Investment Report for a Mini-Grid Pilot Program at Agriculture Commercial Clusters in Ethiopia

Veritas Consulting

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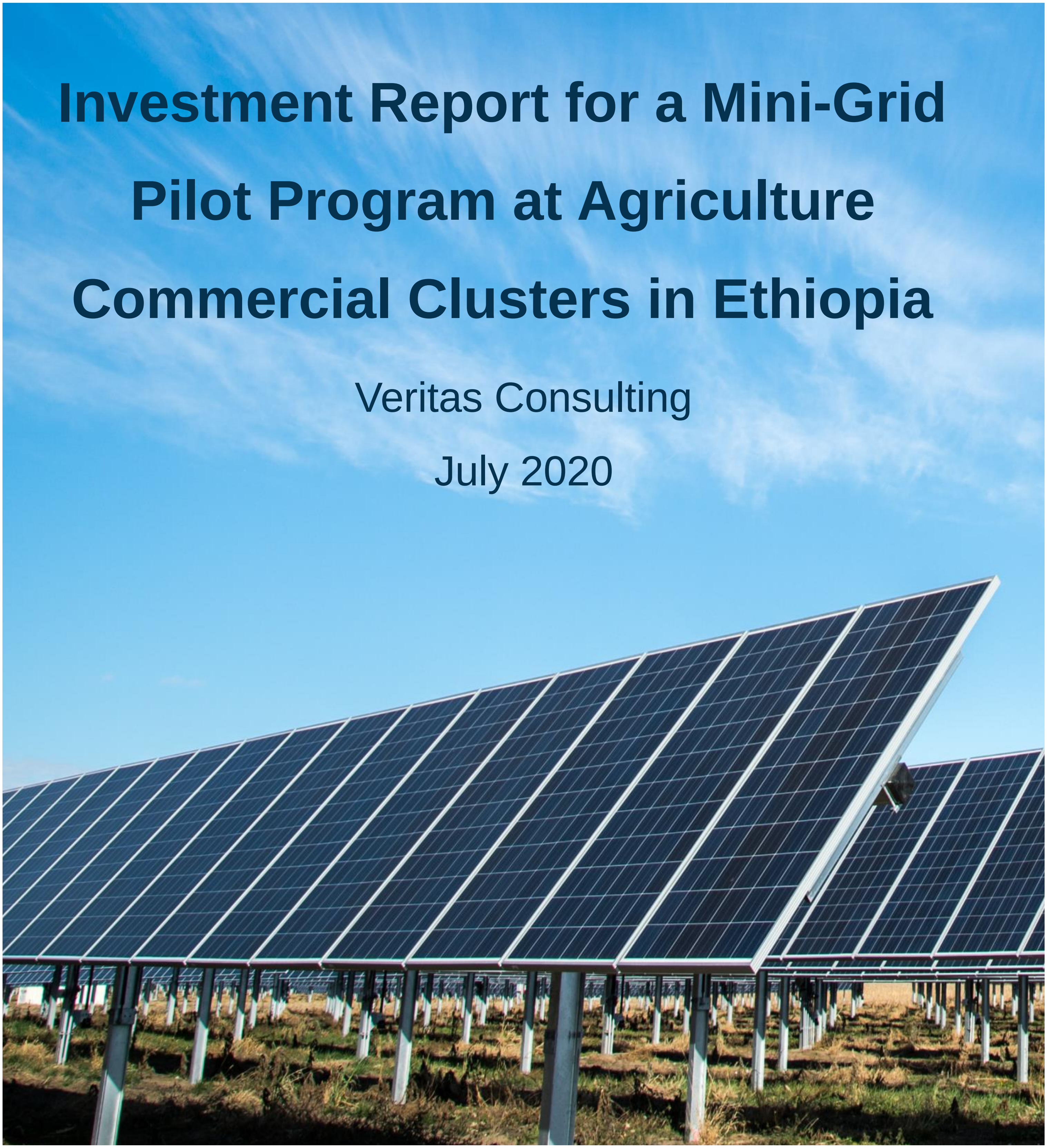

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ACRONYMS

AMDA – African Mini-grid Developers Association
ATA- Ethiopian Agricultural Transformation Agency
ACC- Agriculture Commercial Clusters
BTS- Base Transceiver Station
BOOT- Build, Own, Operate, Transfer model of public-private partnerships
CapEx- Capital Expenditures
CRGE- Climate Resilient Growth Economy
EEA- Ethiopian Electric Authority
EEU- Ethiopian Electric Utility
EPC- Engineering, Procurement and Construction model of public-private partnerships
ERG- Ethio Resource Group
ETB- Ethiopian Birr
FAO- Food and Agriculture Organization
GIZ- Deutsche Gesellschaft für Internationale Zusammenarbeit
GoE- Government of Ethiopia
GTP II- Ethiopia's Growth and Transformation Plan II
ha- Hectare
IAIP- Integrated Agro-Industry Park
IEA- International Energy Agency
IKI- International Climate Initiative
IRR- Internal Rate of Return
Km- kilo-meter
kWh- kilowatt-hour
MCC- Milk Collection Center
MoA- Ministry of Agriculture
MoH- Ministry of Health
MoTI- Ministry of Trade and Industry
MoWIE- Ministry of Water, Irrigation and Energy
NDC- Nationally Determined Contributes
NEP 2.0- National Electrification Program 2.0
NGO- Non-Governmental Organization
NPV- Net Present Value
OpEx- Operational cost
PPP- Public-Private Partnership
PV- Photovoltaics
RBF- Results-Based Financing
SNNP- Southern Nations, Nationalities and Peoples
SSN- SouthSouthNorth
USAID- United States Agency for International Development
USD- United States Dollar
Wp- Watt peak
WTP- Woreda Transformation Plan

DISCLAIMER

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ABOUT THIS DOCUMENT

This document is an output from the Mobilising Investment Project, an initiative of the Climate and Development Knowledge Network (CDKN) and Low Emission Development Strategies Global Partnership (LEDS GP) contracted through SouthSouthNorth (SSN). Mobilsing Investment's primary objective is to build funding support for the implementation of Nationally Determined Contributions (NDC) in seven developing countries in order to drive climate action with increased urgency and ambition. In Ethiopia SouthSouthNorth engaged in extensive stakeholder engagement and commissioned scoping studies. The energy sector generally, and renewable energy mini-grids for rural electrification in particular, emerged as a pivotal driver of Ethiopia's developmental agenda and key to the country achieving it's NDC targets. With support from the Government, SSN designed this engagement in order to build funding momentum for the sector. By publishing pre-feasibility studies on a collection of potential rural mini-grid sites at agricultural collectives, and illustrating their investment potential, it is hoped this report will move this nascent sector towards reaching its potential and in the process address climate risks and support the sustainable development of the water, food and energy nexus.

EXECUTIVE SUMMARY

In 2019, Ethiopia's Ministry of Water, Irrigation, and Energy (MoWIE) launched the National Electrification Plan 2.0, which envisions an ambitious target of universal electrification by 2025. Consistent with recent broad reforms in the country, the Plan outlines a substantially enhanced role for private investors. This pre-feasibility report focuses on commercial viability models for ten pilot sites, with discrete tariff targets and clear potential for scale-up beyond the pilots. To date, only one commercial mini-grid has been commissioned in Ethiopia and the main objective in developing this report is to build funding momentum for the off-grid component of NEP 2.0.

Prior research indicates that there are several barriers to the growth of the mini-grid sector. These include sensitivity to cost-reflective tariffs, an underdeveloped private sector, a lack of affordable funding options, and a cumbersome investment process since such investments have little precedence. It bears further reflection that most urban areas are electrified through the national grid at highly subsidized rates that see urban households paying less than $0.05/kWh for electricity. The rural population is largely aware of the highly subsidized power rates delivered to their grid-connected urban peers and have similar expectations for themselves.

The 'ABC' business model helps to address the challenge of securing commercial tariff rates and providing households with rates comparable to the grid; the ABC model is also one that the Ethiopian government finds acceptable. The ABC model assumes the following segmentation of a rural community customer base: The Anchor (A) customer, a customer who has a high demand for electricity and is creditworthy; the Business (B) customer, a second source of revenue in addition to the anchor customer coming from business customers; and the Community (C) customer, private households that use electricity for domestic needs.

In the Ethiopian context, the 'ABC' model assumes that household consumers pay a tariff comparable to the grid, business consumers (shops, MSES, etc.) pay a stepped-up tariff to the households, and that an individual company (or set of customers) with a commercial need for power in a rural area pay a cost-reflective tariff sufficient to cross-subsidize households.

This is not a new model for developing countries, and a challenge is identifying the appropriate anchor customers. For this study, we have selected villages participating in the Agricultural Commercialization Clusters (ACC) initiated by the Ethiopian Agricultural Transformation Agency (ATA). Specifically, we focus on the clusters that are engaged in horticulture crops, since they have exceptional load requirements owing to the power required for irrigation. The sites selected range from 100 to 685 irrigation farmers in a given catchment area who are presently using diesel generators to provide their power. Developers who wish to pursue these opportunities must keep in mind that project viability will depend on transitioning farmers from diesel generators to solar electricity, and will also require working with the ATA to support the farmer to adopt more appropriate irrigation activity.

This report further shares the details of preliminary site validations, and provides a power assessment and estimated financial returns for each site as well as all ten sites as a packaged investment.

The financial return for investors is considered for individual projects and aggregated across all ten sites as an investment package. This implies that the cross-subsidy will not only be within consumer segments at a specific site, but also across sites. The analysis targets a 10-year Internal Rate of Return (IRR) with a range between 20% - 25%. This analysis is viewed across three scenarios, and various cases. The three scenarios include:

1) Scenario 1 - An $0.18/kWh anchor tariff, a household tariff of $0.067, a connection fee of $30, and no results-based finance (RBF) subsidy.
2) Scenario 2 - An $0.18/kWh anchor tariff, a household tariff of $0.067, a connection fee of $151, and no RBF subsidy.
3) Scenario 3: A $0.067/kWh anchor tariff for all customers, a connection fee of $151, and an RBF subsidy of 43%.

The IRRs for these three Scenarios are 17.6%, 19.2%, and 22.6%, respectively. The first two scenarios, in this case, do not earn returns that reach the target IRR range. We additionally consider a higher anchor tariff of $0.30 for Scenario 1, which yields a 30% IRR (this tariff range is within the regional norm for productive use). The below table summarizes the above four results.

Table 1: Summary of Project Return Scenarios

	IRR	Anchor Tariff	Household Tariff	RBF	Connection Fee
Scenario 1	17.6%	$0.18	$0.067	-	$30
Scenario 2	19.2%	$0.18	$0.067	-	$151
Scenario 3	22.6%	$0.067	$0.067	43%	$151
Scenario 1–V2	30.0%	$0.30	$0.067	-	$30

Irrigation use is the principal power consumption for these sites, so an additional set of analyses is conducted assuming significantly diminished (approximately 40%) demand from the base case for anchor customers. In this diminished demand scenario, if we adjust scenario 1 anchor tenant tariffs to $0.31 and $0.40, this yields IRRs of 15% and 25%, respectively.

Given favourable tariffs and effective management of risks, these sites have the potential to be commercially viable. As is the case with most mini-grid investments, there will need to be some negotiation on tariffs and potentially on subsidies, as well as some consideration for ensuring that the power demand estimates from key customers do not deviate substantially.

An additional consideration for developers is the Government of Ethiopia's preference to pilot both joint venture and wheeling public/private models alongside a fully private model as part of this initiative. Given that it may not be practical to pilot three different business models for this small sample of ten sites, further discussion will be needed with the Government in order to craft an approach that delivers a successful pilot program and builds investment momentum while addressing the Government's policy position as articulated in NEP 2.0.

The work of this team will expand in 2020/2021 to prepare these pilot sites for investment. This expanded work will further develop the analysis required to ensure anchor irrigation demand, an enabling framework for investment in close collaboration with MoWIE, and validation of cost and revenue parameters. Several private sector workshops are envisioned with MoWIE taking a principal leadership role, and with sectorally recognized institutions such as the African Mini-grid Developers Association further supporting outreach.

1 Introduction

The investment cases outlined in this document are the product of a year-long engagement that Veritas Consulting has conducted for SouthSouthNorth (SSN) as part of a broader multi-country support package from the International Climate Initiative (IKI) of the German Government. The full report of this engagement can be found on the SSN website[1]. The development of these investment cases has received strong support from the Ministry of Water, Irrigation, and Energy (MoWIE), and continued project development support is envisioned.

