Uganda, Data Brief

Irrigation on Smallholder Farms

A Columbia World Projects Initiative carried out by
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Irrigated Farm in Uganda

Quadracci SUSTAINABLE ENGINEERING LAB.

COLUMBIA UNIVERSITY IN THE CITY OF NEW YORK

COLUMBIA WORLD PROJECTS

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Executive Summary

Electricity access targets for ambitious programs such as M300 and ASCENT are summarized in household electrification numbers, but these programs are designed to unlock electricity's ability to drive socio-economic development. Of the 600 million people without access in Africa, most are rural, poor, and dependent on agriculture. Yet, there is an opportunity. Sub-Saharan Africa is home to a quarter of the arable land in the world but only 10% of agriculture production. Electricity can help unlock access to **irrigation** which can dramatically improve productivity of agriculture. Directing investments, agronomy and hydrology to where farmer-led irrigation clusters are found would ensure that these farmers have overcome other constraints of water and market access.

It is in this spirit that Columbia World Projects (CWP) launched the "Using Data to Catalyze Energy Investments" initiative in 2019 in Uganda. In addition to a focus on **Productive Uses of Energy (PUE)**, such as agro-processing businesses and cold storage facilities, we also studied **irrigation clusters**. Key objectives of this work are to help the government, private sector, and donors plan energy sector investments.

A related objective was to establish evidence of demand to inform electricity access planning. We should have a forthcoming brief on that soon. The irrigation effort benefited from consultations with key stakeholders within the Government of Uganda, principally the Ministry for Energy and Mineral Development (MEMD), and Ministries of Agriculture, Water and Environment and Local Governance- ensuring close alignment of activities with national goals.

An important aspect of the project was studying smallholder irrigation practices to support energy planning and electrification investments to enhance agricultural productivity. Smallholder farming is the primary livelihood for most households in rural Uganda, and improvements in this area could benefit millions. Currently, irrigation is rare, mostly manual, and relies on surface water or shallow wells. However, mechanized irrigation, such as using pumps, could increase water access, improve crop yields, enhance food security, and raise rural incomes.

This brief describes the component of the CWP 2022 survey effort focused on smallholder irrigation throughout rural Uganda, including the methodology used as well as key findings.[1] The survey covered over 13,000 sample areas (SAs) spanning all of Uganda's rural parishes and utilized advanced methodologies, including satellite imagery, machine learning, and geospatial

[1]See other CWP briefs on topics such as cost-effective data collection methods and rural businesses focused on Productive Uses of Energy (PUEs) here).

analysis. Two survey instruments, the Farmer Interviews and Plot Observations, yielded data related to irrigation.

Key insights from these surveys regarding the presence of smallholder irrigation and related practices are presented below.

- **Geographic extent of irrigation:** At least one irrigated plot was found in 70% of surveyed areas, with significant variations between regions.
- **Prevalence of manual irrigation:** The majority (85%) of farmers rely on labor-intensive, manual irrigation methods, using handheld containers for both water transport and distribution.
- **Irrigation focuses on cash crops:** Approximately 90% of irrigated crops are grown for sale, the main ones being tomatoes, cabbage, leafy greens, and eggplant.
- **Water sources for irrigation:** Farmers rely primarily (73%) on surface water and shallow wells for irrigation.
- **Regional differences:** Irrigation patterns differ between the drier and more sparsely populated portions of the country, particularly the North and Northeast, where irrigation is less common and irrigated plots tend to be smaller, compared with the wetter, more densely populated areas closer to Lake Victoria and in the East, where irrigation is more easily found and irrigated plots tend to be larger.
- **Size of irrigated plots:** Irrigated plots were found to be substantially smaller (20-40% in size) than non-irrigated plots.
- **Clusters of irrigating farmers:** Clusters of irrigating farmers (at least 3 plots within 100 m) could be found throughout the country.

Survey goals and approach

Survey program goals/objectives:

While a comprehensive national census of irrigating smallholder farmers is beyond the scope of this study, the survey's primary goal was to identify the presence of irrigation across rural Uganda and characterize its practices. The data provides insights for policymakers and other stakeholders to identify areas where irrigation has the potential to be mechanized and supported by electrification and represents significant loads to integrate into energy planning decisions.

In order to efficiently enumerate the entire rural landscape within the given budgetary and time constraints, surveying was targeted toward rural areas with human habitation and activity while excluding other areas (nature reserves, scrublands, large swamps, and unpopulated mountainous areas). To maximize coverage, the survey targeted rural areas with human activity,

excluding uninhabited regions. The process included:

- **Land Cover Analysis:** Using satellite imagery and machine learning, over 11.1 million hectares (ha) of cropland were identified, forming the basis for survey areas.
- **Sampling Strategy:** Ensured every rural parish was represented. Enumerators prioritized areas near water sources to maximize irrigation observations.

Land Cover Analysis:

This process involved two steps: First, a visual inspection of publicly available high-resolution satellite imagery was performed in 2020 to create a training dataset of observations of key land cover features such as buildings, farm plots, and forested areas. This training set was then employed for a land cover analysis using machine learning on a set of ~40-50 publicly available spatial data layers at 250 m resolution across Uganda. The results of the classification included identification of these features within each 250 x 250 m cell nationwide, including cropland, buildings, and woodlands, as well as mixtures of these land cover types. The results of the land classification can be seen in Figure 1. The areas of greatest interest for this project are those designated as “Cropland” (tan) and ‘Buildings and cropland” (darker brown). Other areas with a mix of cropland and other features are relevant and included in the rural survey, but cover only a small portion of Uganda’s total area.

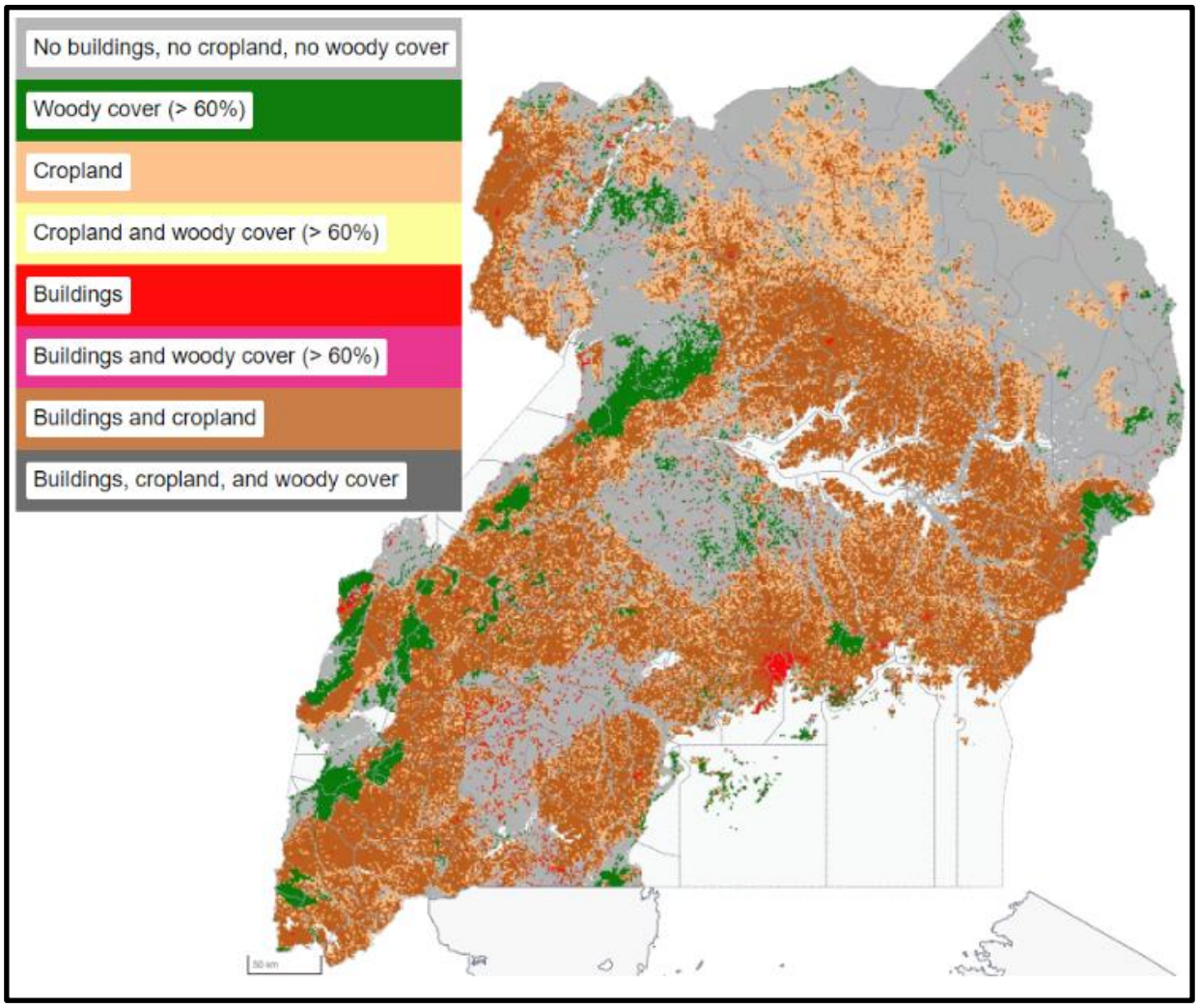

Figure 1. Land cover classification showing cropland and mixed-use areas across Uganda

This land cover classification determined that approximately 11.1 million ha of land throughout Uganda – out of a total land area of 20.4 million ha, or 24.1 million ha including water bodies – had at least some cropland present, though, it is critical to note, not necessarily 100% coverage with farm plots. For comparison, data from UBOS[2] states that an average of 5-7 million ha of land nationwide was cultivated nationwide between 2015 and 2021. This is roughly one-half of the 11.1 million ha (or 110,000 sq km) of land that the QSEL land cover analysis predicted to contain at least some cultivated land.

[2] UBOS, Area planted for selected Food Crops, 2015-2021(Ha) - Last Updated on 17th December 2023 (https://www.ubos.org/wp-content/uploads/statistics/Area_planted_for_selected_Food_Crops,_2015-2021(Ha).xlsx)

Sampling Strategy:

These 11.1 million hectares with cropland present became the focus of the two agricultural surveys. A total of 19,530 individual Sample Areas (SAs) of 2.5 km by 2.5 km (6.25 sq km each) were delineated within this 11.1 million ha to which enumerators may be sent to interview farmers (**Farm Plot Interview**) and to look for clusters of irrigated plots (**Plot Observation**). However, this number was reduced in two subsequent steps described below.

In parallel with spatial and geographic factors, there are political concerns integrated into the sampling program. Through ongoing discussions with MEMD, CWP learned of the importance that Uganda's national leadership has placed on the Parish Development Model, a national rural development effort focused on needs and priorities specifically at the level of the Parish. In response, the CWP national surveying effort was adapted in two ways: First, the protocol added an interview survey specifically addressed to a Parish leader to capture energy-related needs and development priorities for the Parish as a whole. Second, given the substantial differences in the sizes of parishes, the sampling plan was adapted to ensure more balanced coverage. SAs were distributed such that each rural parish included at least one SA (so no parish was missed) and a maximum of three SAs (so that larger, sparsely populated parishes were not over-sampled). To maximize the chances of finding irrigating farmers, in the 1,917 parishes large enough to contain more than 3 Sample Areas (SAs), the specific SAs selected were those nearest identifiable surface water sources (rivers or lakes).

