching water). Thus, it is likely that having a crossbreed dairy cow increases time demands for both men and women; however, it is also likely that women feel competing demands on their time more acutely. From the individual surveys, we found that women have a higher work burden (24%) and lack of leisure time (18%) than men (8% work burden and 6% lack of leisure time). However, based on our field observations and individual survey data, men are disproportionately responsible for traveling farther away from the home (e.g., taking milk to the market). Here is an example of how one man farmer described the challenge of providing water:

> Another challenge is the source of water and it is a major challenge here on my farm because we have these other public boreholes but they are far. Bringing water to the farm from the borehole is quite a challenge, but right now I tried to dig an unprotected well that is serving me right now on my farm. I dug it and I only need some support to protect it and buy a pump that will pump this water up. So we still have a problem of water that we give to our cows, and the calves can risk [sic] and fall in that unprotected well. Otherwise, it is a reliable source of water because it doesn't dry up because it is forty feet and it is in a swamp. (HH 649 man)

Another man describes the way the water for cows takes priority over fetching water for household drinking, and the frustration of relying on boreholes as the primary water source, but the danger of relying on other sources of water in terms of potential harm to the cows. He said:

> In a day we fetch water twice in this household, the first water we fetch is for the cows then the second is for using at home. Where we fetch water if we are going to the borehole the distance is one and a half kilometer from here but there are very many people who get water from that borehole, so it takes time for you to access water. You have to line up and spend a lot of time in the line waiting for water and you end up getting little water which may not be enough for your cows, then when you go to the swamp, it is also a kilometer from here or one and a half kilometers, at the swamp, there is no lining up to get water but the only problem is that it has worms which affects the cows. (HH 475 man)

One issue that became apparent through our interviews is that although men and women experience providing water for cows as time consuming, women in woman-headed households disproportionately have to pay for water delivery and have to manage herdsmen to provide water for their cows. One woman farmer said:

> When I am personally present at the farm all the water will be fetched from the borehole; but when I am not there the herdsman gives them dirty water from the water holes. Personally I do not like that water because it is not good water. (HH 444 woman)

Another woman farmer said:

> That [water] is the first challenge. The other thing is the herdsmen. You cannot do everything yourself: milk, feed, water, spray and all these other things… because even at home there is work waiting for you. The herdsmen are expensive to maintain. (HH 412 woman)

One of our women interviewees also remarked on the communal aspect of sharing water resources. This relates to a larger literature that has focused on community sharing to ensure water security in African communities and the important role that women play in community water maintenance (Bauchspies 2012; Naiga et al. 2017). The farmer noted that in her village "there was no borehole, we would fetch the water from [a nearby village] like I have told you. The entire village was suffering, but when my son constructed this well, I decided to allow everyone from the village to fetch water from here. Isn't that a good thing?" (HH 446 woman).

Only one farmer spoke directly about the ways in which inserting crossbreeds into Ugandan production systems changes the labor demands, especially the demand for water; however, he did not acknowledge who in the household is impacted by these changes. He said:

> These milk cows give big quantities of milk but again the number of cows you keep and the way you keep them must change, because you must feed them well. But you find that when we get drought you find that we fail to get enough grass for these cows for them to give you enough milk. Then another thing, we had a problem of water, they were not getting enough water, yet our local cows can walk to go and look for water, but these ones must get everything there, you must just bring them everything in one place. (HH 454 man)

Water quality

Another common theme that emerged from the interviews was the issue of clean water for cattle. As alluded to in earlier quotes, many farmers expressed issues with having access to clean water for their cattle and most linked cows drinking dirty water with contributing to cattle falling sick. One man farmer elaborated on this point:

> The water we give to these cows is still a problem in this area because of the worms. We take our cows to the swamps to drink water, this water is not clean for these cows. Because of this you will find that the cows will need to be treated almost every month just because of the worms they get from drinking dirty water in the swamps. The alternative is usually the borehole, which we use during the dry season, but the borehole has many challenges: there are usually very many people who want water from that borehole, meaning you can't take your cows there when people need water. (HH 475 man)

One woman farmer explained that despite having a watering hole, her household still fetches the water and brings it to the animals; otherwise, she said, "[the cows] step in the water and they make it dirty. When the animals drink such dirty water they end up frequently becoming sick, meaning that you also have to keep de-worming them so that they do not fall sick" (HH 412 woman).