The International Energy Agency's Stated Policies Scenario predicts that energy demand will rise by 1.3% each year until 2040, with increasing demand for energy services unrestrained by further efforts to improve efficiency. However, the IEA also indicates that electricity use grows at more than double the pace of overall energy demand, confirming its place at the heart of modern economies.[2] Although Ethiopia's electricity access has increased from 5% in 2000 to 45% in 2018, and is targeted to reach 100% by 2025, at present roughly 55% of Ethiopians have no access to any electricity source.

The scalability and effectiveness of mini-grids make them ideal for electrifying remote areas that are a significant distance from a centralized grid and have concentrated loads.[3] Electrifying remote rural areas and addressing the inadequate access to electricity affecting millions of Ethiopians is capital intensive and requires an innovative approach. The goal of upscaling mini-grids in Ethiopia can best be realized through the formulation and implementation of consistent policies. While public resources will remain a key part of the funding mix, a concerted effort is needed to harness substantial private investment in rural electrification and thus bridge the funding gap.

This document presents a pre-feasibility study of selected mini-grid investment opportunities in Ethiopia that can be viable for commercial mini-grid investment. Since this is a pre-feasibility study, we caution that developers and investors will need to undertake full feasibility efforts prior to making any investment decisions.

1.1 Methodology

The data collection for this report, which was used to build an investment profile for each site, was subject to dependencies from various stakeholders. The Veritas team designed and implemented a methodology with a limited number of subjective factors introduced, while still maintaining a robust enough set of data from which key investment indicators could be developed.

A. Site Selection

The pilot sites were selected by initially undertaking a top-down filtering criterion; this is covered in greater detail in section 4.4 of this report. Thereafter, further filtering parameters were used to identify sites with focused irrigation activity. The power needs for pumping water were presented to MoWIE, and a request was placed with the ATA to identify appropriate sites. The site criteria included: i) a catchment area of at least 100 farmers growing horticulture crops and already using or requiring irrigation; ii) location in an off-

1 https://southsouthnorth.org/portfolio_page/mobilising-investment-for-ndc-implementation/
2 International Energy Agency, 2019, World Energy Outlook 2019.
3 New Climate Institute; EED Advisory, 2018, *Ambition to Action: The Role of Renewable Energy Mini-Grids in Kenya's Electricity Sector*.

grid area; iii) active production of crops rather than being in a development phase; and iv) belief of local officials in investment amenability.

Horticulture farmers were selected for two reasons. First, most horticulture crops have significant irrigation needs, and thus power requirements tu pump and distribute the water. Second, horticulture products tend to have higher price points, and horticulture farmers tend to be more profitable; this translates to higher 'ability to pay', and if the improved access to irrigation by way of electric power can support these efforts then this addresses the question of 'willingness to pay'. The stipulation for at least 100 farmers is an estimate that sets a threshold for a minimum potential load. Active production was preferred to planned horticulture development so that mini-grid development is not delayed based on farming development, and so that potential power requirments could be more directly compared against diesel generator activity (the incoming electricity would be a substitute to diesel-powered pumps). Amenability to investment was an import factor as well, as demand must ultimately emanate from the customer. It should be noted that the selection process could have focused on the most attractive potential sites. However, that would defeat the purpose of a pilot – assessing the feasibility of the hypothesis before scaling up.

B. Data Collection

All of the ten sites were categorized into region, woreda and kebele levels. The principal agriculture liaison was an ATA cluster coordinator for the particular kebele. Preliminary phone interviews with the cluster coordinator gave the team the opportunity to conduct a pre-assessment for each site and to define the sampling method and resources required to collect the data.

The design for the sample size of households and business interviews was determined through a purposive sampling that undertook several iterations. Because it is cluster farming, farmers are concentrated according to the crop they are producing and the survey team demarcated the area in each community where horticulture farming was taking place. The site-level sample size was set at 40 households for household interviews and at 7 to 15 respondents for businesses depending on the number of operating businesses at each site.

This data serves to provide customer groupings for which we later ascribe power demand levels. The data can also serve as the principal inputs in the financial model used to develop investment requirements and potential returns. Here we highlight specifically the efforts undertaken to identify the amount of land presently being irrigated, since the principal power requirement will be irrigation and the measurement criteria we deploy at this stage is size of land and crop type.

C. Survey Questionnaires

Three categories of questionnaires were developed, as presented in Table 2.

Table 2: Categories of survey questionnaires and themes

SURVEY THEMES	INTERVIEWED RESPONDENT
□ Population & demographic of the site □ Site overall profile, power accessibility, road access	Kebele Administration officials or Development Agents
□ Household profile /demographic □ Household power consumption usage □ ACC farming practices and trends □ Irrigation usage □ Willingness to pay	Household farmers and ACC farmers
□ Business profile / including revenue	Public and private enterprises

□ Business power consumption usage □ Willingness to pay	

Source: Veritas

D. Validation Teams

Validation/survey teams were assigned based on their experience working in the region. Each team consisted of a supervisor and four data collectors who worked for a period of 2-4 fieldwork days depending on the area coverage, ease of terrain, and concentration of activity. All horticulture farms were geotagged so that the total area under irrigation could be assessed.

These teams were segmented into three categories:

High-level data collectors/team leader – Responsibility began in advance of the site visit by securing the appropriate approval letters for the survey and submitting them to woreda officials. Then, the team would secure kebele and village demographic data from both administrative entities. Woreda officials were also able to provide broader electricity information. Kebele officials were able to gather key community individuals for the survey and assist in travel logistics.

Data collectors – These individuals collected two types of data, the first of which was general power demand and demographic data through household and MSE surveys. The second type of data collected was an assessment of all irrigating farms. For the latter, a group identified primary crops, geo-tagged each farm, and analayzed individual farms and aggregate village irrigation capacity.

Community liaison - In addition to the traditional validation team, a senior community liaison officer was assigned to each region. This individual was responsible for explaining the purpose of the visit to the woreda and kebele officials, and most importantly to the community.

There were also unique challenges in the data collection. These communities are farming communities and most do not have a town center, therefore travel within the communities can be difficult as there are no roads, with rain periods providing particlulary difficult logistics challenges. Additionally, since it has been nearly 15 years since the last national census, the teams were dependent on kebele and woreda officials for all of their data; this required multiple efforts to communicate with these officiials prior to the physical validation, and usually a day or more of face-to-face meetings to secure the information. Lastly, for some of the sites, there are no easy access roads to reach them from, which required substantial off-road travel for up to a day. In the context of Ethiopia, these challenges are expected and officials were relatively accommodating based on prior experiences and expectations.

2 Market opportunity

2.1 Overview of market dynamics

Ethiopia is Sub-Saharan Africa's second-most populous country, with over 100 million people living within its borders. It is among the continent's least developed countries, but also has the fastest-growing economy; in fact, the International Monetary Fund reports that Ethiopia had the fastest growing economy in the world over the last decade[4]. However, access to electricity services remains a challenge, particularly in dispersed rural areas where approximately 35%[5] of the population lives in about 7 million households. "At an aggregate level, about 96% of urban households are connected to the grid (Addis Ababa scores 99.9%), whereas only 27% of rural households have access to electricity services, and mostly through off-grid solutions."[6] Ethiopia's Growth and Transformation Plan (GTP), a series of five-year plans, envisions the country reaching middle-income status by 2025. It calls for an increase in agricultural productivity, a strengthening of industry, and a fostering of export growth. The plan is to drive development with a transition to carbon-neutral energy, limiting net greenhouse gas emissions (GHG) to a 64% reduction from projected 'business-as-usual' (BAU) emissions in 2030. Since rural electrification is key to achieving these goals, solar energy mini-grids will play a vital role.[7]

In March 2019, the Government of Ethiopia (GoE) launched the National Electrification Program 2.0 (NEP 2.0), an updated action plan that aligns with GTP goals and seeks to achieve universal electricity access by 2025 through aggressive power generation and connection targets. The plan envisions 65% of access coming from grid solutions and 35% coming from off-grid solutions. The expansion of off-grid access is expected to come primarily through the Ethiopian Electric Utility (EEU), a public company with a monopoly over distribution and retail of power. As part of the effort to meet the off-grid targets, the EEU plans to develop 285 standalone mini-grids at suitable locations with more than 1,000 potential beneficiaries each where there is a high likelihood that mini-grid will be able to drive significant economic development. Additionally, the NEP 2.0 provides substantial latitude for both private sector development and public-private partnerships to meet national off-grid electrification goals and NEP 2.0 has identified potential for approximately 1,150 mini-grids for implemention by the private sector or cooperatives.

The utilization of clean energy measures to ensure climate-friendly sustainable growth is one of the NEP 2.0 goals; this is consistent with Ethiopia's national climate change strategy as articulated in the Climate Resilient Green Economy (CRGE), and is central to the country's nationally determined contributions (NDC). The NEP 2.0 has set ambitious targets for expanding access to off-grid energy through solar technologies, and further emphasizes that "mini-grid solutions may constitute the least expensive option to adequately serve loads that are located in remote and dispersed areas."[8] Most importantly for private developers, the NEP 2.0 envisions a strengthened role for the private sector in supporting the off-grid component of the national electrification program.

4 International Monetary Fund. Article IV 2018 and 2019 Consultation. IMF Article IV, 2019
5 Ministry of Water, Irrigation and Energy in Ethiopia
6 Ethiopian National Electrification Plan 2.0 (NEP2.0), Ministry of Water Irrigation and Energy, 2019
7 Ethiopian Growth and Transformation Plan GTP II, Ministry of Finance and Economic Development, 2015
8 Ethiopian National Electrification Plan 2.0 (NEP2.0), Ministry of Water Irrigation and Energy, 2019

2.2 Existing Private mini-grids Investments

There are several mini-grid projects that were built by the EEU and other actors; we further detail these projects here.

The EEU has started developing 285 off-grid sites, as indicated in the NEP 2.0. To date, 12 sites are being implemented, 25 sites have been tendered for engineering, procurement, and construction (EPC) delivery, and an additional 50 sites have been validated for future EPC tenders. Beyond these efforts, several non-government organizations (NGOs) are working in the sector. The European Union (EU) is working with the Agro-Industrial Park, while the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) has built 5 small hydro-based mini-grids with an installed capacity of 7kW – 55kW in Oromia and SNNP regions. The Italian Agency for Development Cooperation plans to build two mini-grids in the Afar region. The GoE has also installed three mini-grids up to 15kW in the SNNPR and Oromia regions, with two donated to the Ministry of Health (MoH) to power a health center. There are no tariff implications, but the health center has been fully functional for years and is deemed to be a success by MoH, GoE and the community. It is our understanding that only one mini-grid —owned and operated by Ethio Resource Group (ERG)— has received a business license, and this was obtained after two years of providing free services whilst negotiating the licensing agreement with the EEA.

In summary, private mini-grid investment is at a nascent stage. This report takes an incremental step forward by proposing further testing and validation of the envisaged ABC model and highlighting investment opportunities at 10 sites that have been validated and analyzed by this study. We expect, and current discussions indicate, that there will be substantial technical assistance as well as access to funding that will help de-risk these investments for private developers.

2.3 ABC Model Approach

Among the principal challenges for private mini-grid investment in Ethiopia has been identifying the mechanisms in which a cost-reflective tariff structure can be introduced. The tariff charged for on-grid power in Ethiopia ($0.02–$0.04 per kilowatt-hour) is highly subsidized, and there has been a demonstrated resistance from rural communities to pay measurably more than grid customers for alternative solutions. The Ethiopian Electric Authority (EEA), the electricity sector regulator, introduced a series of new regulations and directives in 2019, some of which directly address this challenge. Specifically, EEA's current guidance suggests they would be amenable to an 'ABC' model and tariff structure where ABC stands for:

- ***Anchor (A) Customer***: The developer should try and identify an anchor customer who has a large, stable, and predictable electricity demand and is creditworthy. The Anchor customer will agree to and can afford to pay a cost-reflective tariff.
- ***Business (B) Customer***: In addition to the anchor customer, a second revenue stream could come from business customers, who put electricity to commercial uses in order to increase operating hours as well as total demand. Businesses are also expected to pay a cost-reflective tariff.
- ***Community (C) Customer***: This segment refers to private households that use electricity for domestic needs such as lighting, mobile phone charging, household appliances, etc.

The structure of tariffs in the ABC model as envisaged by EEA is one of inclining segment tariffs; household customers are charged a tariff that is roughly equivalent to the subsidized grid rate in 2022 (approximately $0.067 kWh), business customers pay a more cost-reflective rate, and high power-consuming anchor customers pay a higher rate which assumes a cross-subsidy to the subsidized household customers. In certain scenarios, business customers might also participate in a level of cross-subsidy. In many other regional markets, the tariff structure has a declining scale, resulting in heavy power users paying lower relative rates. In Ethiopia, there is an acute sensitivity to household rates, and there is a public sector direction that households be charged tariffs in line with heavily subsidized grid rates.