After SAs were balanced across rural parish areas, and urbanized areas were filtered out, a final rural sampling plan was created that included 13,349 Sample Areas (SAs) of 2.5 x 2.5 km, out of the earlier 19,500 similar size cells with some cropland across the country. The result is shown in Figure 2. Figure 3 also shows the total number of SAs by District.

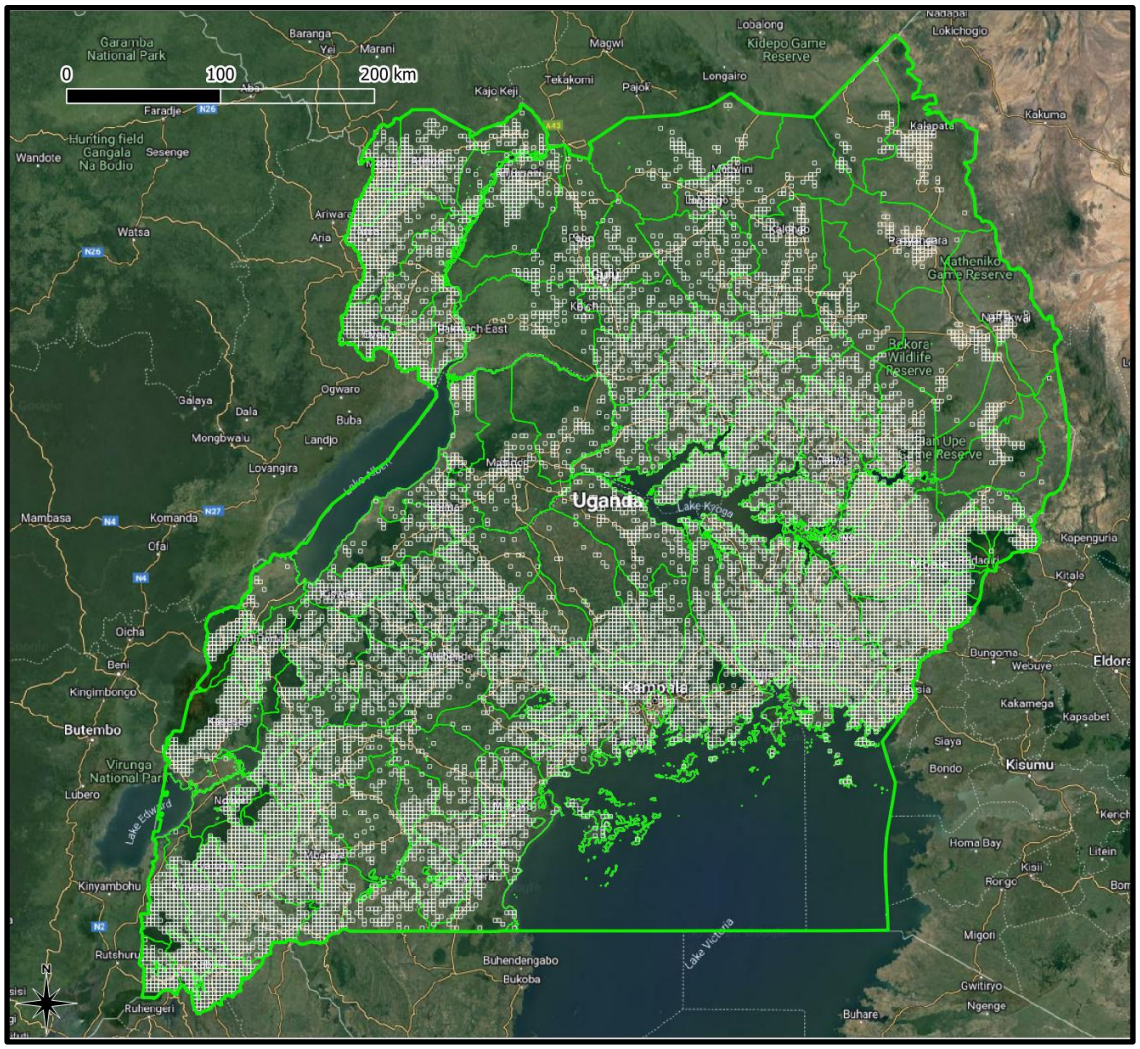

Figure 2. Rural Sample Areas (SAs) visited in national survey (13,349 areas of 2.5 x 2.5 km each)

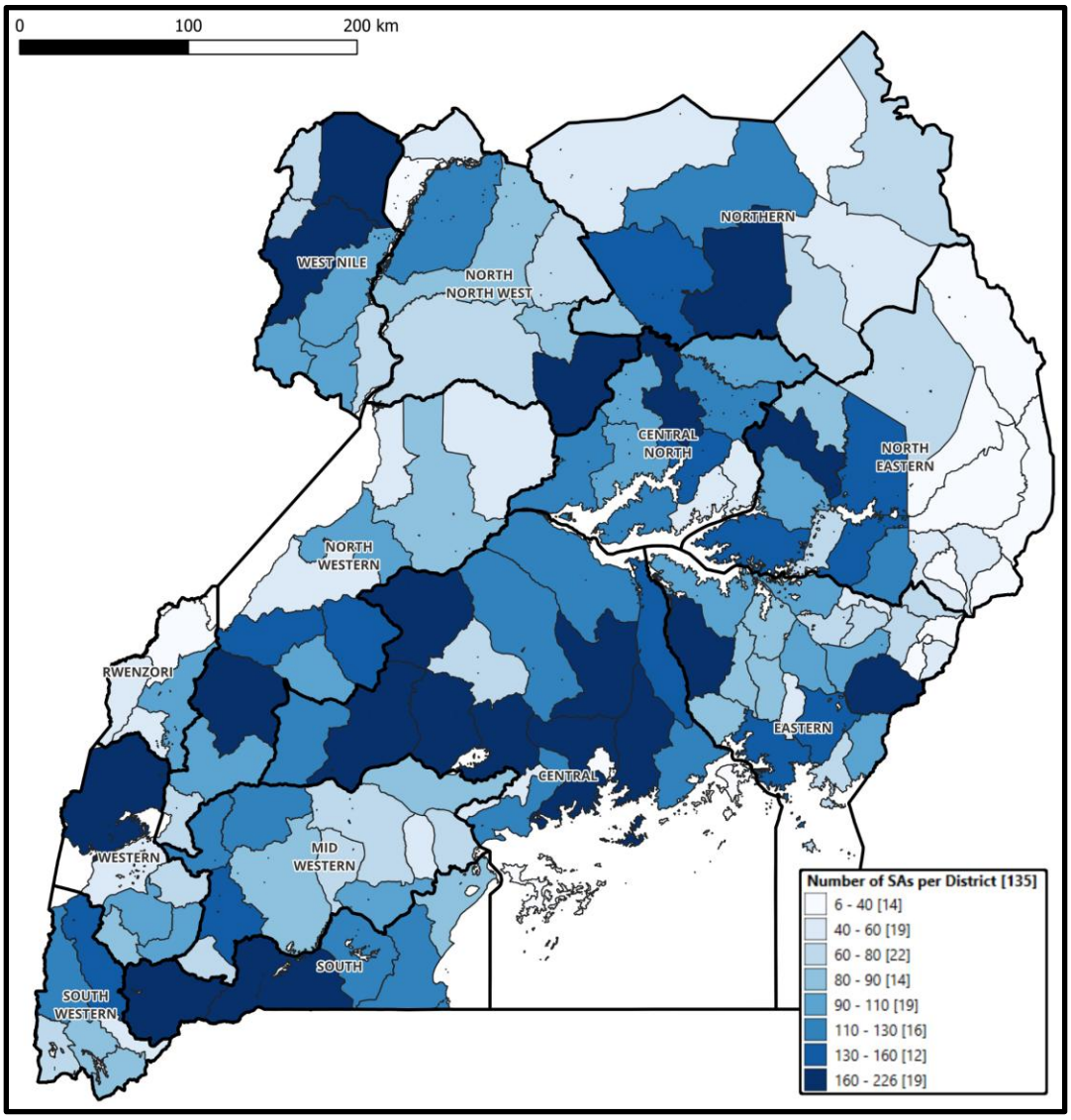

Figure 3. Number of Rural Sample Areas (SAs) visited in national survey by District

These sample areas (SAs) were the focus of the agricultural surveying efforts. Once arriving at a Sample Area, CWP Enumerators aimed to complete 2 types of surveys to determine the presence of irrigation and obtain characteristic information:

1. **Farmer Interview:** A detailed interview, including geolocation, with a farmer, preferably one that irrigated within the last year. If an irrigating farmer could not be found within the SA, CWP enumerators interviewed a farmer within the SA who did not irrigate.
2. **Plot Observations of Irrigation Clusters:** A brief description, with geolocation, of specific irrigated plots occurring as part of a cluster. For this survey, a "cluster" is defined as three

or more irrigated plots[3] within a 5-minute walk. If any clusters were reported by local informants, enumerators traveled to the area described and performed plot observations on all plots in the cluster up to a maximum of 8 plots per cluster. The enumerator then continued to ask about other clusters of irrigated plots, and repeated plot observations at each plot within the cluster. Plot observations were not conducted for non-irrigated plots.

It is important to note that this methodology was an effort to characterize smallholder farming practices throughout Uganda, with an emphasis on irrigation. It was not a census or a randomized sample to determine the percentage of smallholder farmers who irrigate, but rather an effort to show the geographic extent of irrigation and to characterize it where it could be found. The sampling program, covering over 13,000 sample areas, ensured that enumerators visited every parish throughout rural Uganda, then interviewed irrigating farmers and observed irrigated plots. Through these two survey types, enumerators captured the GPS location, plot size, crops grown, irrigation methods, water sources, power sources, and other characteristics to understand the irrigation practices in each SA. The following sections discuss the results of this data collection process.

Detailed Survey findings

Through a combination of Farmer Interviews and Plot Observations, CWP enumerators collected data for more than 37,000 individual irrigated and non-irrigated plots (see examples, Figure 4 below).

[3] For this survey, an "irrigated plot" was considered to be one that either was currently irrigated or had been irrigated within the past one year. To make this determination, enumerators used a combination of observational evidence (e.g. green crops among a predominantly dry surrounding landscape) or reports from local informants.

Figure 4. Examples of Irrigated Plots

Figure 5 shows data for the location of farmer interviews conducted throughout the survey's 13,349 Sample Areas (SA). The boundaries are for Uganda's 13 electricity service territories[4] while each colored pixel represents one SA. Areas where smallholder farmers who had irrigated in the past year could be found and interviewed by CWP enumerators are shown in green (9,292). For the remaining SAs (4,057, in red), CWP enumerators could not find and interview any irrigating farmer and instead interviewed non-irrigating farmers.[5]

[4] A map of Uganda's 13 electricity distribution service territories can be found on page 35 of the Uganda Electricity Connections Policy (MEMD) available for download from various sources, including the Uganda Electricity Regulatory Authority (ERA) website: www.era.go.ug/index.php/resource-centre/regulatory-instruments/policies/318-electricity-connections-policy/download

[5] In rare cases, an SA displayed in red included irrigated cropland but an interview with an irrigating farmer did not take place because the irrigation was conducted on a larger scale (e.g. sugarcane plantations rather than smallholder farming).