Our own basic water testing found that some boreholes had high levels of nitrates, as did a few wells (see **Figs. 3** and **4**). Sites 400 (see **Fig. 3**) and 500 (see **Fig. 4**) both had water sources with nitrate levels considered unsafe. Site 600 was not included because all water sources that were tested fell within the normal range. The number of boreholes, not simply unprotected water sources, which had higher than normal nitrate levels is concerning. As boreholes are generally considered "clean" water for human and animal consumption, nitrate levels > 10 mg/L are considered unsafe for daily consumption, especially for pregnant women and children.

Discussion and conclusion

Asset transfer programs have been embraced as a type of development programming that can increase household well-being and women's empowerment, and create a pathway out of poverty (Das et al. 2013; Rawlins et al. 2014; Jodlowski et al. 2016). However, the assets (in this instance crossbreed dairy cattle) are technological interventions situated in a technoscience landscape of material, social, and semiotic relationships. EADD programming specifically targets smallholders, including women. These smallholders must increase their inputs in terms of time, labor, and money (for veterinary drugs, herdsmen, etc.), but they must also wrestle with less malleable factors, notably their

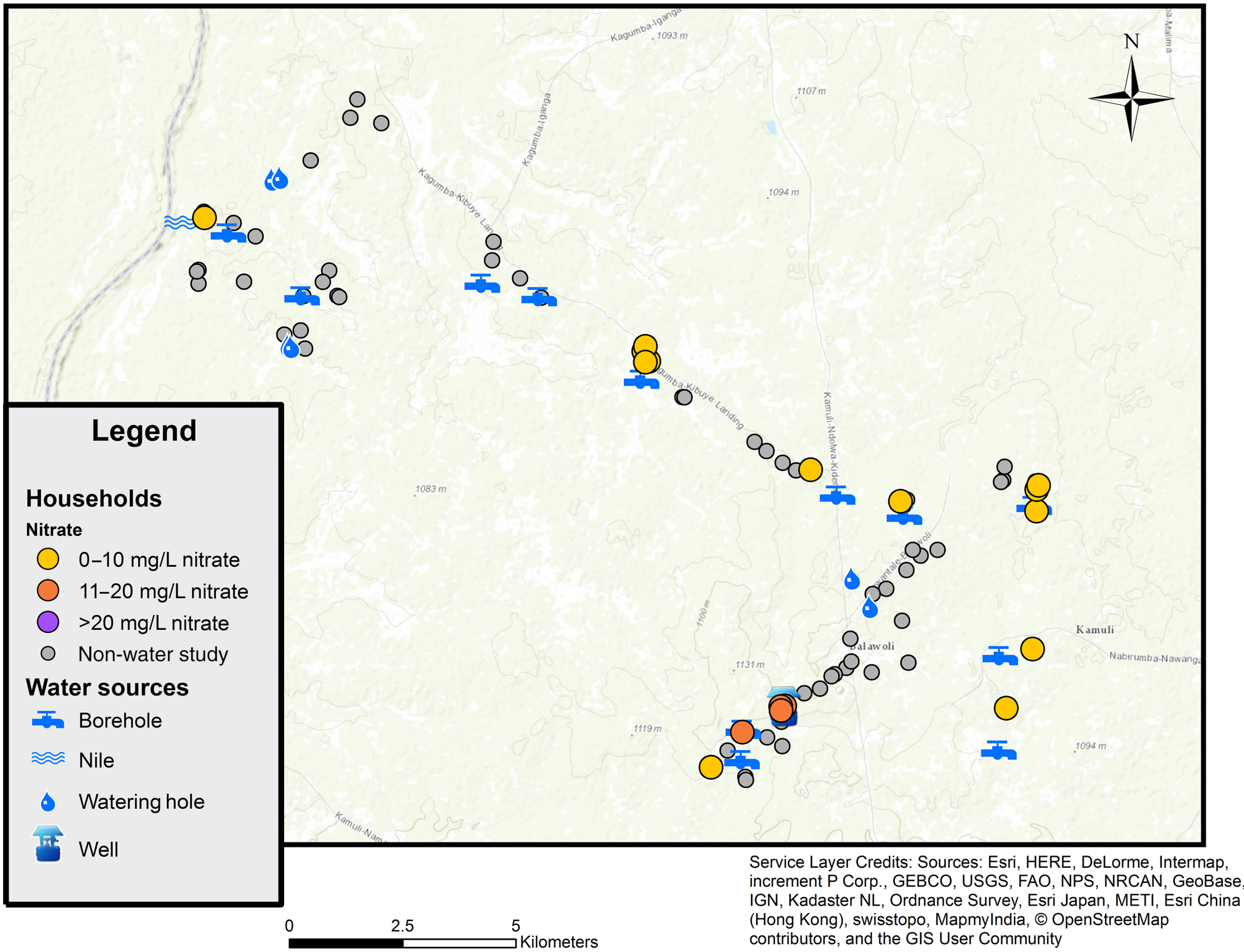

Fig. 3. Nitrate levels of water sources, East Africa Dairy Development 400s (site 1).