2.4 Leveraging National Programs

Due to relatively low economic activity and a predominance of manual work, identifying anchor customers has proven particularly challenging in rural Ethiopia, just like it has been in rural areas elsewhere. One of the often-articulated challenges of doing business in Ethiopia is that the government and development sector have a disproportionately large economic footprint in the country. While, in many circumstances, this certainly has a crowding-out effect on the private sector, it can also serve as an opportunity to leverage the work done by the government and development organizations. In Ethiopia, this large footprint provides us with unique opportunities for the development of anchor loads at a significant scale.

To this end, we have identified four national programs which demonstrate sufficient productive use potential to support commercial mini-grid investments. These four programs reflect the general thrust of public investment in Ethiopia; the agriculture sector is substantially represented in these programs, the potential for the light industry is among the productive use cases, and the potential for overall societal development provides an underpinning. The four programs are:

1. Agriculture Commercial Clusters (ACCs) run by the Ethiopian Agricultural Transformation Agency (ATA)
2. Milk Collection Centers (MCCs) run by USAID and Ministry of Agriculture (MoA)
3. Integrated Agro-Industry Parks (IAIPs) run by the Ministry of Trade and Industry (MoTI)
4. The Woreda Transformation Plan (WTP) which is designed to be run cross-sectorally

Of the four programs mentioned above, this report finds that ACCs currently present the strongest case for the productive use of power and are also ideal sites for mini-grid investments. The principal factors that led to the determination of ACCs as ideal mini-grid sites are that they are already operational, and potential power demand can be assessed from existing activities. In addition, access to affordable clean energy by farming communities supports increased agricultural productivity and improved rural livelihoods, has the potential to drive exports and earn much needed foreign exchange, and is aligned with key policy and climate change strategies. The other three initiatives, despite each showing promise, are not yet ready for full-scale mini-grid investment. For example, the WTP is still in its early stages with a pilot site, MCCs do not yet have the scale and concentration of activities within a given geography, and IAIPs are not yet fully up and running. It is expected that all three programs will be attractive for investment at some juncture, and thus should be closely monitored. However, for this business case, we will now focus on ACCs, and, more specifically, ACCs for horticulture crops.

2.5 Deeper dive into ACCs

ACCs were established to create a scalable model for agricultural production with the goal of increasing the potential for commercialization and industrialization. They are an ideal anchor client because they have a pool of economic actors within a narrow geographic area.

Agriculture in Ethiopia has traditionally been subsistence-based, with smallholder farmers working small plots of land, using basic hand tools, and only growing what they can eat or sell locally. Despite efforts to introduce more modern agricultural practices, limited progress has been made; mechanization and the use of improved inputs are not widespread, and productivity remains much lower than its potential. ACCs were established to change that by introducing a concentration of similar agricultural activities in a specific geographic area that can benefit from scaled interventions and the introduction of investments that enjoy economies of scale. Prioritized in GTP II as a key driver of agricultural transformation, the ATA has organized over 1.2 million farmers into ACCs, which have several nearby local government offices, health centers, schools, and businesses that also enjoy benefits.

The ACC concept was developed as a mechanism to integrate the interventions prioritized within specific geographies, targeting a limited number of high-value commodities. Since there are clusters with 60–400 farmers producing the same product in one contiguous area, the integration allows the farmers and value chain actors to benefit from economies of scale not afforded by more disparate smallholder farmers. For sellers of agricultural inputs, buyers of farm produce, or a mini-grid investor, this set-up means that there are very low transaction costs because one can deal with a cluster as one entity. Examples of economy of scale benefits include infrastructures such as irrigation, high quality and cost-effective inputs, processing and storage facilities, finance, and markets. This integration not only benefits the farmers, but can also benefit other value chain actors and the broader rural non-farm economy while also supporting larger structural investments.

ACCs have the potential to be a conduit for infrastructure development and knowledge delivery, enabling modern seed, fertilizer, and chemical inputs to reach farmers more easily. Above all, they create a process for farmers to switch from subsistence agriculture to commercial farming. That, in turn, creates opportunities for cost-effective social and private investment in these communities. For this investment project, we are primarily interested in the need for increased provision of power for improved productivity, which can be ideally delivered through mini-grid power generation.

ACCs function at a woreda level, where ATA focuses its interventions on one or two of the primary commodities. In the 2018-2019 pilot year, approximately 600,000 farmers were engaged in the ACC clusters. In the subsequent pilot year, over 1.2 million farmers were organized into ACCs.

The priority crop commodities for the ACCs are (cereals) wheat, maize, sesame, and malt barley; (horticulture) tomato, onion, banana, mango, and avocado. The ACC initiative prioritizes the ten commodities mentioned above across 284 woredas within four regions of Amhara, Oromia, SNNPR and Tigray. Maize has the widest coverage in terms of hectares and can be found in 91 woredas across three of the regions (the exception is Tigray). Following maize, wheat is the most prevalent priority crop; it is the primary crop in 79 woredas and present in all four regions. The five ACC commodities that are horticulture crops (tomato, avocado, mango, banana, onion) are the crops of greatest interest to this investment project; they require substantial quantities of water to be productive and are good candidates for power-dependent irrigation. They are highly perishable once harvested, and significant value chain development is required to meet the aggregation, cold storage, and refrigerated transportation needs. Through the ACCs, this value chain development is largely underway, and the pipeline of horticulture clusters is substantial. Horticulture clusters are found in 17 woredas that span 425 kebeles across all four of the regions. While the exact number of specific communities that have scaled horticulture ACCs likely does not equal that of cereals[9], there are at least several hundred, and more are under development.

The power demand for irrigation is fairly clear, but the willingness and capacity to pay market reflective rates and, in some cases, of cross-subsidy, needs to be addressed. Through interviews with the Ministry of Agriculture, ATA, cluster coordinators, and farmers, the consensus is that horticulture crops have a much

9 Interviews with the ACC team at ATA indicate that are well over 5,000 ACCs for cereals.

higher revenue potential than cereals. In ideal circumstances, a horticulture farmer can earn up to 10 times more than cereal farmers on the same amount of land. For example, a commercial avocado farmer can earn USD$30,000 per hectare (ha) or more per year, while a commercial maize farmer can typically earn (at most) USD$2,400 per ha per year.

Market prices for horticulture crops are substantially higher and farmers typically experience up to a 30% increase in yield per harvest, with up to three harvests per year with irrigation. Without irrigation, some horticulture crops are simply not feasible; those that are feasible remain limited to the single annual harvest, with possibly reduced yield even during that single harvest as compared to irrigated crops. These benefits are not as pronounced for cereals, which have longer growth periods and thus are limited in their number of harvests.

The figure below demonstrates the impact that irrigation can have on crops as compared to strictly rain-fed farms. It is important to note the comparatively high impact that irrigation has on horticulture versus cereal crops. Income from rainfed horticulture production is, on average, 3 times that of cereals without irrigation; with irrigation, that figure rises to 4.3[10].

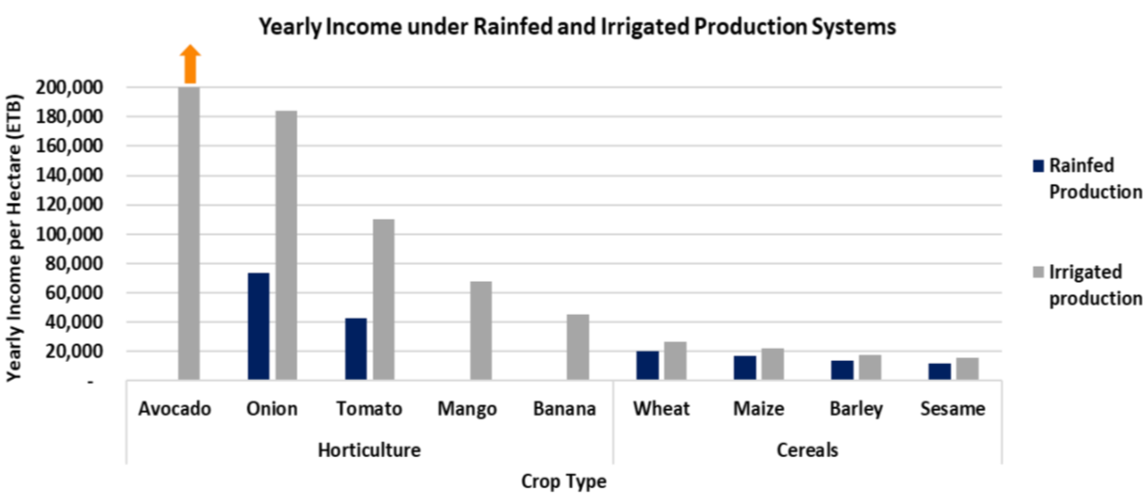


Figure 1: Annual income under rainfed and irrigated production systems

The transformative potential of mini-grids for rural horticulture communities has also initiated a discussion among key sector actors about leveraging such power investments with more centralized and efficient irrigation systems for these communities. This includes potentially adopting drip irrigation methods. Such assessments are ongoing and premature at this stage, and are outside of the scope of

10 Source: Veritas market research (note, we believe avocado figures are substantially higher, but are capped due to scale purposes)

this report. Nevertheless, potential investors should further consider these factors as more detailed due diligence is undertaken.

2.6 Irrigation Demands of Horticulture Crops

Water pumping for crops is a major demand of small-scale farmers. The Food and Agriculture Organization (FAO) estimates that only about 37% of all vegetable production in Ethiopia is irrigated.[11] The current patterns of irrigation are therefore clearly limited in scale and dependent on rainwater. Ethiopia's unpredictable rainfall patterns occur in two distinct seasons; "the small rains" during February and March and "the big rains" from June to September do not ensure a consistent supply for the country's crops.[12] Increasing rainfall variability due to climate change adds further risk to the medium-term agriculture outlook.

Moreover, Ethiopia's observed irrigation practices currently do not meet international standards and practices.[13] The average Ethiopian farmer does not follow normal irrigation practices. Instead, they physically inspect the soil by touching it; if the soil appears to be dry, the farmer will then irrigate for an extended period. Others simply irrigate for hours on end and then stop. Most farmers currently only use furrow irrigation, a type of surface irrigation in which trenches or "furrows" are dug between crop rows in a field, which greatly limits the efficiency of their water usage. Farmers flow water down the furrows (often using only gravity), and it seeps vertically and horizontally to refill the soil reservoir. Overall, there is no structured/scientific way that many Ethiopian farmers go about watering their crops.

As discussions on these pilots progress, the Veritas team is working with MoWIE and ATA to assess reasonable levels of intervention and enhanced irrigation practices from farmers. These discussions include considerations of more centralized irrigation systems and their potential methods of introduction. The end goal is to maximize crop productivity with the most efficient use of groundwater.

The efficiency of electric pumping irrigation will depend on a confluence of factors, including the type of pump used, the crops that are being grown, and the water source. Different irrigation methods will be more effective for certain crops. The water source— whether it is surface water, shallow groundwater, or deep groundwater— will also inform which type of pump to use because pumps vary in technical specifications regarding pumping depth and volume output. Large-scale pumps are the most efficient method for surface water, whereas drip irrigation is likely better equipped to support shallow and deep groundwater. While farmers would also need to use more water on average, there is greater growth potential with these water sources than traditional trough irrigation methods that are presently applied by smallholder farmers.

The sustainability of water sources is an additional issue that needs to be addressed, and there are ongoing discussions about interventions to assess the capacity of the water sources at each site to support farmers and other communities dependent on the water. It is important to incorporate environmental and social safeguards into future program activities. In particular, an independent assessment of the broader hydrogeological regime is needed so that sustainable groundwater abstraction rates may be determined and factored into program scaling.

All in all, there is no one-size-fits-all method that can be used in approaching each site. In order to meet demand and improve production rates, we can use electric pumps to improve farmers' current production

11 FAO. Ethiopia Irrigation Market, 2015

12 Ministry of Agriculture and Rural Development, Addis Ababa, Ethiopia, 2009, p. 4, [Agricultural Investment Potential of Ethiopia].

13 Agricultural Transformation Agency (ATA)

practices. In turn, this will help grow the farmers' incomes through increased production and sales volumes. Increased irrigation can also stimulate job creation through the local management of irrigation systems in the area.