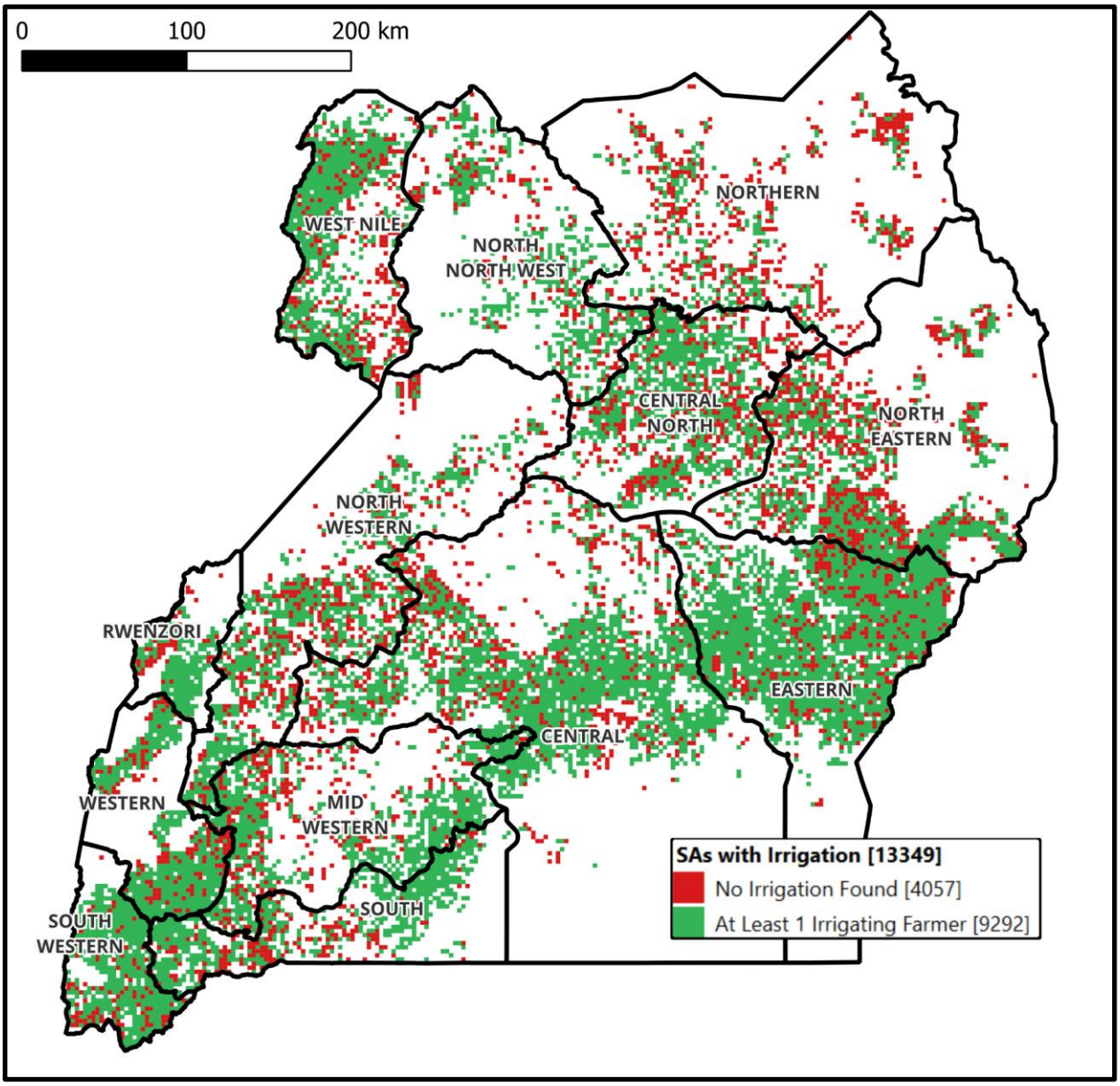

Figure 5. Sample Areas (SAs) Where Irrigating Farmers Were Found

As explained previously, these results do not indicate the frequency of irrigation among all farmers or farm plots, but rather the presence or absence of irrigation in a given area. The cells where irrigating farmers were interviewed show both that irrigation is more widespread throughout Uganda than may be generally assumed and that it does not appear to follow simple geographic patterns. This analysis indicates that, within all areas nationwide that include cropland, there is roughly a 70% chance that at least one irrigating smallholder farmer can be found in any given 2.5 x 2.5 km area.

Note that white areas were not surveyed either because the land cover analysis did not show evidence of cultivation or human settlement or because these areas were determined to be urban (towns and cities) and thus excluded from this rural survey effort.

The map below presents data for the presence of irrigation at the district level, specifically the percentage of SAs in each district for which CWP enumerators were able to interview an irrigating farmer. These results show that irrigation was more often found in more populous areas closest to Lake Victoria and in the Eastern region.

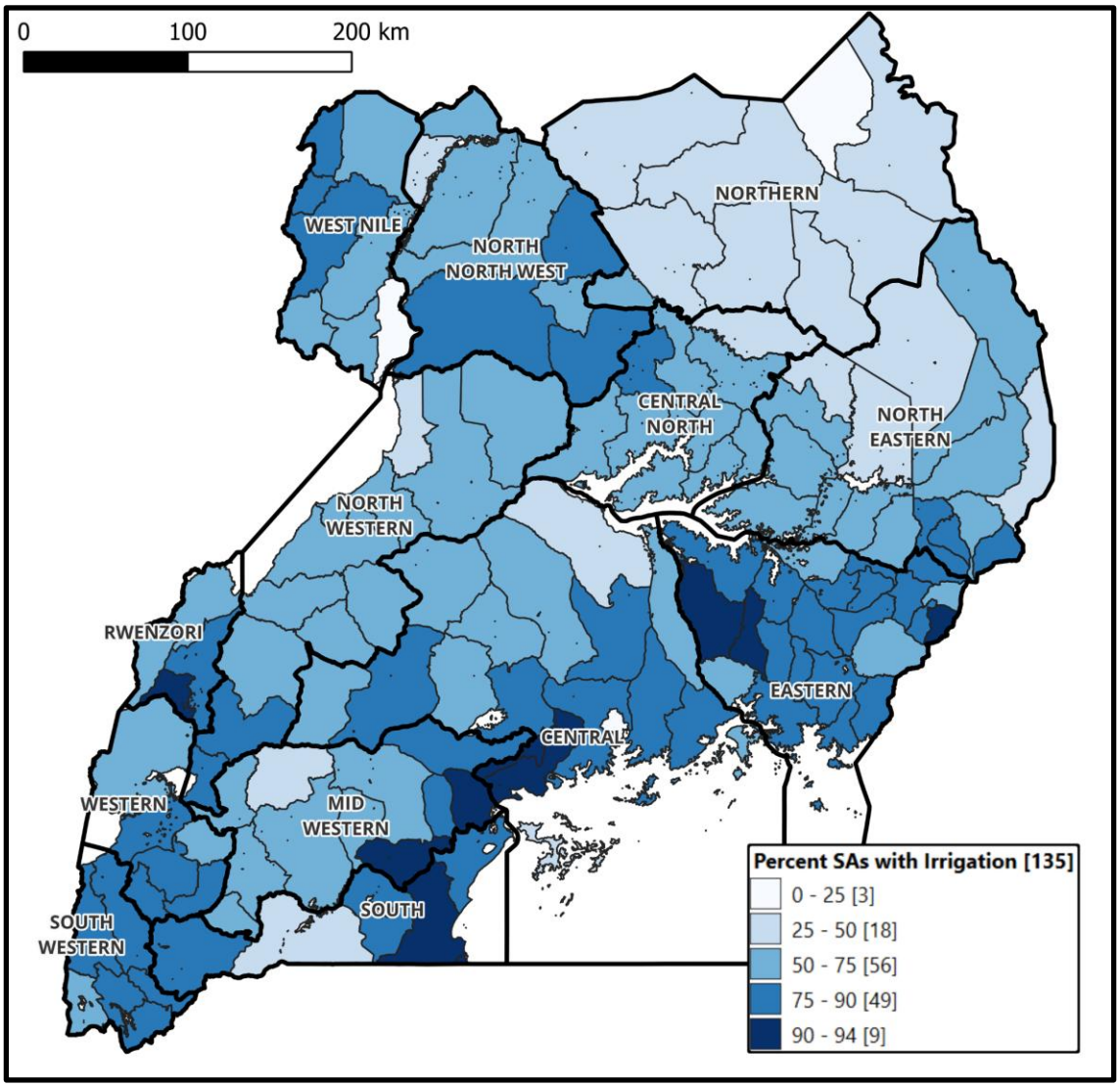

Figure 6. Percent of Sample Areas (SAs) visited in each District in which at least one irrigating farmer could be found

Farmer interviews captured which crops were most frequently grown by irrigating and non-irrigating farmers, as well as the intended use of the crop (i.e. sale vs. self-consumption).

Responses indicate that irrigation tends to focus on crops such as tomatoes, cabbage, leafy greens, and eggplant, most of which are grown for sale, while rainfed cultivation tends to focus on staple crops such as maize and cassava, which are both sold and consumed by the household. On the issue of sale vs. self-consumption, when asked "What is your PRIMARY intention for this crop?" farmers reported that roughly 90% of irrigated crops were intended for sale, whereas only about 50% of non-irrigated crops were intended for sale.

Details for the geographic patterns for specific crops are shown in the tables and maps below for each district and service territory. Figure 7 shows that, at the district level, the most common irrigated crop reported by smallholder farmers nationwide is tomatoes, and as seen in Figure 8, the second most common crops across districts are a combination of leafy greens and cabbage. The following table (Table 1) shows that cabbage, leafy greens, and eggplant are commonly grown as well.