environment and the availability of water. Safe water continues to be a scarce resource for large portions of rural Ugandans (Afrobarometer 2015; Naiga et al. 2015, 2017). In this context, an asset transfer program has inserted a technology that is water intensive and requires safe water to ensure optimal performance into a space that is periodically water scarce and (or) lacking safe water. Moreover, where one's household and cattle are situated determines, in a non-random way, who has easier access to clean water for the maintenance of this technology. It is within this context that we set out to explore the gendered dimensions of water collection.

Similar to the results of previous studies, it is clear that having a crossbreed dairy cow increases the labor time of household members, for both men and women (Johnson et al. 2016). However, our results, as well as those of other studies (Bergman Lodin et al. 2012; Malapit et al. 2014; Bain et al. 2016), confirm that time poverty is gendered in Uganda. Women overwhelmingly report that they have too much work

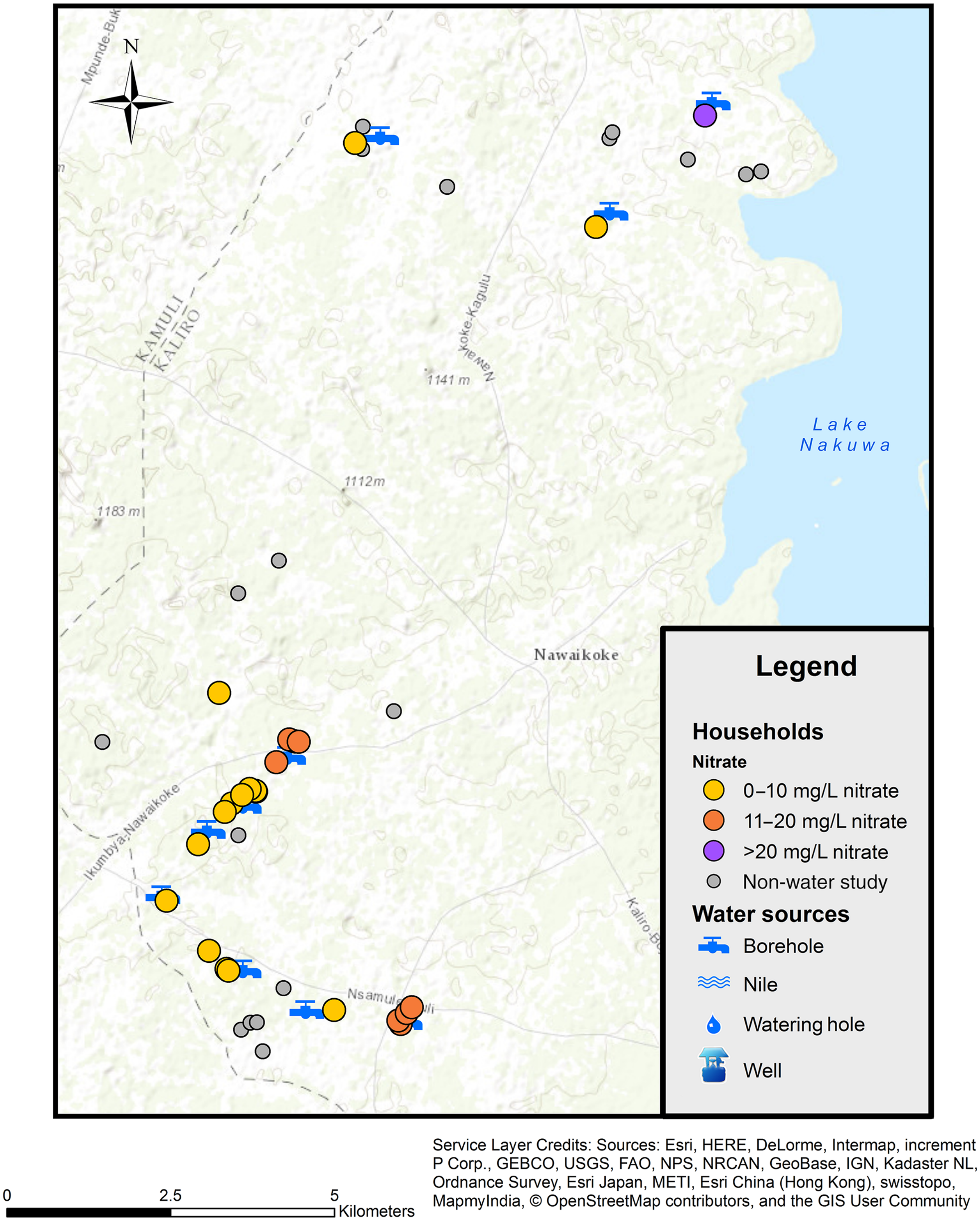

Fig. 4. Nitrate levels of water sources, East Africa Dairy Development 500s (site 2).

and not enough leisure. Thus, our study finds that the technological intervention of crossbreed dairy cows demands more labor from both men and women, but that the strain on women appears to be acute, in that they must make trade-offs in how they use their time to complete all the other tasks that already occupy their day.