2.7 Transitioning from diesel to electric pumps

One of the main challenges in mini-grid development is finding a site with enough significant productive use activities that can be translated into electricity demand. In many cases, mini-grid developers will select a site and attempt to stimulate productive use activity. In our approach for these pilots, we have identified sites where a critical mass of residents are already engaged in productive use activities for irrigation, using alternative (diesel) power methods. That said, productive use activity at these sites is not universal. The farmers at these sites can be grouped into those who currently practice irrigation and those who currently do not practice irrigation. The table below exhibits how many farmers from the 11 pilot sites belong to each group.

Table 3: Number of farmers that practice irrigation per pilot site

	Group 1: Irrigated (ACC) Farms	Group 2: Non-Irrigated Farms	Percent of Farmers in the Area Practicing Irrigation
Telifa	300	0	100%
Damba	225	7	97%
Tankua	378	17	96%
Huluku	200	20	91%
Laelay Adie	180	20	90%
Toli Kersu	685	90	88%
Alege	189	45	81%
Lelicho	215	97	69%
Chefe Kora	100	118	44%
Murche	165	225	42%
Kuleta	165	296	36%
Total	2802	935	75%

Source: Veritas

The first group uses diesel pumps to irrigate their land. On average, they make up 75% of the farmers found at the pilot sites. These farmers pay ETB 18.5 per liter of diesel and must manage ongoing maintenance requirements of combustible powered machinery. They often face difficulties when acquiring diesel due to its episodic unavailability and the fact they must travel (on motorbikes) to nearby areas to obtain it. Despite the challenges these farmers face, they have already made a capital investment in diesel-powered pumps, and a firm case must be made that using electric power is a more viable economic option.

The second group of farmers currently does not practice irrigation despite the higher income they can earn using irrigation. Discussions with farmers and local agricultural experts indicate that a principal reason why these farmers do not engage in horticulture crops is the high upfront costs associated with irrigation. There is some confidence that a reasonable number of these farmers will begin to engage in horticulture should electricity become available in their area.

Ultimately, a more detailed assessment will need to be conducted at each site to assess how many current irrigation farmers will transition to solar pumps and how many present non-irrigating farmers will adopt more profitable crops. The key figure for the first group will be the current cost of diesel and the comparable cost of electricity. The initial rough analysis indicates that the current diesel OPEX for a farmer is approximately \$0.45/kWh; this figure needs to be further assessed for the various types of pumps and uses being employed.

3 Investment highlights

3.1 Sites Summary

Although 10 pilot sites have been selected from the horticulture ACCs, we conduct the analysis based on eleven potential sites.[14] These sites were selected in consultation with MoWIE and with recommendations from ATA. The parameters for site selection included a minimum of 100 horticulture farmers within a potential mini-grid catchment area and a community that is 'perceived' as amenable to private investment. Furthermore, ACCs are currently only present in four regions of the country, and the allocations per region are consistent with the public allocation criteria. The summary below outlines the preliminary site validation data.

Several aspects of the data are observed and interpreted as follows:

1) The sites have a heavy concentration of farmers – on average, there are approximately 255 farmers and the number of irrigated farms range from 100 to 685.
2) There may be additional demand since, on average, 95 farmers at each site do not practice irrigation. If one were to assume that a principal constraint for not engaging in higher-value horticulture crops is the required capital investment, then the possible addition of these farmers to the irrigation power demand could be substantial.
3) Household numbers are almost equivalent to the total number of farms. There are very few non-farming residents in these communities, and, in many of these communities, households are typically spaced out evenly from one other.
4) The town center for a kebele is typically several kilometers away from the villages we envisage for these mini-grids. The kebele center typically has a concentrated set of households, several shops and small government offices, clinics, and schools. For this project, we do not model a connection to the kebele center. However, there is design work to be undertaken that reviews the cost and revenue implications of doing so.
5) Six of the sites use rivers as a main source of water for irrigation and farming, while five sites use groundwater as a water source.
6) The average farm size for the sites ranges from 0.1 to 1.6 hectares. Six of the sites have average farm sizes of 0.6 hectares or smaller, while the remaining five sites have average farm sizes of 1.2 hectares or larger.

The following sub-sections present a summary of the profiles for each pilot site. This data was collected by Veritas's validation teams that spent from 3 to 5 days at each site. **We again caution that this is a pre-feasibility study. In the case of full feasibility, more senior teams would spend longer periods of time on site verifications, including data verification beyond local officials.**

[14] The allocation criteria provided by Government to Veritas is four sites in Oromia, three in Amhara, two in SNNP and one in Tigray. At presented there are 11 sites as there are two potential sites in Tigray, which will ultimately be narrowed to one

Table 4: Summary of pilot sites

Customer Segments		*Oromia/ Toli Kersu/ (TQ, BT, KB)	Oromia/ Golbe/ Chefe Kora	Oromia/ Gololе/ Huluku	Oromia/ Dankaka/ Alege	Amhara/ Jigna/ Damba	Amhara/ Bebkes/ Tankua	Amhara/ Wagetera/ Telifa	Tigray/ Maru/ Kuleta	Tigray/ Haftom/ Laelay Adie	SNNP/ Ganta Kenchamo/ Murche	SNNP/ Arsedo Mero/ Lelicho
Anchor customers/ ACC farms	**Irrigated Farms (ACC Farms)**	**685**	**100**	**200**	**189**	**225**	**378**	**300**	**165**	**180**	**165**	**215**
	Total irrigated land (ha)	42	50	64	119	50	473	450	224	77	203	333
	Average farm size (ha)	0.1	0.5	0.3	0.6	0.2	1.3	1.5	1.4	0.4	1.2	1.6
	Number of diesel generators	112	2	45	150	200	138	250	33	0	5	12
	Source of water for irrigation/farming	River	Groundwater	Ground water	Groundwater	River	River	River	Groundwater	Groundwater	River	River
	Principal Crop	Banana and Avocado	Onion and tomato	Onion and tomato	Onion, Tomato, Avocado	Onion and tomato	Onion and tomato	Onion and tomato	Onion and Tomato	Onion and mango	Banana	Avocado
Business/ Enterprise/Other	Number of Schools	1	0	1	1	1	1	1	1	1	1	1
	Number of Health facilities	1	0	0	0	0	0	0	0	0	0	1
	Religious centers	8	4	2	1	0	1	1	1	1	2	5
	Gov't office	10	1	3	0	0	0	0	0	0	0	0
	SMEs	1	0	0	1	0	0	0	0	0	0	6
	Souk	16	2	0	4	7	11	6	3	0	5	4
	BTS within the village (Y/N)	No	No	No	No	No	No	No	No	No	No	No
Community customers	**Total Number of HH in the village**	**652**	**178**	**220**	**234**	**228**	**358**	**300**	**451**	**220**	**420**	**312**
	High Income HH	245	46	150	206	17	56	60	40	20	9	150
	Regular/ basic Income HH	407	132	70	28	211	302	240	411	200	411	162

3.1.1 Oromia Region

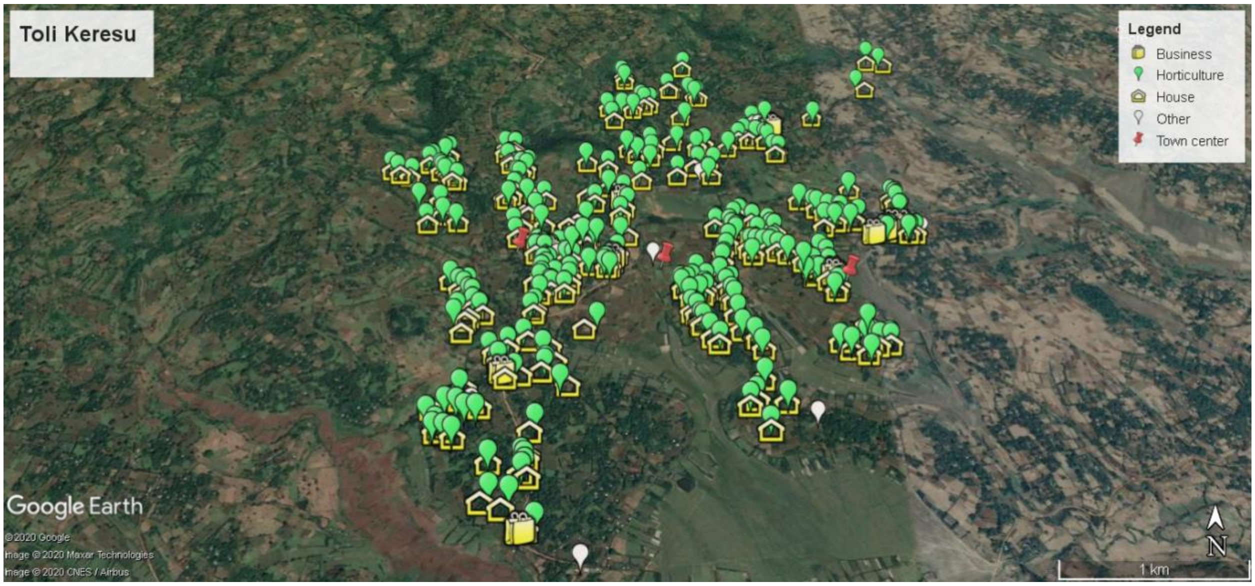
Toli Kersu/ (TQ, BT, KB)

Toli Kersu is the pilot site with the highest number of irrigated (ACC) farms, but has the smallest acreage. Thus, this site has the least amount of irrigated farmland. All farms are located next to households.

Table 5: Site summary of Toli Kersu

Site summary	Customer Segments	*Oromia/ Toli Kersu/ (TQ, BT, KB)
Anchor customers/ACC farms	**Irrigated Farms (ACC Farms)**	**685**
	Total irrigation farm size	42
	Average farm size	0.1
	Number of Diesel Generators	112
	Source of water for irrigation/farming	River
	Principal Crop	Banana And Avocado
	Non -irrigated farms (Non- ACC Farms)	90
	Percentage of non -irrigated farms	12%
Community customers	Total Number of HH in the village	652
	Premium or High Income HH	245
	Regular/ basic Income HH	407

Figure 2: Site-level mapping of Toli Keresu - basic site data



Golbe / Chefe Kora

Chefe Kora is on the smaller end of the scale as a rural community. The farmers have organized themselves into two groups of 40 farms and 60 farms. Unlike the majority of the sites that have access to roads all season, Chefe Kora only has access to roads during the non-rain season, thus limiting farmers' ability to expand to broader markets. This may also limit commissioning to non-rain seasons.

Table 6: Site summary of Chefe Kora

Site summary	Customer Segments	Oromia/ Golbe/ Chefe Kora
Anchor customers/ACC farms	**Irrigated Farms (ACC Farms)**	**100**
	Total irrigation farm size	50
	Average farm size	0.5
	Number of Diesel Generators	2
	Source of water for irrigation/farming	Groundwater
	Principal Crop	Onion and tomato
	Non -irrigated farms (Non- ACC Farms)	118
	Percentage of non -irrigated farms	54%
Community customers	Total Number of HH in the village	178
	Premium or High Income HH	46
	Regular/ basic Income HH	132

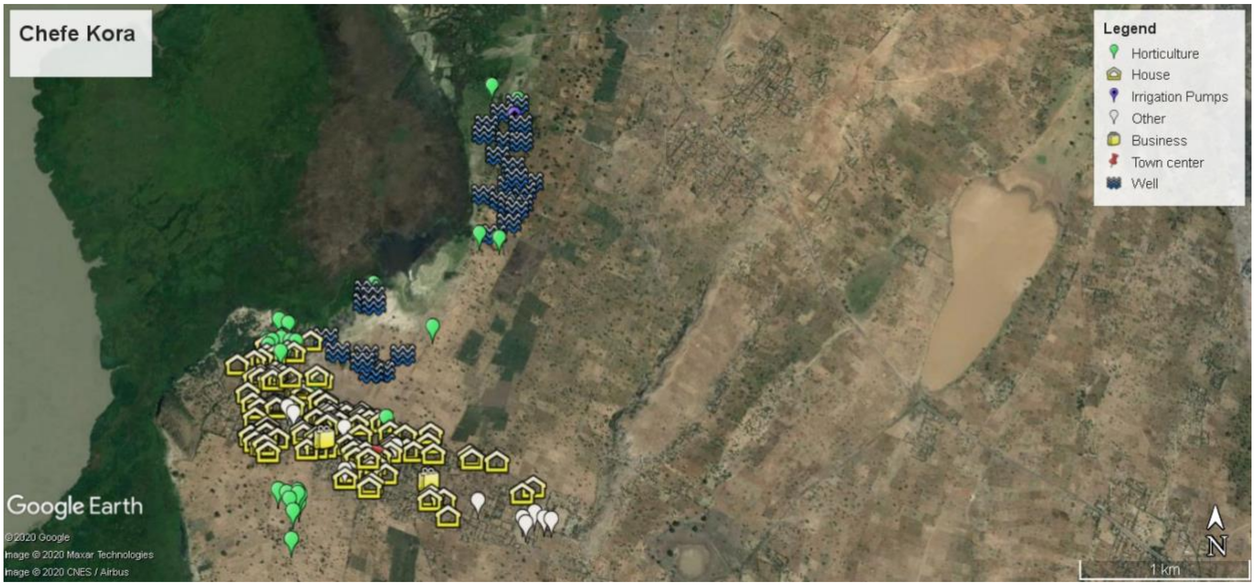


Figure 3: Site-level mapping Chefe Kora - basic site data

Golole / Huluku

Huluku is the second-smallest pilot site based on the total number of households in the village. The village has access to roads all season, which allows farmers to access multiple markets to sell their products.