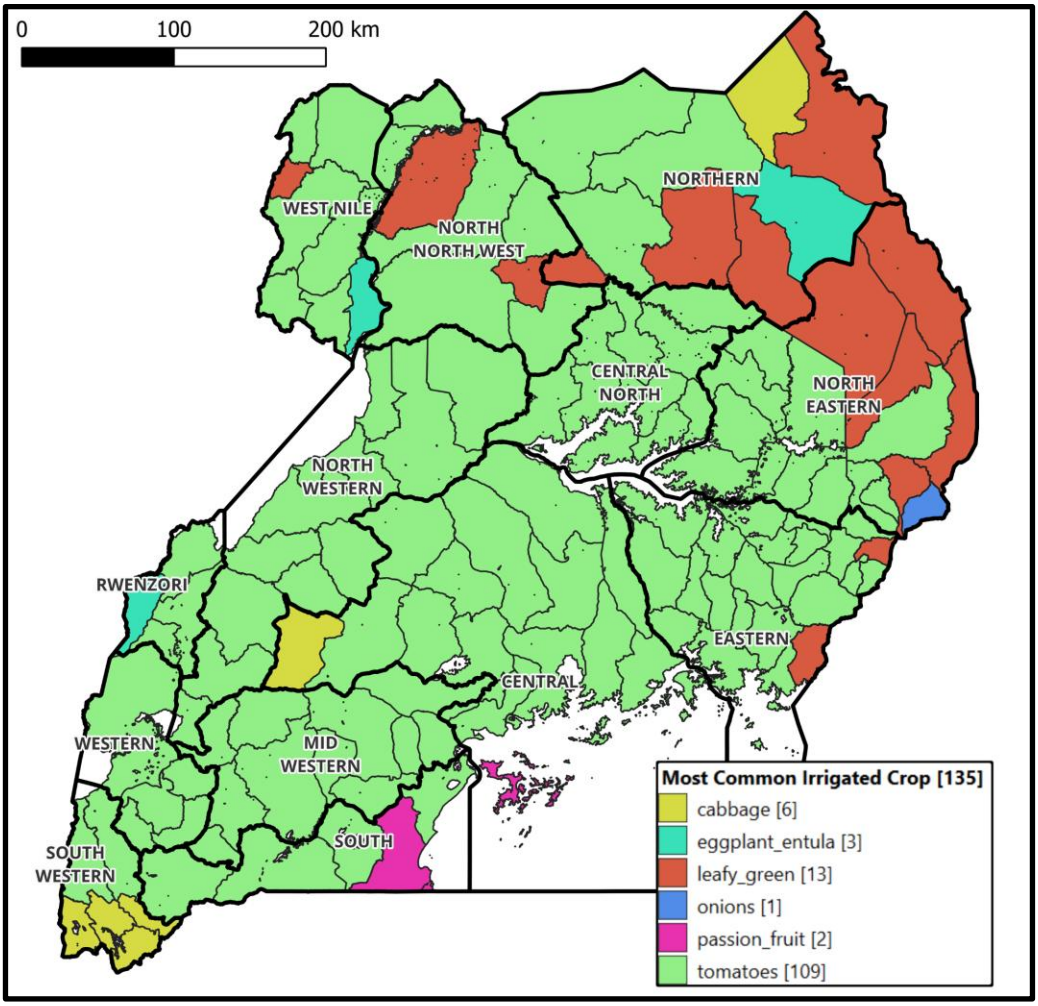

Figure 7. Most Common Irrigated Crop across 135 Districts

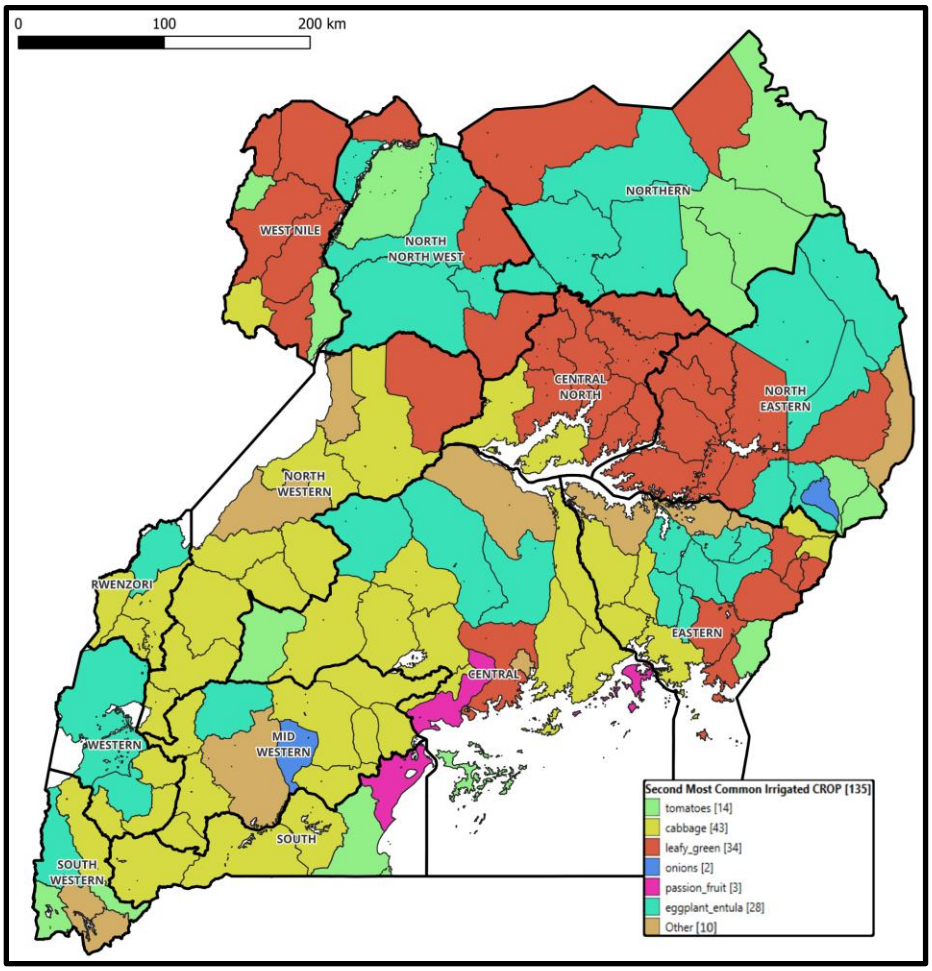

Figure 8. Second Most Common Irrigated Crop across 135 Districts

Service Territory	Total	beans	cabbage	eggplant entula	leafy green	maize	onions	passion fruit	peppers	potatoes	tomatoes	melons
CENTRAL	1708 (18%)	3%	14%	13%	5%	6%	1%	7%	4%	1%	42%	2%
CENTRAL NORTH	717 (7%)	1%	7%	9%	17%	3%	3%	0%	2%	1%	47%	3%
EASTERN	1711 (18%)	1%	10%	10%	13%	3%	0%	3%	2%	1%	47%	3%
MID WESTERN	686 (7%)	3%	17%	10%	1%	3%	3%	10%	4%	1%	41%	2%
NORTH EASTERN	774 (8%)	1%	4%	6%	21%	2%	6%	2%	1%	4%	46%	2%
NORTH NORTH WEST	494 (5%)	0%	7%	15%	24%	1%	2%	0%	1%	1%	36%	1%
NORTH WESTERN	740 (8%)	4%	19%	8%	3%	4%	2%	5%	1%	2%	45%	2%
NORTHERN	340 (4%)	1%	8%	18%	24%	6%	2%	0%	2%	1%	26%	1%
RWENZORI	183 (2%)	1%	22%	17%	2%	0%	2%	1%	6%	0%	43%	1%
SOUTH	602 (6%)	2%	20%	10%	1%	2%	2%	16%	6%	0%	35%	2%
SOUTH WESTERN	502 (5%)	2%	31%	11%	3%	2%	2%	3%	2%	6%	32%	1%
WEST NILE	664 (7%)	1%	8%	4%	30%	1%	4%	0%	4%	5%	40%	2%
WESTERN	443 (5%)	2%	19%	21%	7%	0%	2%	4%	0%	0%	43%	0%
TOTAL	9564 (100%)	171 (2%)	1251 (13%)	1044 (11%)	1072 (11%)	282 (3%)	196 (2%)	407 (4%)	231 (2%)	150 (2%)	3990 (42%)	187 (2%)

Table 1. Frequency of Irrigated Crops Reported by Service Territory.

(Due to the omission of rare crops (<=1%) percentages for crops across each row may not add to 100%)

For non-irrigated crops, Figure 9 shows maize and cassava to be roughly equally prominent throughout much of the country, while sorghum is important in the northeast, and plantains, beans, and potatoes are important in the southwest. Table 2 shows these patterns in more quantitative detail.

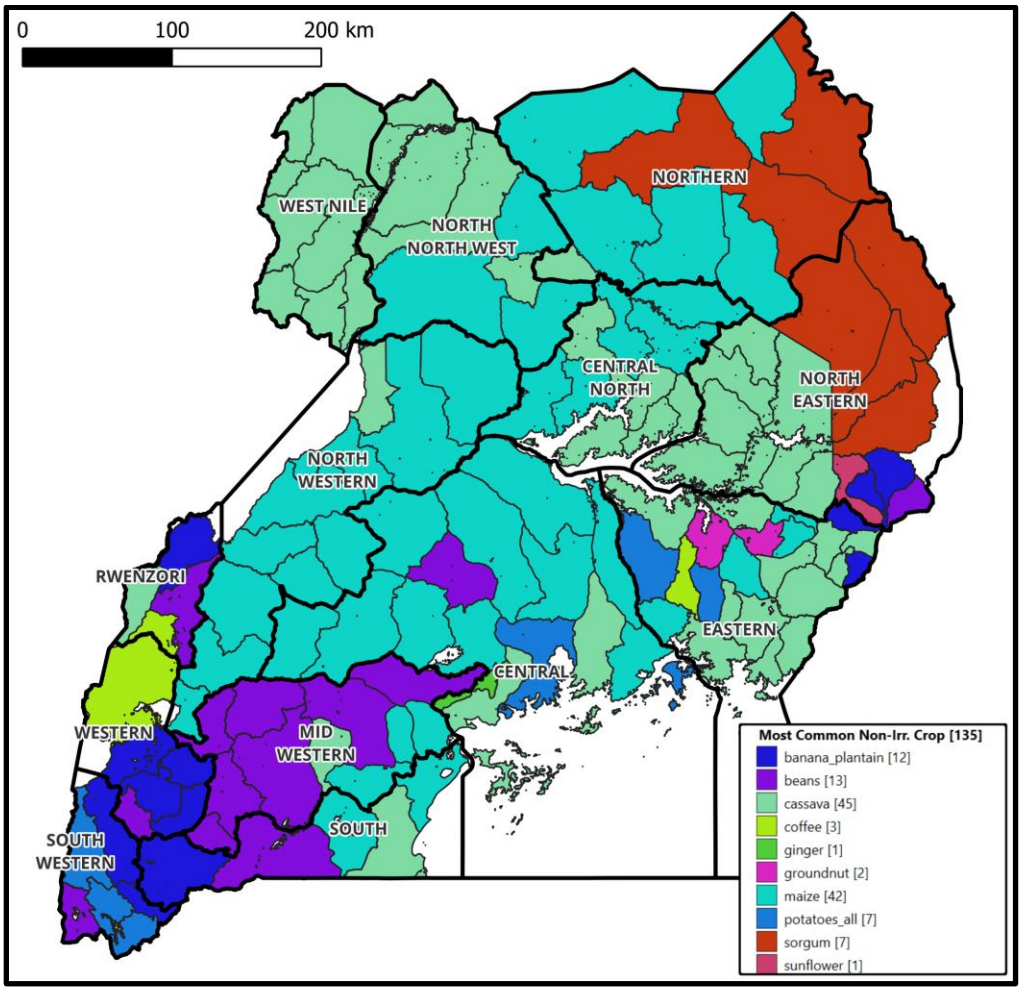

Figure 9. Most Common Non-Irrigated Crop across 135 Districts

Service Territory	Total	banana plantain	beans	cassava	coffee	ground nut	maize	potatoes	sorgum	sun flower	tomatoes
CENTRAL	495 (15%)	2%	17%	8%	2%	3%	46%	10%	0%	0%	2%
CENTRAL NORTH	301 (9%)	0%	1%	27%	0%	2%	31%	4%	7%	9%	2%
EASTERN	314 (9%)	4%	4%	38%	4%	10%	15%	8%	2%	1%	2%
MID WESTERN	231 (7%)	10%	45%	8%	6%	3%	16%	5%	0%	0%	2%
NORTH EASTERN	532 (16%)	1%	1%	67%	0%	1%	5%	4%	13%	2%	1%
NORTH NORTH WEST	149 (4%)	1%	1%	34%	0%	2%	17%	5%	11%	7%	1%
NORTH WESTERN	328 (10%)	5%	7%	14%	2%	2%	48%	9%	1%	0%	2%
NORTHERN	335 (10%)	0%	1%	11%	0%	4%	25%	1%	31%	9%	1%
RWENZORI	37 (1%)	8%	16%	30%	14%	0%	3%	8%	0%	0%	0%
SOUTH	164 (5%)	19%	40%	2%	1%	5%	15%	8%	1%	0%	1%
SOUTH WESTERN	90 (3%)	9%	14%	2%	4%	0%	9%	27%	4%	0%	3%
WEST NILE	270 (8%)	0%	3%	66%	0%	1%	8%	2%	8%	0%	1%
WESTERN	121 (4%)	21%	25%	8%	18%	3%	2%	6%	0%	1%	2%
TOTAL	3367 (100%)	137 (4%)	363 (11%)	958 (28%)	76 (2%)	100 (3%)	754 (22%)	212 (6%)	250 (7%)	85 (3%)	51 (2%)

Table 2. Frequency of Non-Irrigated Crops by Service Territory (<=1% Not Included in table)

(Due to the omission of rare crops (<=1%) percentages for crops in each row may not add to 100%)

The table below shows the median sizes of irrigated vs. non-irrigated plots visited during both farmer interviews and plot observations, by service territory. Irrigated plots tend to be far smaller than non-irrigated plots, 20-40% of the size, depending on how survey data are compared. This is likely because most smallholder irrigation is done manually using surface water (explored in the following section). It also suggests the potential for an increase in irrigated areas through mechanization of smallholder irrigation.