The practice of raising crossbreed cows more intensively, as opposed to traditional dairy cows raised extensively in fields, seems on the surface to be beneficial for women in that women are much more likely to stay near the home. However, as the interview with one man farmer (HH 454) highlighted, this means all the inputs now need to come closer to the cow, which is clearly the case for water. Fetching water for the cow is time intensive, and for woman-headed households that have to pay someone to fetch water, it can be an added cost. Moreover, a lack of access to clean water, which especially occurs when boreholes are broken, can contribute to increase illnesses in the cows, which is an additional burden for households.

Our results support the existing literature regarding women and children providing the primary source of labor for dairy production in Uganda, including fetching water (Balikowa 2011). However, our results within the youngest age category (9 to 17 years old) contradict prior studies that suggest girls are the primary water fetchers (Asaba et al. 2013; Magala et al. 2015; Naiga et al. 2017). The issue of children and water collection is an area for further exploration. For example, we did not systematically collect data on how water is carried by children (e.g., using a bicycle versus carrying on one's head, etc.), but prior studies have suggested that boys are more likely to have access to and use a bicycle (Asaba et al. 2013). Thus, children's access to assets like bicycles might help explain gender differences among children in water collection, as well as distances traveled from the household. How children carry water also has health implications, with the use of a bicycle causing less bodily harm for hauling water than carrying water on one's head (see Asaba et al. 2013 for a discussion of health impacts such as headaches, chest pain, and nose bleeds). We also did not explore the gender and age dynamics that occur at boreholes, where long lines are common and tensions can run high, sometimes culminating in fights (Asaba et al. 2013). The two EADD communities we surveyed were new to the EADD program. Ideally, moving forward, the 2016 survey data will serve as a baseline for future studies evaluating the effectiveness of EADD programming relative to the non-EADD community, with particular emphasis on gendered outcomes.

Our research also suggests that water quality, not simply quantity, is a critical factor that needs to be considered in asset transfer development programming. There is an extensive literature that has focused on the issue of clean water for human consumption, but in the social sciences less attention has been given to thinking about clean water for animals, especially improved breeds that require more water than indigenous breeds. Existing literature has noted that illnesses caused by unsafe water sources tend to have gendered consequences, in that women are tasked with caring for the sick (Naiga et al. 2017). Our basic water testing suggests that some boreholes that are considered "safe" sources of water are potentially unsafe. Several boreholes had higher than recommended levels of nitrates, which can be detrimental for both human and animal health. Lower quality water that can cause humans, especially children, and dairy cows to be sick has the potential to negatively impact the overall goal of raising households out of poverty, increasing food security, and empowering women.

Drawing on science and technology studies, our results are important for better understanding that improved cattle breeds are always situated within diverse and complex social, environmental, and political spaces. Although many think improved agricultural technologies are vital for poverty reduction and improved food and nutritional security in a developing country like Uganda (Kabunga 2014), science and technology scholarship cautions against embracing a narrowly crafted narrative of technological progress, whether it be for the purposes of ensuring food security (Jiang 2017) or for providing safe water (Bauchspies 2012). If we frame food security and household nutrition as a strictly scientific concern, the dominant focus is limited to the scientific, displacing other equally important social, environmental, economic, and political domains (Yamaguchi 2016). In other words, so long as the problem is understood as a scientific and technical matter, then the ownership of this problem is given to the scientific experts (Yamaguchi 2016). Thus, understanding the complex systems within which crossbreed dairy cattle are situated provides individuals and development programming more flexibility in cultivating solutions.

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Author contributions

ER, CB, HB, and NS conceived and designed the study. ER, CB, HB, and NS performed the experiments/collected the data. ER, CB, HB, and NS analyzed and interpreted the data. ER, CB, HB, and NS contributed resources. ER, CB, HB, and NS drafted or revised the manuscript.

Competing interests

The authors have declared that no competing interests exist.

Data accessibility statement

All relevant data are within the paper.

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