Table 7: Site summary of Huluku

Site summary	Customer Segments	Oromia/ Golole/Huluku
Anchor customers/ACC farms	**Irrigated Farms (ACC Farms)**	**200**
	Total irrigation farm size	64
	Average farm size	0.3
	Number of Diesel Generators	45
	Source of water for irrigation/farming	Groundwater
	Principal Crop	Onion and tomato
	Non -irrigated farms (Non- ACC Farms)	20
	Percentage of non -irrigated farms	9%
Community customers	Total Number of HH in the village	220
	Premium or High Income HH	150
	Regular/ basic Income HH	70

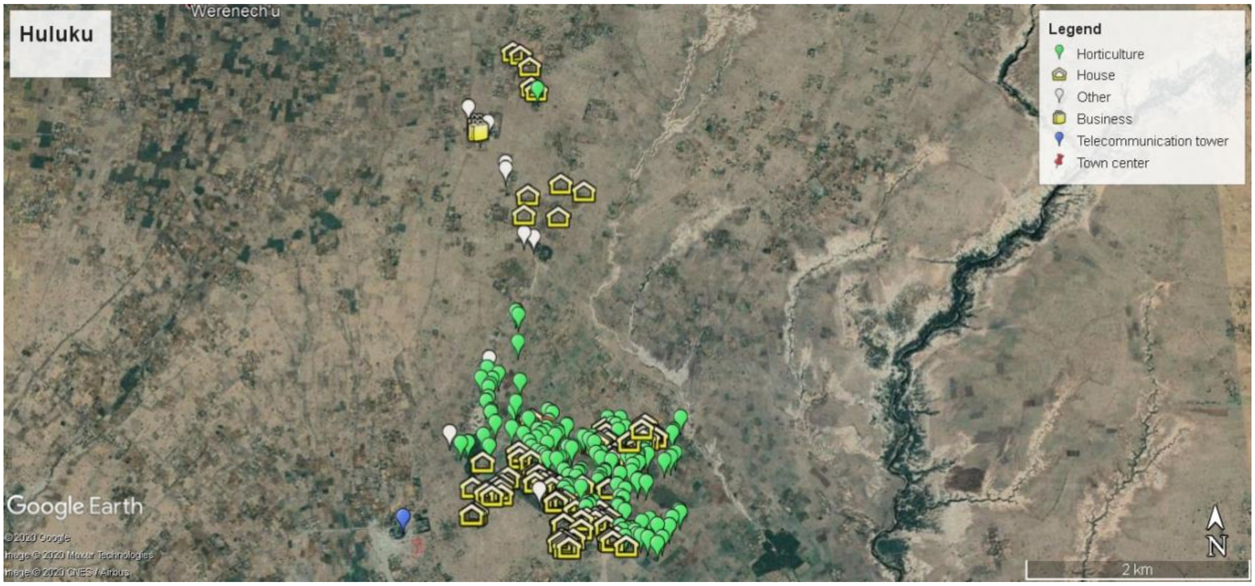


Figure 4: Site-level mapping of Huluku - basic site data

Dankaka / Alege

Alege is one of the smaller pilot sites in terms of the total number of households. Of all the farmers in the community, 19% do not practice irrigation, so there is potential to expand services to them.

Table 8: Site summary of Alege

Site summary	Customer Segments	Oromia/Dankaka/Alege
Anchor customers/ACC farms	**Irrigated Farms (ACC Farms)**	**189**
	Total irrigation farm size	119
	Average farm size	0.6
	Number of Diesel Generators	150
	Source of water for irrigation/farming	Groundwater
	Principal Crop	Onion, Tomato, Avocado
	Non -irrigated farms (Non- ACC Farms)	45
	Percentage of non -irrigated farms	19%
Community customers	Total Number of HH in the village	234
	Premium or High Income HH	206
	Regular/ basic Income HH	28

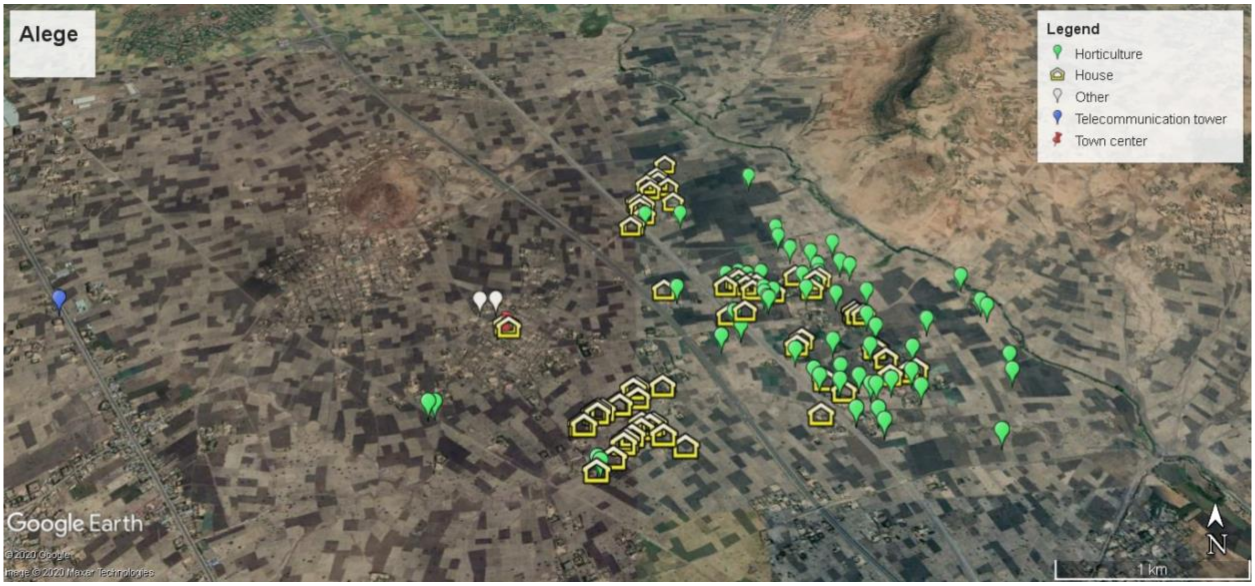


Figure 5: Site-level mapping of Alege - basic site data

3.1.2 Amhara Region

Jigna / Damba

Damba is a mid-sized pilot site located near Lake Tana, a major groundwater source for the region. The village has access to roads all season, which allows farmers to access multiple markets to sell their products.

Table 9: Site summary of Damba

Site summary	Customer Segments	Amhara /Jigna / Damba
Anchor customers/ACC farms	**Irrigated Farms (ACC Farms)**	**225**
	Total irrigation farm size	50
	Average farm size	0.2
	Number of Diesel Generators	200
	Source of water for irrigation/farming	River
	Principal Crop	Onion and tomato
	Non -irrigated farms (Non- ACC Farms)	7
	Percentage of non -irrigated farms	3%
Community customers	Total Number of HH in the village	228
	Premium or High Income HH	17
	Regular/ basic Income HH	211

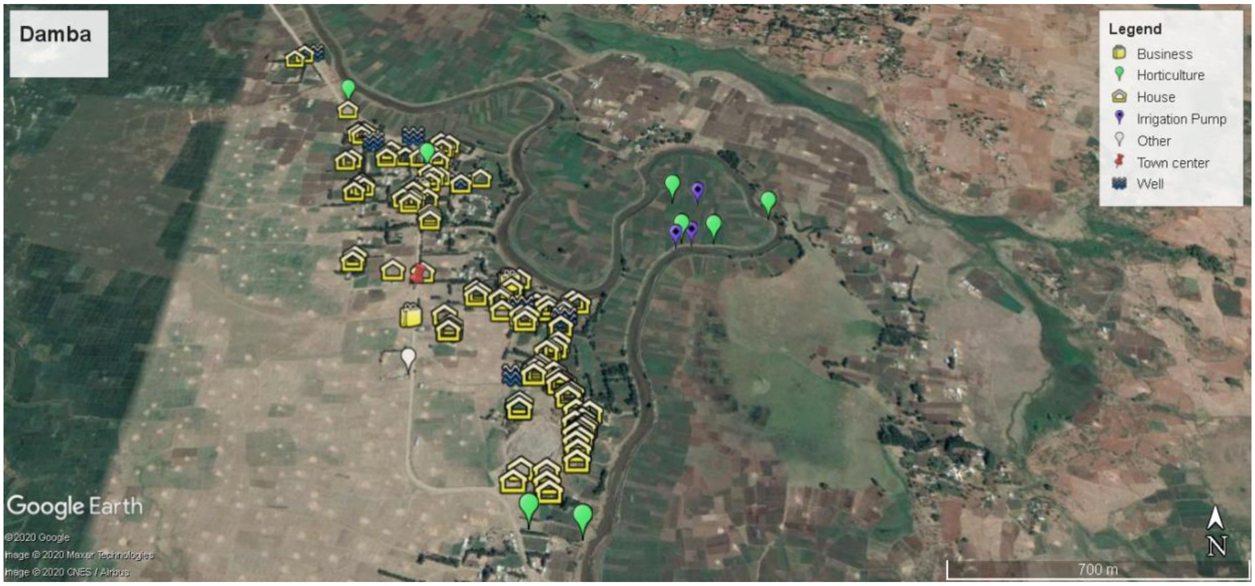


Figure 6: Site-level mapping of Damba - basic site data

Bebkes / Tankua

Tankua is one of the larger pilot sites based on the number of households in the village, and has the second largest number of irrigated ACC farms. The village has access to roads all season, which allows farmers to access multiple markets to sell their products.

Table 10: Site summary of Tankua

Site summary	Customer Segments	Amhara / Bebkes /Tankua
Anchor customers/ACC farms	**Irrigated Farms (ACC Farms)**	**378**
	Total irrigation farm size	473
	Average farm size	1.3
	Number of Diesel Generators	138
	Source of water for irrigation/farming	River
	Principal Crop	Onion and tomato
	Non -irrigated farms (Non- ACC Farms)	17
	Percentage of non -irrigated farms	4%
Community customers	Total Number of HH in the village	358
	Premium or High Income HH	56
	Regular/ basic Income HH	302

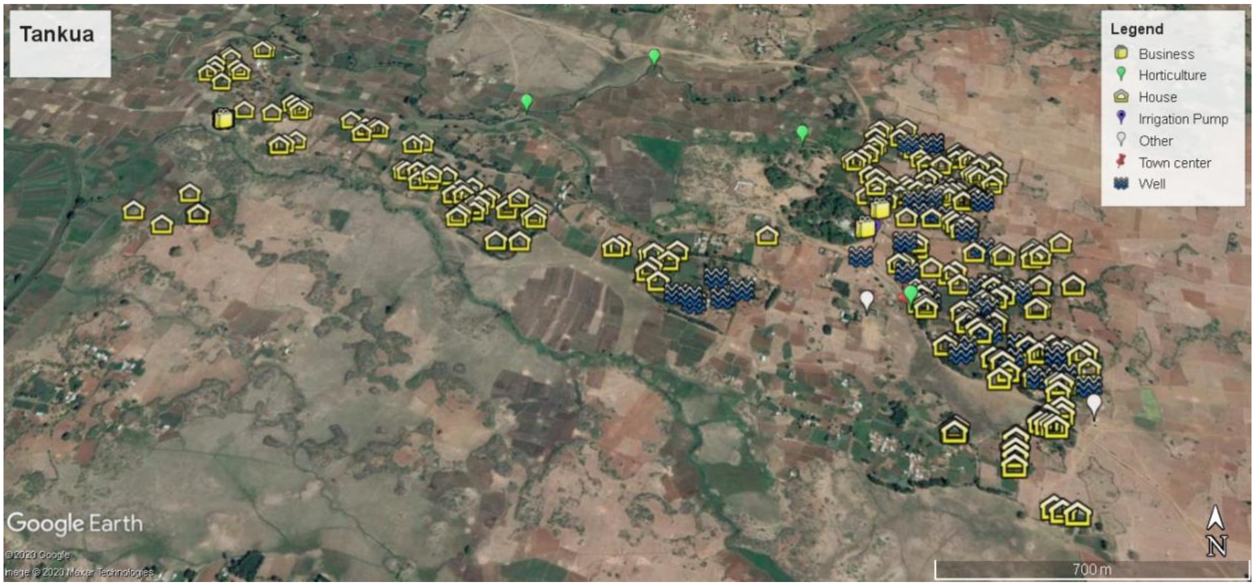


Figure 7: Site-level mapping of Tankua - basic site data

Wagetera / Telifa

Telifa is a mid-sized pilot site based on the number of households in the village. There is no potential to increase access to irrigation since all farms are already irrigated. The village has access to roads all season, which allows farmers to access multiple markets to sell their products.