	Median Plot Sizes (sq m)		
Service Territory	**Non-Irrigated Plots** (Farmer Interviews, n = 3,664)	**Irrigated Plots** (Farmer Interviews, n = 10,120)	**Irrigated Plots** (Plot Observations, n = 23,967)
CENTRAL	1,200	800	420
CENTRAL NORTH	1,600	375	200
EASTERN	1,350	1,000	600
MID WESTERN	1,200	900	550
NORTH EASTERN	2,400	720	525
NORTH NORTH WEST	1,200	270	180
NORTH WESTERN	1,860	700	308
NORTHERN	1,500	375	200
RWENZORI	888	533	308
SOUTH	1,350	750	575
SOUTH WESTERN	450	375	160
WEST NILE	1,210	250	100
WESTERN	1,250	375	200
TOTAL	**1,500**	**600**	**350**

Table 3. Median area of irrigated & non-irrigated plots from Farmer Interviews & Plot Observations

The map below shows the median plot sizes of only the irrigated plots surveyed in the Farmer Interviews. The larger irrigated plots tend to occur in more southern districts, with the largest plots seen in districts some distance from the most densely populated areas around Lake Victoria.

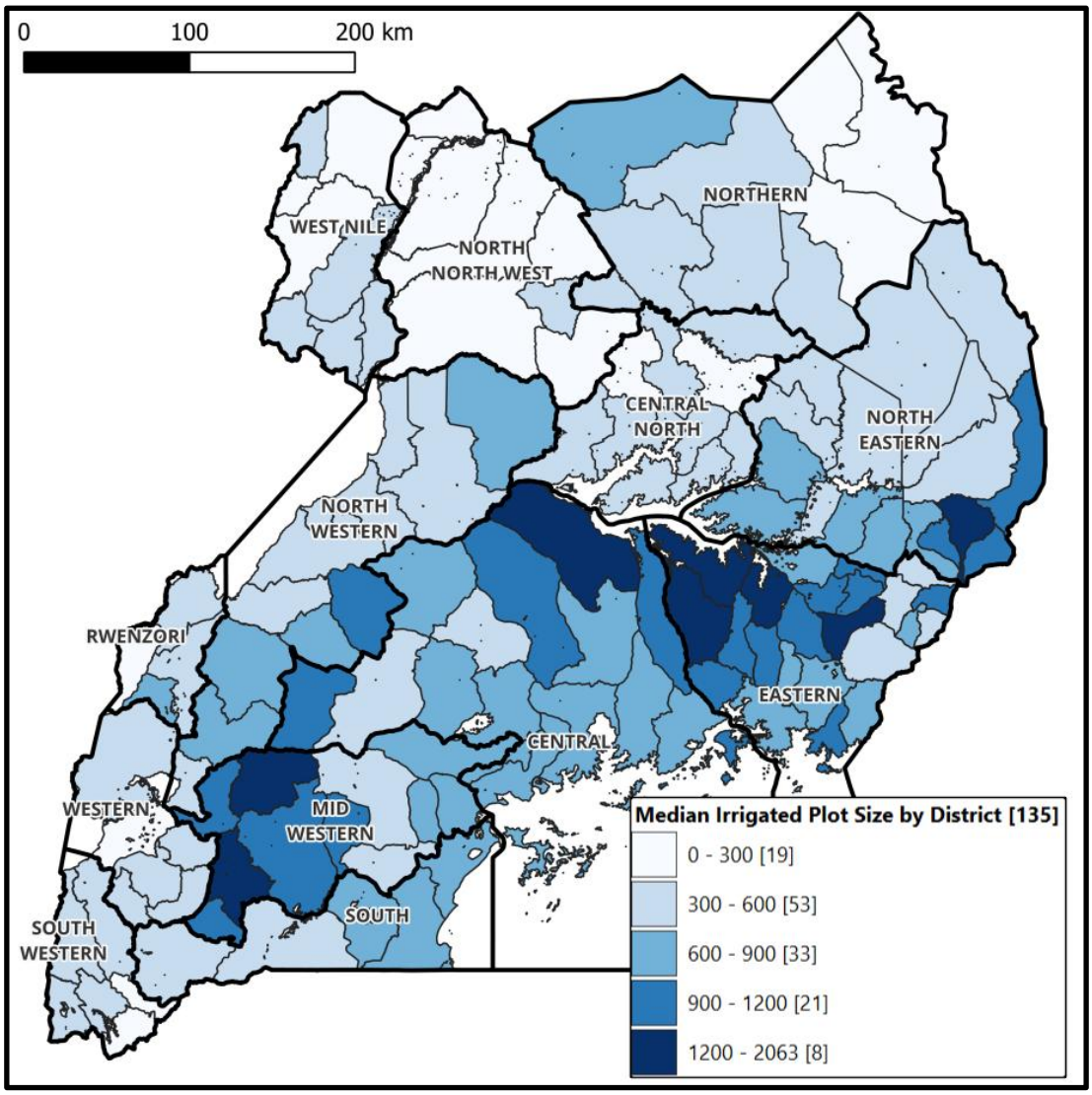

Figure 10. Median sizes of irrigated plots across 135 districts (from Farmer Interviews)

Power Sources and Modes of Irrigation

A potentially important path to increasing the productivity of irrigated farming is to shift from manual to mechanized irrigation. In addition, areas that already have some mechanized irrigation offer an indication of where further investment may be successful, since other key factors – markets for the sale of irrigated crops, and farmer know-how – may already be in place. For these reasons, it is critical to understand the patterns of use of different power sources to move or lift water to irrigate plots.

Figure 11. Examples of Manual Irrigation

Figure 12. Small-scale mechanized irrigation

The table below of power sources used for irrigation shows that the overwhelming majority (nearly 90%) of irrigation is done manually (with handheld containers such as watering cans). Most mechanized irrigation is done with fuel-powered pumps (9% of all irrigators), with only a very small fraction using solar pumps (1% of all irrigators). It is also important to note that gravity irrigation is rare in this dataset because rice cultivation, one of the main uses for gravity irrigation, was excluded from the survey.[6]

[6] Rice cultivation is both very common and requires such a large quantity of water that it is generally done in areas near rivers and streams, and so does not follow the irrigation practices that are the target of this study.

Service Territory	Total	grid	mini	fuel	gravity	manual	other	solar
CENTRAL	1,532 (17%)	0%	0%	15%	1%	83%	0%	1%
CENTRAL NORTH	665 (8%)	0%	0%	7%	3%	89%	0%	1%
EASTERN	1,571 (18%)	0%	0%	5%	2%	91%	0%	1%
MID WESTERN	635 (7%)	0%	0%	14%	2%	84%	0%	0%
NORTH EASTERN	725 (8%)	0%	0%	10%	10%	76%	0%	4%
NORTH NORTH WEST	477 (5%)	0%	0%	9%	3%	87%	0%	1%
NORTH WESTERN	664 (8%)	0%	0%	9%	2%	88%	0%	0%
NORTHERN	297 (3%)	0%	0%	6%	3%	89%	0%	2%
RWENZORI	179 (2%)	0%	0%	2%	0%	97%	0%	1%
SOUTH	567 (6%)	0%	0%	13%	1%	85%	0%	0%
SOUTH WESTERN	445 (5%)	0%	0%	2%	0%	98%	0%	0%
WEST NILE	648 (7%)	0%	0%	4%	1%	93%	0%	2%
WESTERN	416 (5%)	0%	0%	1%	3%	96%	0%	0%
TOTAL	8,821 (100%)	12 (0%)	4 (0%)	759 (9%)	211 (2%)	7,741 (88%)	1 (0%)	93 (1%)

Table 4. Irrigation Power Sources by Service Territory

(Values in each row and the "Total" column each add to 100%.)

The map below shows the spatial patterns for the fraction of farmers who reported using pumps. While the overwhelming majority of irrigation does not use pumps, the prevalence of mechanized pumping is highest (rising to about 20-35%) in the districts in the Southwest, near Lake Victoria, and small portions of the Eastern Province.

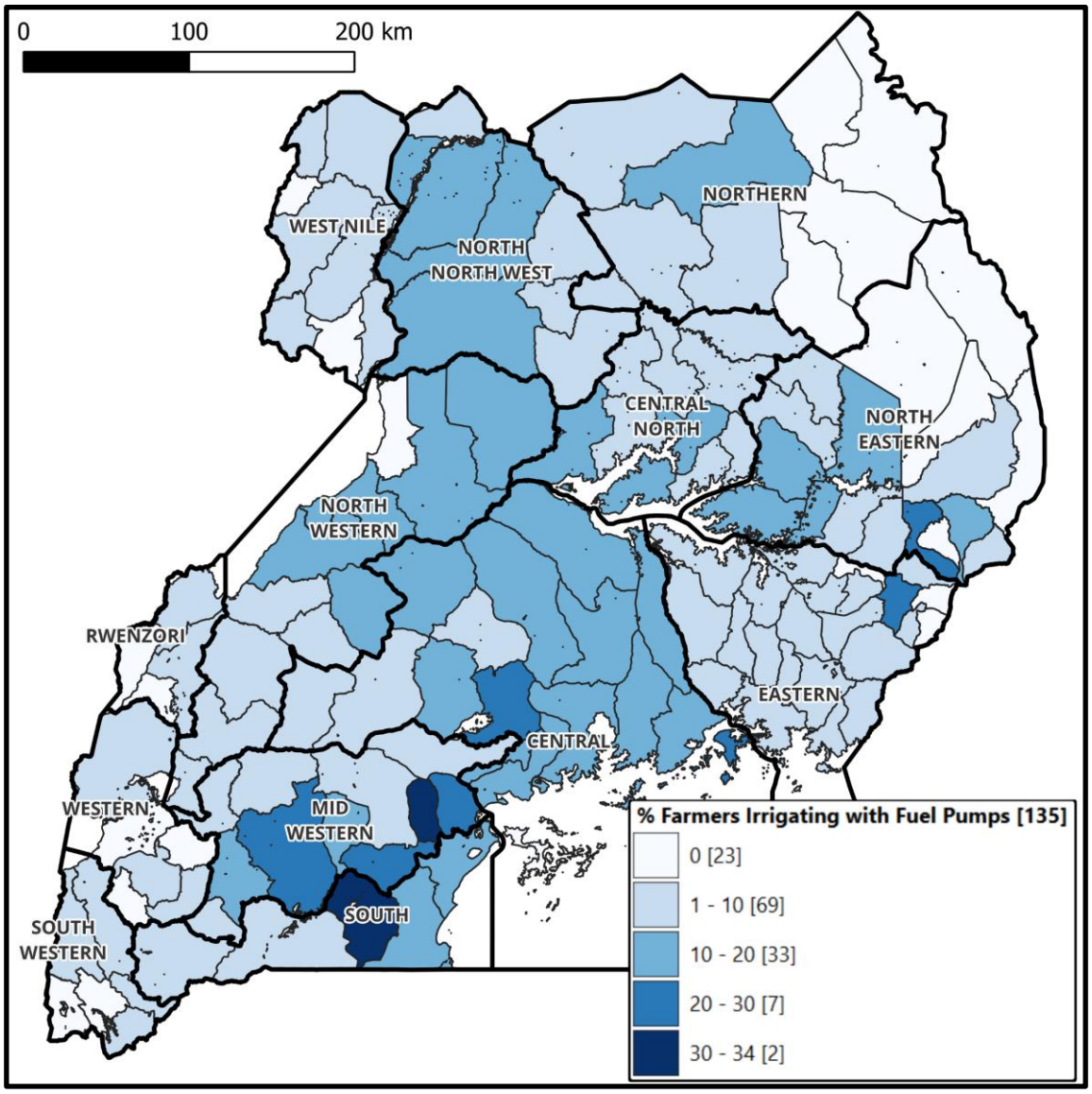

Figure 13. Percentage of Interviewed Irrigating Farmers Using Fuel Pumps by District

The tables below detail the equipment used for the transport of water from the source to the farm plot and distribution or dispersal throughout the plot area. The overwhelming fraction (85%) of farmers use manual methods with handheld containers for both water transport and distribution.

Service Territory	Total	handheld	motor	pipes	trenche	other
CENTRAL	1532 (17%)	80%	3%	16%	2%	0%
CENTRAL NORTH	665 (8%)	85%	1%	11%	3%	0%
EASTERN	1571 (18%)	90%	1%	7%	2%	0%
MID WESTERN	635 (7%)	81%	2%	16%	1%	0%
NORTH EASTERN	725 (8%)	72%	0%	22%	6%	0%
NORTH NORTH WEST	477 (5%)	83%	1%	12%	5%	0%
NORTH WESTERN	661 (7%)	86%	1%	11%	2%	0%
NORTHERN	297 (3%)	85%	0%	9%	6%	0%
RWENZORI	179 (2%)	94%	3%	3%	0%	0%
SOUTH	565 (6%)	82%	2%	15%	1%	0%
SOUTH WESTERN	443 (5%)	96%	0%	3%	0%	0%
WEST NILE	648 (7%)	88%	0%	7%	4%	0%
WESTERN	416 (5%)	92%	1%	4%	3%	0%
TOTAL	8814 (100%)	7468 (85%)	104 (1%)	999 (11%)	235 (3%)	8 (0%)

Table 5. Methods of water transport (from source to plot), by Service Territory

(Values in each row and the "Total" Column each add up to 100%.)

Service Territory	Total	drag hose	drip	furrows	handheld	sprinklers	water	other
CENTRAL	1727 (18%)	15%	0%	3%	79%	2%	1%	0%
CENTRAL NORTH	713 (8%)	9%	1%	3%	86%	1%	0%	0%
EASTERN	1620 (17%)	6%	1%	3%	89%	1%	0%	0%
MID WESTERN	678 (7%)	14%	1%	2%	82%	1%	0%	0%
NORTH EASTERN	758 (8%)	14%	2%	6%	72%	6%	0%	0%
NORTH NORTH WEST	506 (5%)	10%	0%	4%	84%	1%	1%	0%
NORTH WESTERN	700 (7%)	9%	1%	3%	86%	1%	0%	0%
NORTHERN	311 (3%)	7%	1%	3%	87%	2%	0%	0%
RWENZORI	179 (2%)	2%	0%	0%	97%	1%	0%	0%
SOUTH	613 (7%)	14%	0%	1%	83%	1%	0%	0%
SOUTH WESTERN	447 (5%)	2%	0%	0%	96%	1%	0%	0%
WEST NILE	664 (7%)	5%	1%	2%	91%	1%	0%	0%
WESTERN	426 (5%)	3%	1%	3%	93%	1%	0%	0%
TOTAL	9342 (100%)	887 (9%)	67 (1%)	260 (3%)	7935 (85%)	142 (2%)	33 (0%)	18 (0%)

Table 6. Methods of water distribution (around/within a plot), by Service Territory

(Values in each row and the "Total" Column each add up to 100%.)

Water Sources

Figure 14: Examples of surface water sources and canals used for irrigation

The following tables show the types of water sources and the distance of those sources from farms. A strong majority (73%) of irrigators used surface water for irrigation. A small but significant portion of irrigators use shallow wells (11%) and boreholes (9%), while a small number use water from a tap or pipe (5%). The most frequently used water sources by district are shown in Figures 15 and 16.

Service Territory	total	borehole	harvested water	shallow well	surface water	tank	tap piped water	trucked water	other
CENTRAL	1532 (17%)	7%	3%	7%	79%	0%	4%	1%	0%
CENTRAL NORTH	665 (8%)	11%	0%	24%	63%	0%	1%	0%	0%
EASTERN	1571 (18%)	15%	0%	6%	75%	0%	3%	0%	0%
MID WESTERN	635 (7%)	3%	2%	15%	70%	0%	9%	0%	0%
NORTH EASTERN	725 (8%)	16%	1%	22%	56%	0%	4%	0%	0%
NORTH NORTH WEST	477 (5%)	8%	0%	15%	75%	0%	2%	0%	0%
NORTH WESTERN	664 (8%)	5%	0%	12%	77%	0%	6%	0%	0%
NORTHERN	297 (3%)	25%	0%	5%	66%	0%	3%	0%	0%
RWENZORI	179 (2%)	4%	0%	1%	75%	0%	20%	0%	0%
SOUTH	567 (6%)	5%	4%	4%	81%	0%	6%	1%	0%
SOUTH WESTERN	445 (5%)	0%	7%	2%	80%	0%	11%	0%	0%
WEST NILE	648 (7%)	3%	0%	19%	76%	0%	3%	0%	0%
WESTERN	416 (5%)	1%	1%	3%	76%	0%	19%	0%	0%
TOTAL	8821 (100%)	762 (9%)	127 (1%)	950 (11%)	6481 (73%)	1 (0%)	468 (5%)	23 (0%)	9 (0%)

Table 7. Water Sources for Irrigation

(Values in each row and the "Total" Column each add up to 100%.)

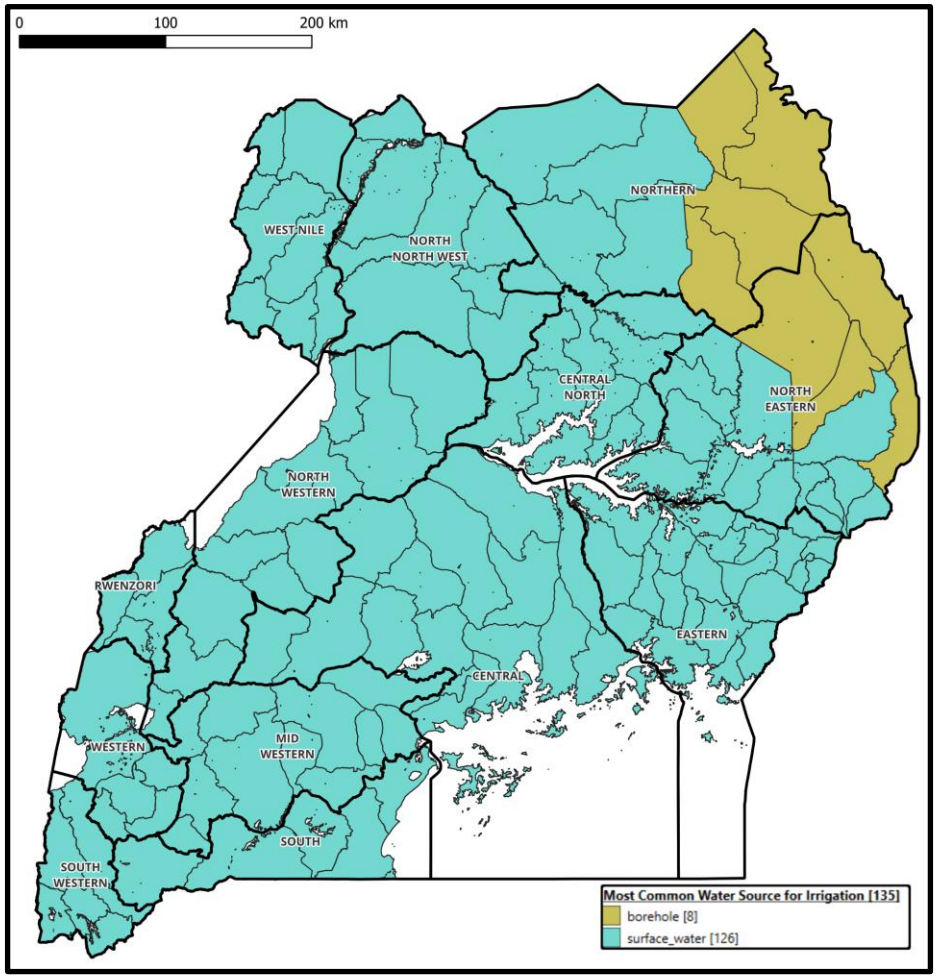

Figure 15. Most Common Water Source for Irrigation by District

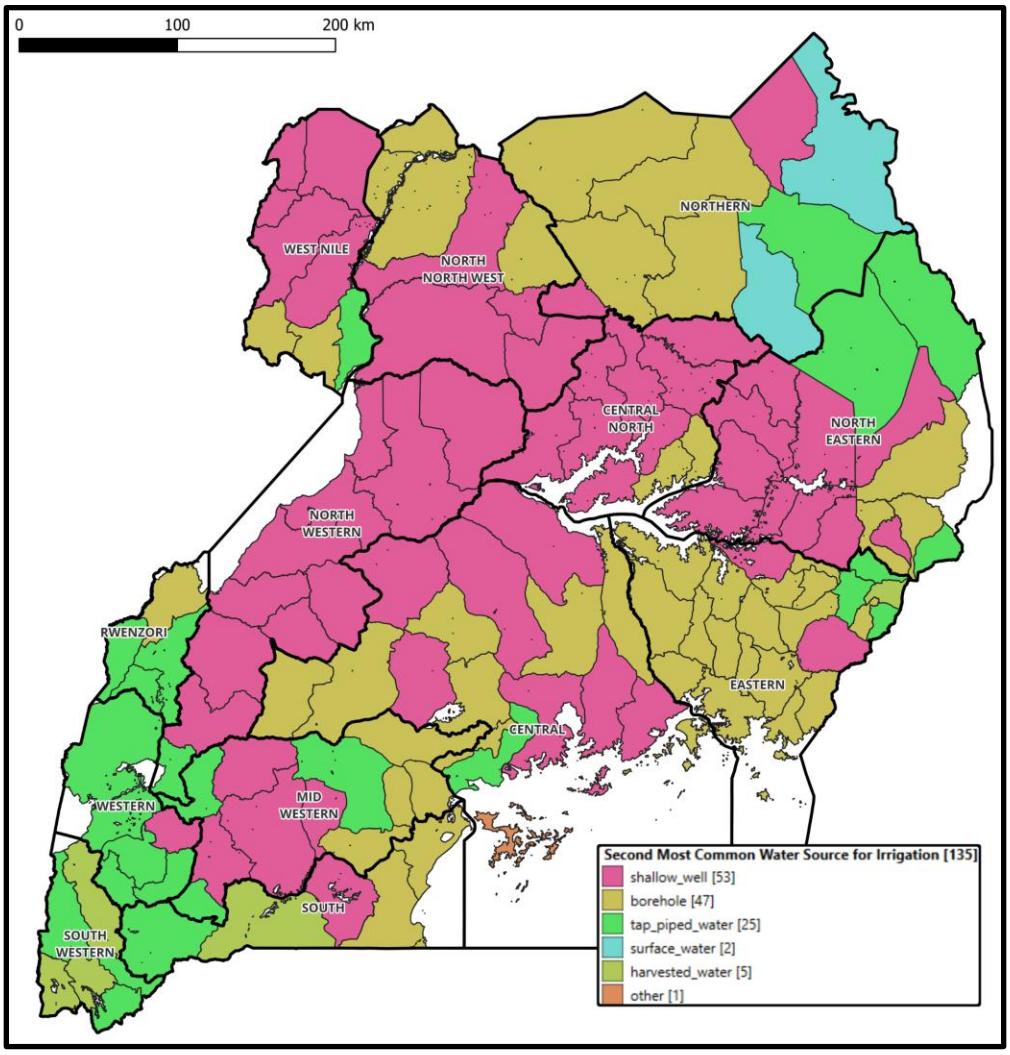

Figure 16. Second Most Common Water Source for Irrigation by District

As seen in the above figures, surface water irrigation is most common, except for the drier northeastern part of the country. These patterns are shown more clearly in the maps in Figures 17-19, which shows the high prevalence of surface water irrigation across most districts, with the exception of the drier parts of the country in the northeast, where boreholes are more prevalent.