Table 11: Site summary of Telifa

Site summary	Customer Segments	Amhara /Wagetera /Telifa
Anchor customers/ACC farms	Irrigated Farms (ACC Farms)	300
	Total irrigation farm size	450
	Average farm size	1.5
	Number of Diesel Generators	250
	Source of water for irrigation/farming	River
	Principal Crop	Onion and tomato
	Non -irrigated farms (Non- ACC Farms)	0
	Percentage of non -irrigated farms	0%
Community customers	Total Number of HH in the village	300
	Premium or High Income HH	60
	Regular/ basic Income HH	240

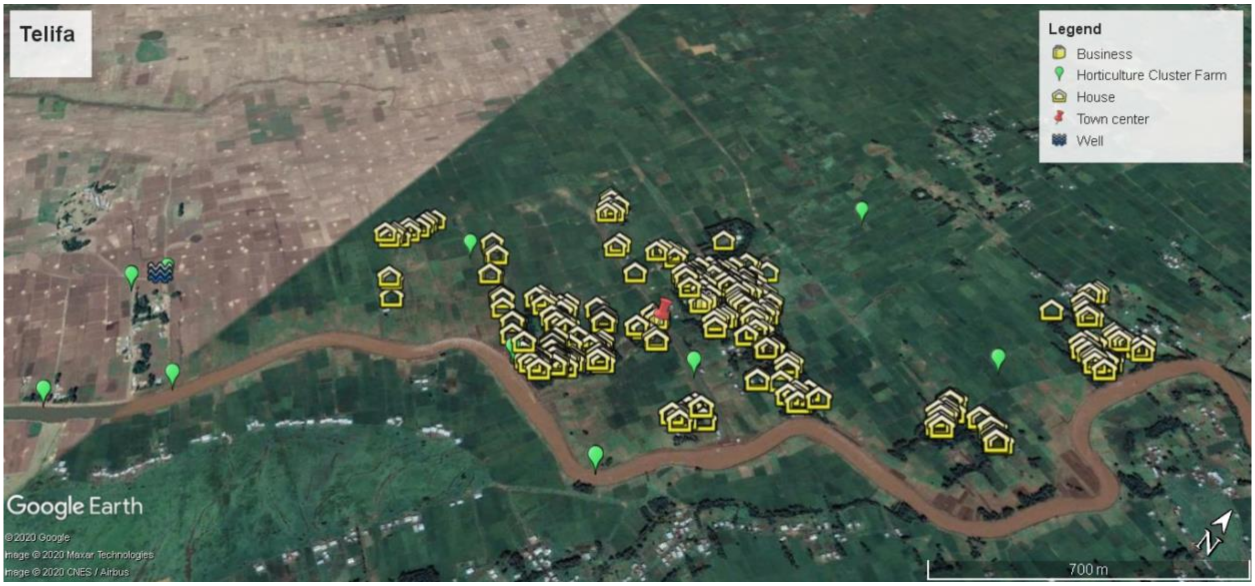


Figure 8: Site-level mapping of Telifa - basic site data

3.1.3 Tigray Region

Maru / Kuleta

Kuleta is the second-largest pilot site based on the number of households in the village. Kuleta has the highest number of non-irrigated farms compared to the rest of the sites, and has access to roads year-round, indicating immense growth potential. In this site, the community lives in the eastern part of the village, while farms are located a few kilometers away in the Western part of the village.

Table 12: Site summary of Kuleta

Site summary	Customer Segments	Tigray /Maru /kuleta
Anchor customers/ACC farms	**Irrigated Farms (ACC Farms)**	**165**
	Total irrigation farm size	224
	Average farm size	1.4
	Number of Diesel Generators	33
	Source of water for irrigation/farming	Groundwater
	Principal Crop	Onion and Tomato
	Non -irrigated farms (Non- ACC Farms)	296
	Percentage of non -irrigated farms	64%
Community customers	Total Number of HH in the village	451
	Premium or High Income HH	40
	Regular/ basic Income HH	411

Figure 9: Site-level mapping of Kuleta - basic site data

Haftom / Laelay Adie

Laelay Adie is the smallest pilot site based on the number of households in the village. The farmers use a diesel generator at one location to pump out groundwater and use canals to distribute the water to the different farms. From the geospatial map below, one can observe that the farms and households are located in a cluster away from each other. The village has access to roads all season, which allows farmers to access multiple markets to sell their products.

Table 13: Site summary of Laelay Adie

Site summary	Customer Segments	Tigray /Haftom /Laelay Adie
Anchor customers/ACC farms	**Irrigated Farms (ACC Farms)**	**180**
	Total irrigation farm size	77
	Average farm size	0.4
	Number of Diesel Generators	0
	Source of water for irrigation/farming	Groundwater
	Principal Crop	Onion and mango
	Non -irrigated farms (Non- ACC Farms)	20
	Percentage of non -irrigated farms	10%
Community customers	Total Number of HH in the village	220
	Premium or High Income HH	20
	Regular/ basic Income HH	200

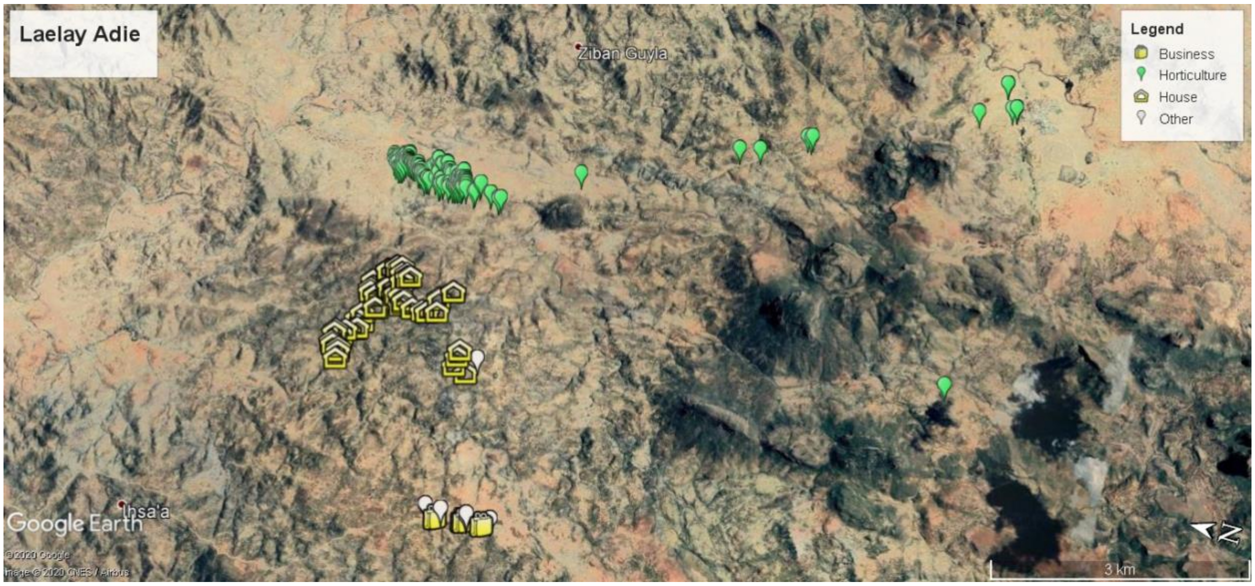


Figure 10: Site-level mapping of Laelay Adie - basic site data

3.1.4 SNNP Region

Ganta Kenchamo / Murche

Murche is the third-largest pilot site based on the number of households in the village, with the potential to transition 58% of the on-site farms to irrigation. The village has access to roads in the non-rain season.

Table 14: Site summary of Murche

Site summary	Customer Segments	SNNP/ Ganta Kenchamo /Murche
Anchor customers/ACC farms	**Irrigated Farms (ACC Farms)**	**165**
	Total irrigation farm size	203
	Average farm size	1.2
	Number of Diesel Generators	5
	Source of water for irrigation/farming	River
	Principal Crop	Banana
	Non -irrigated farms (Non- ACC Farms)	255
	Percentage of non -irrigated farms	61%
Community customers	Total Number of HH in the village	420
	Premium or High Income HH	9
	Regular/ basic Income HH	411

Figure 11: Site-level mapping of Murche - basic site data

Arsedo Mero / Lelicho

Lelicho is a mid-sized pilot site with year-round access to roads, something that allows farmers to access multiple markets to sell their products.

Table 15: Site summary of Lelicho

Site summary	Customer Segments	SNNP /Arsedo Mero / Lelicho
Anchor customers/ACC farms	**Irrigated Farms (ACC Farms)**	**215**
	Total irrigation farm size	333
	Average farm size	1.6
	Number of Diesel Generators	12
	Source of water for irrigation/farming	River
	Principal Crop	Avocado
	Non -irrigated farms (Non- ACC Farms)	97
	Percentage of non -irrigated farms	31%
Community customers	Total Number of HH in the village	312
	Premium or High Income HH	150
	Regular/ basic Income HH	162

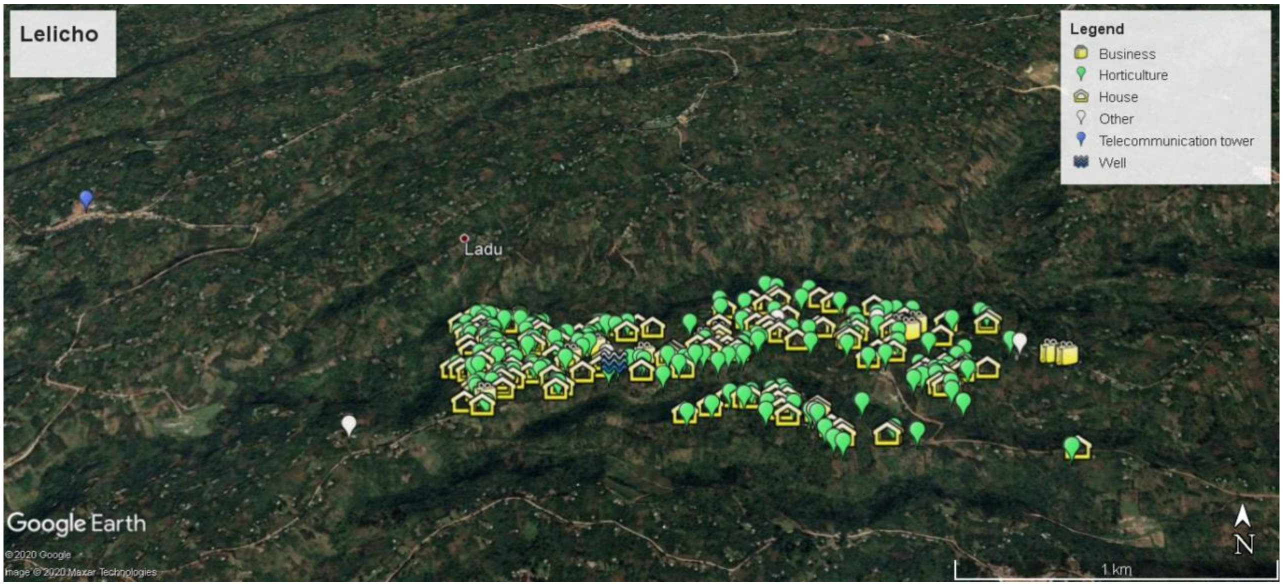


Figure 12: Site-level mapping of Lelicho - basic site data

3.2 Power assessment

The key drivers for power system design are capacity utilization and reliability – the aim is to ensure that most of the available energy is consumed at all times while providing a supply that people can count on.

At the same time, as demand may expand over time, there should ideally be ‘room to grow’. Thus, developers need to estimate current energy demand, peak loads carefully, and forecast its growth rate to design an appropriate power system that can provide reliable service in line with the prevailing quality of service standards.

An undersized system may require upgrading shortly after commissioning, incurring additional costs associated with civil works, labor, and logistics in addition to the added power system components. Excess capacity results in underutilized capital. Therefore, the designer must carefully balance the cost of expansion, expected growth rate, and the prevailing cost of capital for the investment.

However, this is not a ‘one size fits all’ solution: a system close to Addis Ababa will be significantly cheaper to expand than one located deep in the Danakil depression.

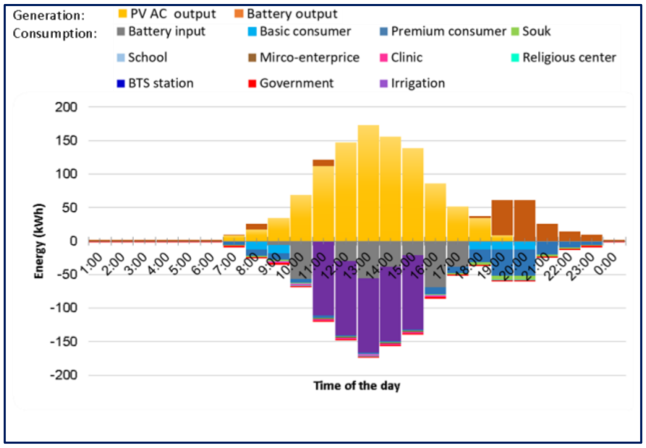
Key factors to assess are:

- **Peak load**: Larger inverters are often more affordable per Wp of rated output than smaller ones. In addition, inverters require specialized expertise to install and commission. Thus, one may choose to oversize the inverter capacity relative to the current load to cater for demand growth.
- **Solar capacity**: Installing PV requires significant land area and adding land later may prove challenging. Also, PV is relatively cheap, and so adding more PV upfront will provide extra energy that can be sold at a relatively low cost.

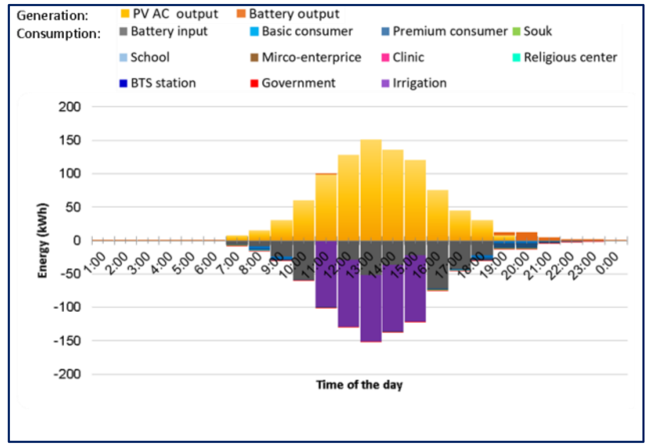
- **Battery capacity**: Batteries are relatively costly components of the system and provide the critical service of availability outside of daylight hours or on days with minimal sunshine. However, battery costs are declining rapidly as new technologies become available and are relatively easily expanded. Therefore, it may be considered that batteries are best sized close to the current nightly demand and expanded as and when that demand has increased significantly.
- **Back-up generators**: Diesel generators are a relatively low-cost way to increase reliability, as the CAPEX and standby costs of the generator are low in contrast to the operational cost, which is high. Therefore, the generator should be designed to meet a significant proportion of demand.

The following figures illustrate the daily load and generation profile at each pilot site. The lower half of the figure is power consumption and the upper half is power generation from PV or batteries. The load profile of each site identifies the customer segment and the time of day that each segment is using power. The purple bars, indicated for daytime periods, illustrate the relatively high power demand for irrigation, and the light blue bars indicate the incremental pick-up in demand from households in the early morning and early evening hours. The substantial gray bars in the figures represent battery charging load. On the other hand, in the upper half of the figures, the yellow bars show PV generation directly from sunlight during the day, while the brown bars show power drawn from the batteries during the evening and night. At all times of the day, the power demand at each site is met by the PV, batteries, or a combination of both.