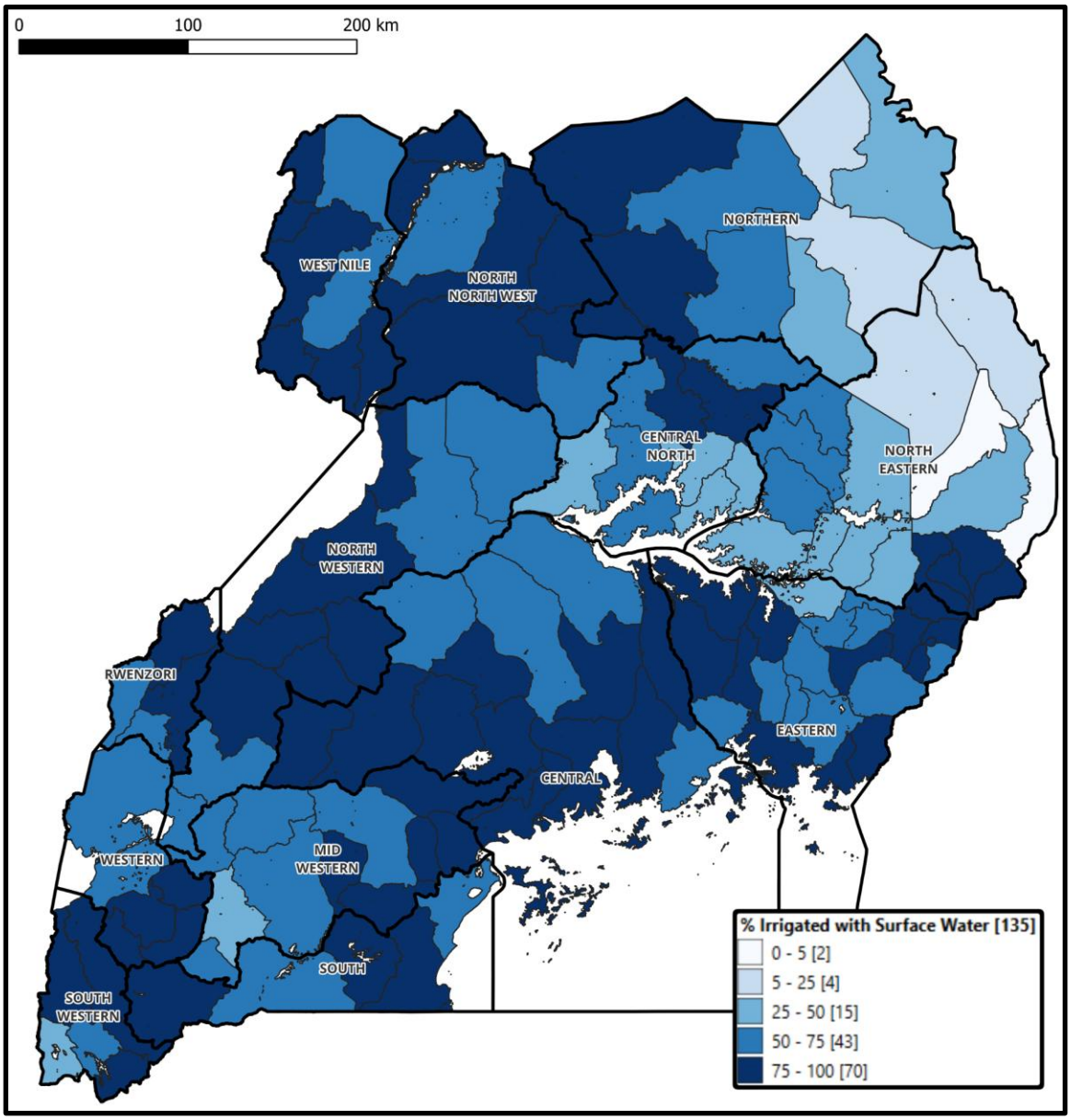

Figure 17. % Farmers Using Surface Water For Irrigation by District

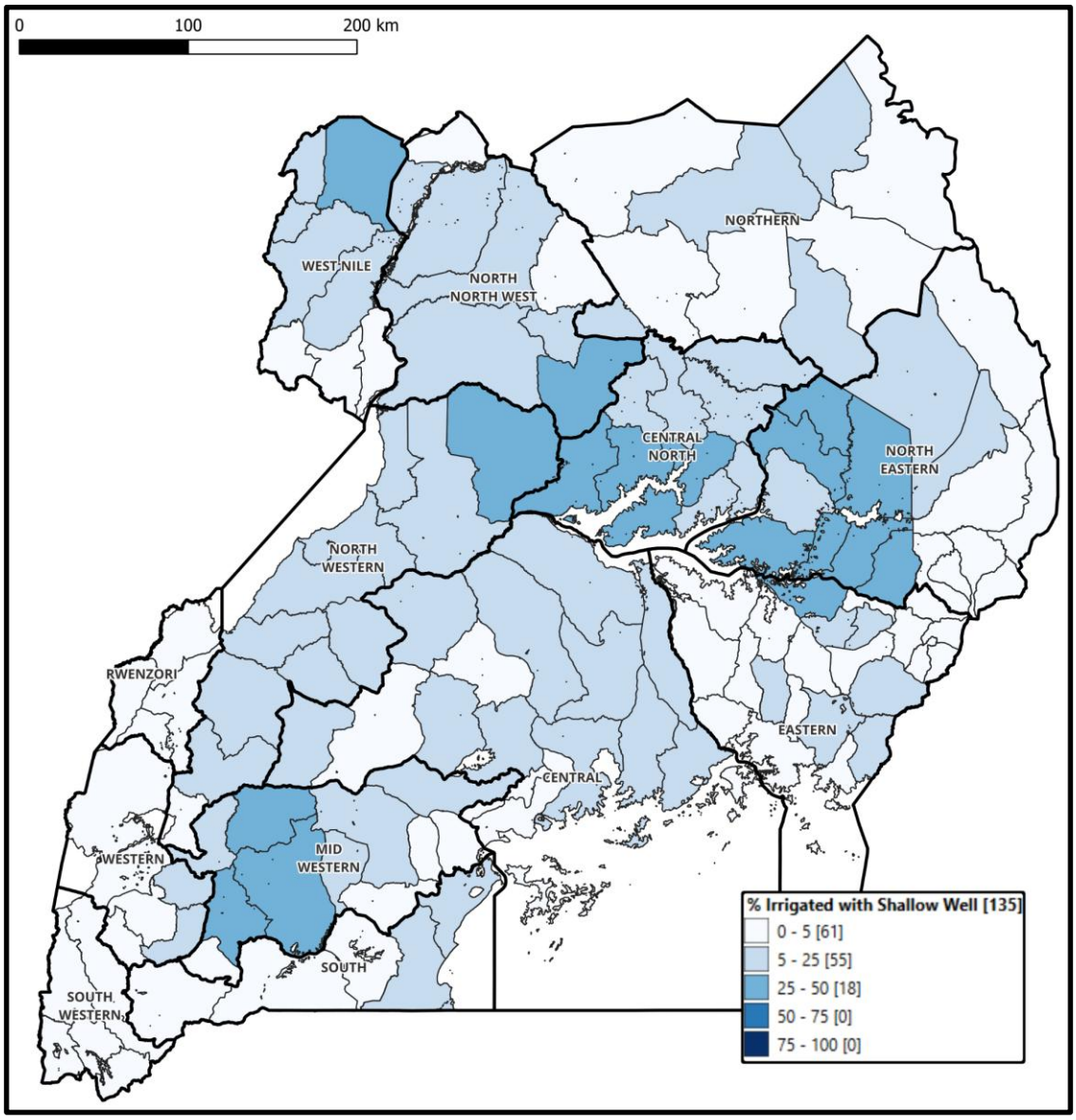

Figure 18. % Farmers Using Shallow Wells For Irrigation by District

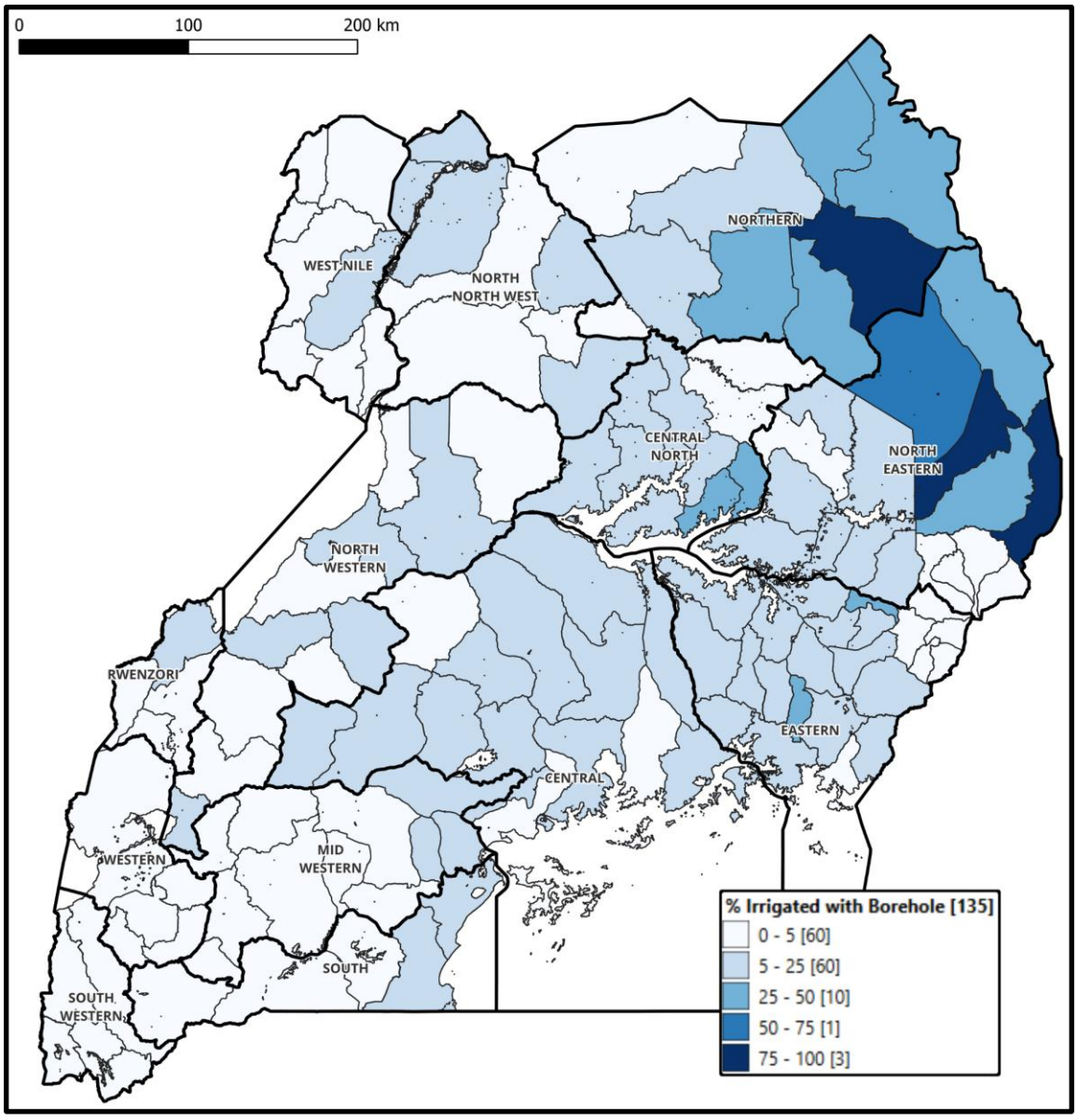

Figure 19. % Farmers Using Boreholes For Irrigation by District

Service Territory	Total	0m (on farm)	within 100m	100m to 250m	250m to 500m	more than 500m
CENTRAL	1,532 (17%)	40%	25%	18%	12%	5%
CENTRAL NORTH	665 (8%)	41%	29%	14%	7%	8%
EASTERN	1,571 (18%)	42%	32%	15%	5%	5%
MID WESTERN	635 (7%)	37%	26%	14%	12%	11%
NORTH EASTERN	725 (8%)	40%	26%	15%	9%	9%
NORTH NORTH WEST	477 (5%)	51%	26%	14%	5%	4%
NORTH WESTERN	664 (8%)	46%	28%	14%	6%	6%
NORTHERN	297 (3%)	34%	35%	17%	6%	8%
RWENZORI	179 (2%)	29%	31%	19%	17%	4%
SOUTH	567 (6%)	35%	25%	16%	15%	9%
SOUTH WESTERN	445 (5%)	28%	40%	19%	11%	3%
WEST NILE	648 (7%)	62%	24%	8%	3%	2%
WESTERN	416 (5%)	31%	35%	19%	9%	6%
TOTAL	8,821 (100%)	3,641 (41%)	2,519 (29%)	1,354 (15%)	770 (9%)	537 (6%)

Table 8. Distance From Farm of Water Source for Irrigation

(Values in each row and the "Total" Column each add up to 100%.)

As seen in Table 8, the water sources used by smallholder farmers tended to be quite close to the farm plots. Most (70%) were either on their farm (41%) or within 100m (an additional 29%).

Clustering

An additional consideration for energy demand planning is the identification of clusters of irrigated plots since the aggregated irrigation needs of multiple plots can present cost-effective opportunities for investment in energy systems, pumps, and other labor-saving equipment that may not be viable for smaller areas. For this analysis, a cluster was defined as a group of at least irrigated 3 plots within 100m of each other. With this definition, we see 4,154 clusters of irrigators found across the country. These are shown in the map below with the point color corresponding to the number of plots that were included in each cluster. There is a noteworthy concentration of clusters with a larger number of irrigated plots (>5 plots) in the Central North and North Northwest Service Territories, near the cities of Lira and Gulu.

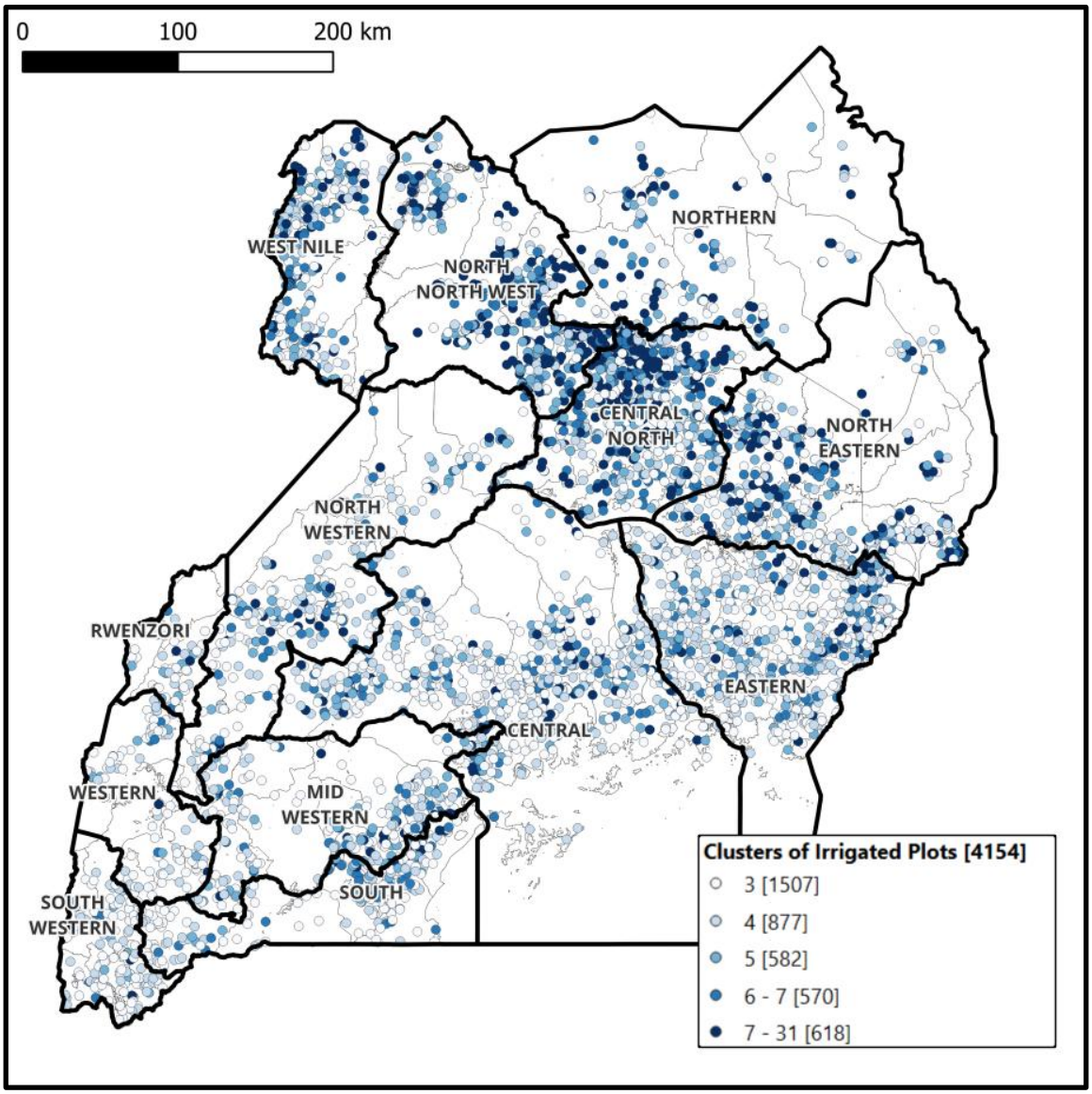

Figure 20. Clusters of irrigated plots across 135 districts

Considering the total size of these clusters, Figure 21 below shows a histogram with counts of clusters by total aggregated areas for constituent plots. The overwhelming majority of these plot clusters (3,242 of 4,154, or 78%) represent a total area of less than 0.5 ha. (5,000 m^2). This leaves around 22% (913 clusters) that have a total area greater than 0.5 ha., about 400 of which are greater than 1 ha.

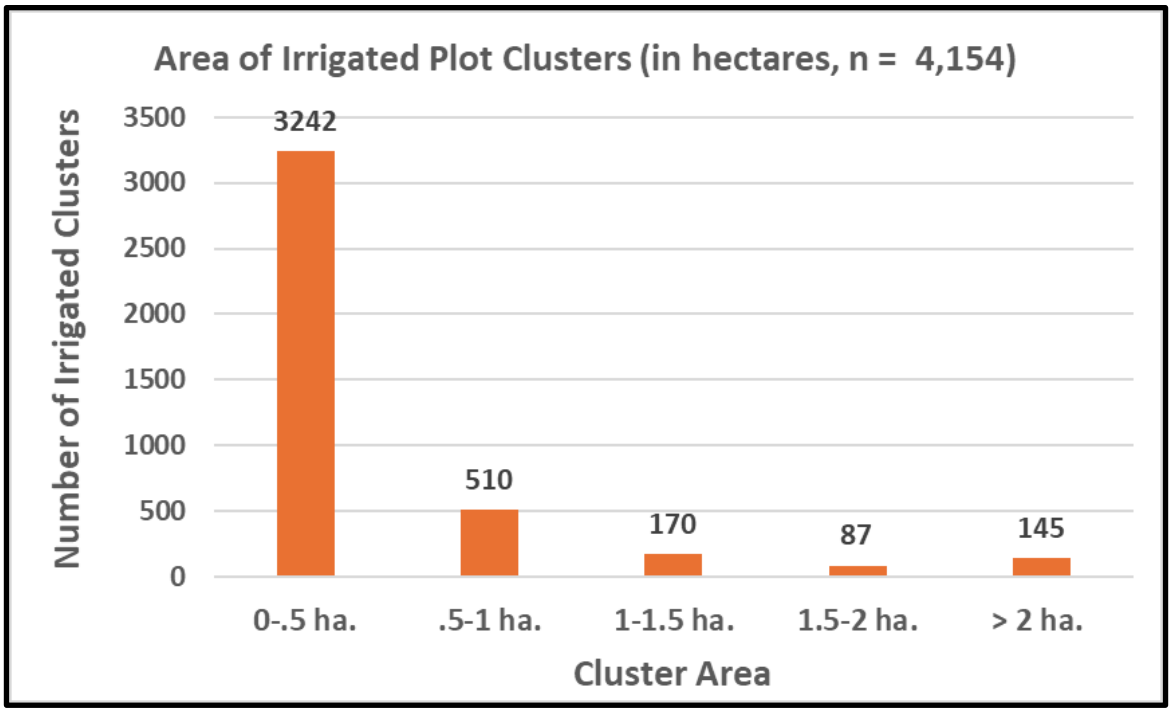

Figure 21. Irrigated plot cluster sizes across 135 districts

With the majority of these clusters being of smaller areas, there may be potential for the introduction of mechanization at various sizes ranging from solutions that focus on small solar pumps for individual farmers, to larger shared solutions that provide access to mechanization to multiple farmers that make up a cluster. These clusters could represent significant energy demands and should be considered when planning for electrification.

Conclusion

While CWP did not attempt a full census of existing irrigation across the country, the presence of irrigation was found to be widespread, occurring in 70% of Sample Areas surveyed throughout rural Uganda. Most irrigation currently depends on manual methods, drawing from surface water and shallow wells. Smallholder farmers primarily cultivate cash crops for sale. Clusters of irrigated crops often aggregate to less than 0.5 hectares, underscoring the need for scalable solutions.

To unlock the full potential of smallholder farming, investment in energy infrastructure is essential. Mechanized irrigation powered by sustainable energy can reduce labor and costs, enabling farmers to expand irrigated areas, grow more crops per year, and significantly boost their incomes. When integrated into energy and electrification planning, these clusters can serve as vital demand hubs alongside other productive uses like grinding mills.

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- Uganda Ministry of Water and Environment (MWE)
- Uganda Ministry of Local Government (MOLG)
- Uganda Electricity Distribution Company Limited (UEDCL)
- UMEME (https://www.umeme.co.ug/)
- Uganda Energy Credit Capitalisation Company (UECCC)

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