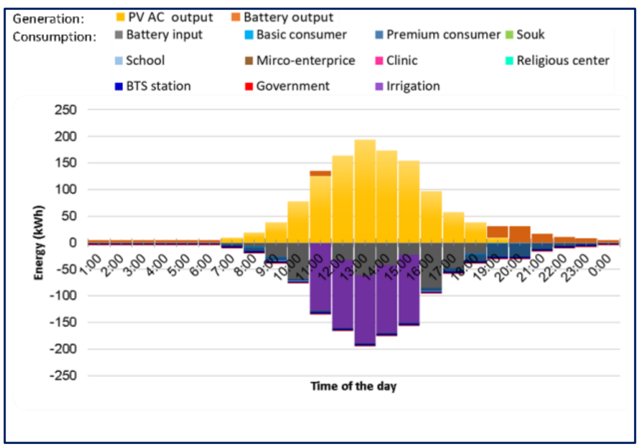
3.2.1 Oromia Region



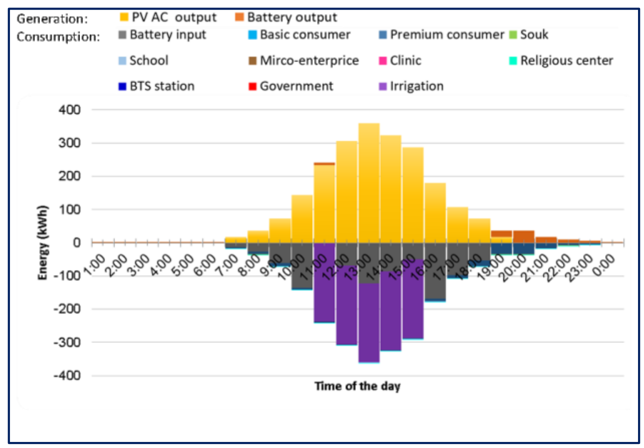
(a) Toli Keresu



(b) Golbe/ Chefe Kora



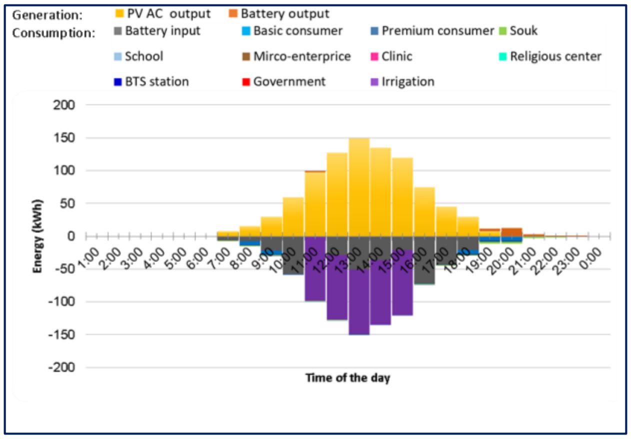
(c) Golole/ Huluku



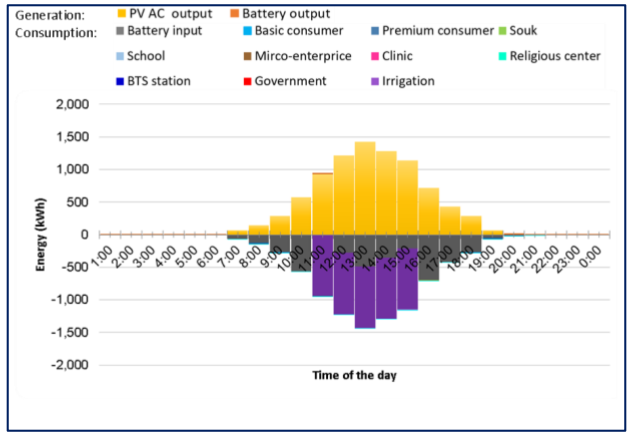
(d) Dankaka/ Alege

Figure 13: Generation and Load profiles for sites in Oromia region

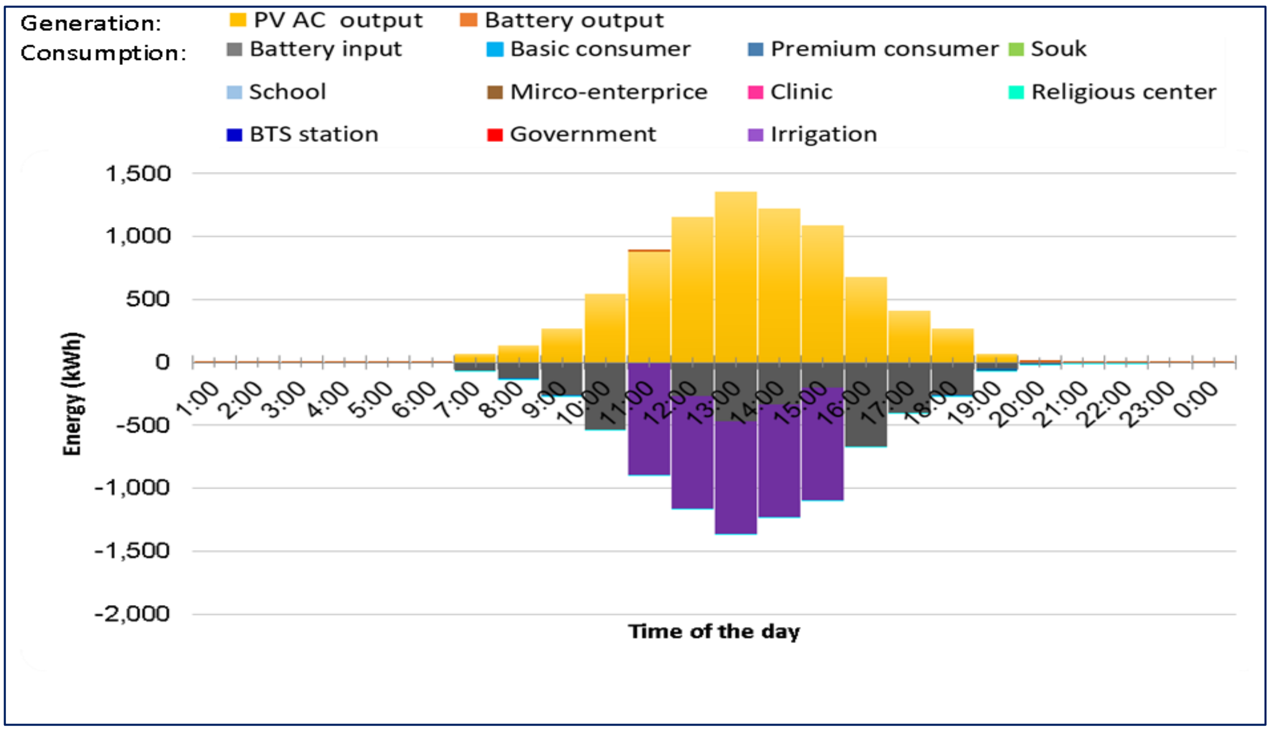
3.2.2 Amhara Region



(a) Jigna/ Damba



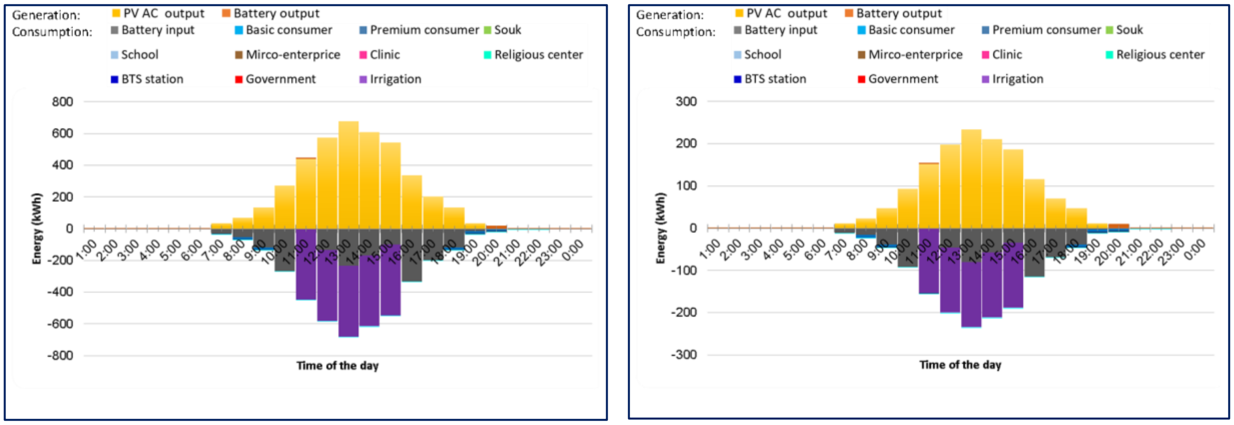
(b) Bebkes/ Tankua



(c) Wagetera/ Telifa

Figure 14: Generation and load profiles for sites in Amhara Region

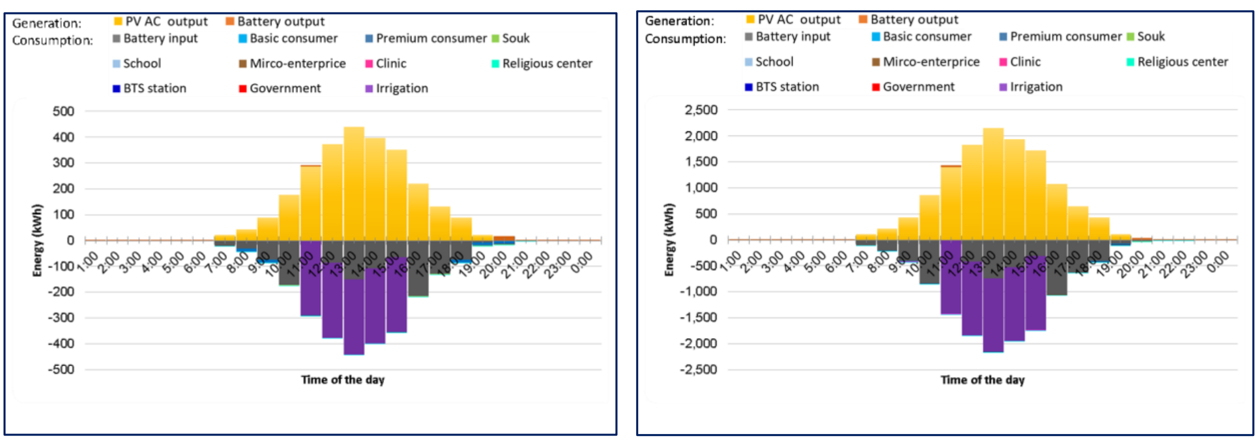
3.2.3 Tigray Region



(a) Maru/ Kuleta (b) Haftom/ Laelay Adie

Figure 15: Generation and load profiles for sites in Tigray Region

3.2.4 Generation and Load profiles for sites in SNNP Region



(a) Ganta Kenchamo/ Murche (b) Arsedo Mero/ Lelicho

Figure 16: Generation and load profiles for sites in SNNP Region

4 Business models

These pilots are intended to be commercial investments spearheaded by the private sector. However, there is a substantial public sector interest to investigate the plausibility of specific public-private models. To this end, three models have been forwarded by MoWIE to test as part of the pilots. The first is a purely private model. The second envisages the EEU providing wheeling capacity, where the public utility invests in building the transmission lines and charging a usage fee; the private developer will invest in the generation capacity and manage retail activities. The last model to be considered is a joint venture between the private sector and the EEU.

Additionally, and not notwithstanding potentially attractive projections, these will be the first suite of mini-grids to be commissioned in Ethiopia; investment process risks remain, as there is limited precedence for officials to draw from. Discussions have begun with potential donors to support these investments with grant funding, and potential developers are encouraged to solicit further grant funders.

5 Financial analysis and investment

5.1 Key Assumptions

The financial analysis presented in this section of the report is assessed utilizing a comprehensive financial model that Veritas and Powerhive developed for the Government of Ethiopia in 2019/2020 as part of the previously referenced foundational project work designed by SouthSouthNorth. The model is intended as a robust tool for the government to assess potential mini-grid investments across a myriad of productive use frameworks and operating platforms. We assume all experienced mini-grid investors have similar in-house tools and given uniform inputs, so the results should not differ materially.

The financial analysis has several inputs and assumptions. In this section, we discuss tariffs and capital structure, which are important parameters that are key to the analysis.

Table 16: Inputs and assumptions of model parameters

Parameter	Input Value	Rationale
ETB/USD, exchange rate	33	The birr depreciates fairly steadily against USD; the analysis should be updated periodically to account for such changes.
ETB depreciation vs USD	10%	There is a significant risk of ETB depreciation against USD, with the growth of the Ethiopian economy and ongoing short trade balance.
Tariff increase, non-irrigation	7%	Inflation in Ethiopia is currently around 15%. We expect that full passthrough of inflation may face some resistance from the GoE.
Tariff increase, irrigation	5%	We believe that it is fair to reduce the relative amount of cross-subsidization over time.

It should be noted that with the assumptions above, revenues in USD terms are worth less each year, as the tariff increases do not equal the expected reduction in ETB value. This is a highly conservative setting, and developers may elect to apply less stringent assumptions.

5.1.1 Tariffs

The tariff is a major factor in determining the financial viability of each project. The basis of our proposed approach is to implement a tariff that will keep households at the approved national grid tariff (a subsidized tariff that is not commercially viable), while also allowing for a higher tariff from various commercial users in order to cross-subsidize the households. We will consider two different installation fees to examine their effects on financial outcomes. Furthermore, we consider a third scenario whereby external subsidies are used to ensure the financial sustainability of the project, assuming the national tariff for all users. The scenarios are as follows:

Table 17: Tariff scenarios

		Scenario 1	Scenario 2	Scenario 3
CAPEX subsidy / Result Based Financing	% CAPEX	0	0	43
OPEX subsidy	% OPEX	0	0	0
Household installation fee	ETB	1000 ($30)	5000 ($151)	5000 ($151)
Household energy charge	ETB/kWh	2.2 ($0.067)	2.2 ($0.067)	2.2 ($0.067)
Business installation fee	ETB	1000 ($30)	5000 ($151)	5000 ($151)
Business energy charge	ETB/kWh	5 ($0.15)	5 ($0.15)	2.2 ($0.067)
Irrigation (anchor) energy charge	ETB/kWh	6 ($0.18)	6 ($0.18)	2.2 ($0.067)

In the first scenario, the anchor irrigation farmers pay a tariff of $0.18/kWh, the business customers pay $0.15/kWh, and households pay $0.067/kWh. In many cases, the households are also the farmers, and it is assumed that they will be charged two separate rates depending on the type of use. In this scenario, the connection fees for irrigation farmers/businesses is $30. The second scenario assumes a substantially higher connection fee of $151 for all customers, which covers a large portion of the actual connection cost (~338/connection on average). The third scenario, with a 43% CAPEX subsidy - structured as results-based financing (RBF) agreement - keeps the connection charge the same at $151, but reduces the tariff to $0.067/kWh for all consumers (the approved national grid tariff).

5.1.2 Capital Structure

The capital structure is another key driver of financial outcomes. In general, increased leverage improves financial returns but also increases risk. The capital structure proposed here could be seen as a 'typical' structure that could be applicable in Ethiopia in general and the mini-grid sector in particular, whereby there is a) an international developer with a minority equity stake, b) a local investor with a majority equity stake, c) a component of (expensive) local debt with low risk relative to income depreciation, and d) a tranche of concessionary hard currency debt (from a Development Finance Institution). With this in mind, the capital structure used in the analysis is presented below.

Table 18: Capital structure

Tranche	Currency	% of capital	(Target) Return/Cost	Tenor (year)
Equity – developer	USD	10%	20% (including carried interest)	10
Equity – investor	ETB	30%	25%	10
Local Debt	ETB	20%	12%	~10
Concessionary debt	GBP	40%	5%	~10

The above tenors are based on a BOOT scenario with a 10-year lifetime, and the debt drawdowns are based on actual expenditure, hence the tenor being approximate.

The authors believe that a suitable target equity return considering the risk and complexity of the project would be 20-25% in real, after-tax terms. The NPV calculations are at a 20% discount rate.

Table 19 shows a summary of key indicators for the 11 sites. The overall CAPEX estimation is $9.1 million, with either the Kuleta or Lealay Adie site to be omitted to bring the number of pilot sites to 10. The largest site is Lelicho at nearly $2.5 million in CAPEX, and the smallest is Damba at approximately $250,000.

Table 19: Capacity and financial outcomes per site

	Est. PV Rating (KWp)	Est. Battery Rating (KWh)	Power System CAPEX	Distribution CAPEX	Distribution $ / Connection	# Hectares Under Irrigation
Toli Kersu	190	258	321,070	143,147	208	43
Chefe Kora	142	48	173,643	110,431	597	51
Huluku	182	113	245,686	104,302	462	65
Alege	338	129	419,857	109,120	453	121
Damba	141	48	172,129	82,864	351	50
Tankua	1,343	81	1,467,851	122,978	331	478
Telifa	1,279	64	1,392,306	83,938	273	455
Kuleta	638	64	709,161	69,105	152	227
Laelay adie	220	32	249,202	82,372	371	79
Murche	458	48	510,740	89,286	209	205

Lelicho	2,163	113	2,356,690	101,910	310	337
Average	645	91	728,940	99,950	338	192
Total	**7,093**	**999**	**8,018,335**	**1,099,454**	**3,715**	**2,110**

Table 20 compares the outcomes at an individual site[15] and project level for each scenario.

Table 20: Return projections by scenario

	Scenario 1		**Scenario 2**		**Scenario 3**	
	IRR	NPV	IRR	NPV	IRR	NPV
Toli Kersu	0.0%	(2,205,185)	0.0%	(2,126,263)	0.0%	(2,063,679)
Chefe Kora	15.1%	(86,303)	16.1%	(65,112)	17.4%	(25,482)
Huluku	11.1%	(169,662)	11.9%	(143,774)	10.19%	(97,946)
Alege	18.8%	(40,646)	19.6%	(13,041)	21.1%	23,412
Damba	14.7%	(79,534)	16.2%	(52,502)	16.8%	(24,826)
Tankua	25.1%	608,956	25.6%	651,452	27.7%	582,699
Telifa	26.8%	781,531	27.2%	816,811	30.0%	736,313
Kuleta	25.5%	328,174	26.8%	380,406	30.2%	361,105
Laelay adie	17.5%	(52,579)	18.6%	(27,150)	19.4%	(6,883)
Murche	23.8%	172,171	25.3%	221,197	28.7%	223,721
Lelicho	27.4%	1,433,507	27.7%	1,471,192	30.3%	1,303,717
Average	18.7%	62,766	19.5%	101,202	21%	92,014
Project	**17.6%**	**1,983,945**	**19.2%**	**2,428,345**	22.6%	1,134,015

[15] Note that the model considers the complete financing structure and associated costs and leverage at the project level. Thus, the 'site IRR' should be seen as a simplified estimate of the individual site's financial performance in order to analyze performance of sites relative to one another.

5.2 Financial Analysis Summary

Initially, this analysis focused on the financial results from Scenario 1; this Scenario has modest connection fees, a 'commercial' tariff for anchor customers, and no RBF. As expected, the amount of energy spent on irrigation is the dominant factor in financial outcomes, as can clearly be seen in each of the scenarios: the more irrigation capacity required[16] on a site, the higher the return. The irrigation concentration at these sites offers a unique opportunity to provide low and cost-reflective rates (i.e. $.18/kWh) for rural communities. However, careful consideration needs to be taken of irrigation practices. The model assumes some level of adopting international best practices, and discussions with ATA indicate that technical support may be forthcoming in assisting this effort. However, in the case that there is resistance by the farmers to adopt such practices, this would result in reduced water demand and affect the business case.

Additionally, there is a limit to the generally solid financial returns: as we can see from site Toli Kersu, which has a relatively small irrigated acreage and a high number of regular customers, the level of cross-subsidization that makes the other sites financially viable does not have much of an impact here. In fact, even when we increase the upfront connection charge paid by all regular customers 5-fold (Scenario 2), the return for Toli Kersu is still negative.

When we compare the hectares under irrigation vs. regular connections with the IRR, the relationship is quite clear. The reason why 'regular connections per hectare' is a good metric is because it approximates the cost and revenue structure very well. The household connections are a cost in the sense that a) they drive the cost of distribution, and b) need to be subsidized for every kWh they consume. Therefore, the larger the number of household connections, the higher the amount of subsidy required. Almost all revenue comes from the irrigation; therefore, the more hectares that need to be irrigated, the more the profit potential. Thus, this 'regular connections per hectare' is a great way to characterize each site, as can also clearly be seen in the plot against IRR shown below.

[16] It should be noted that the irrigation demand depends heavily on the availability of water and the level of sophistication of the farmer. The amounts assumed here are 'best practice', which may or may not be feasible in reality.

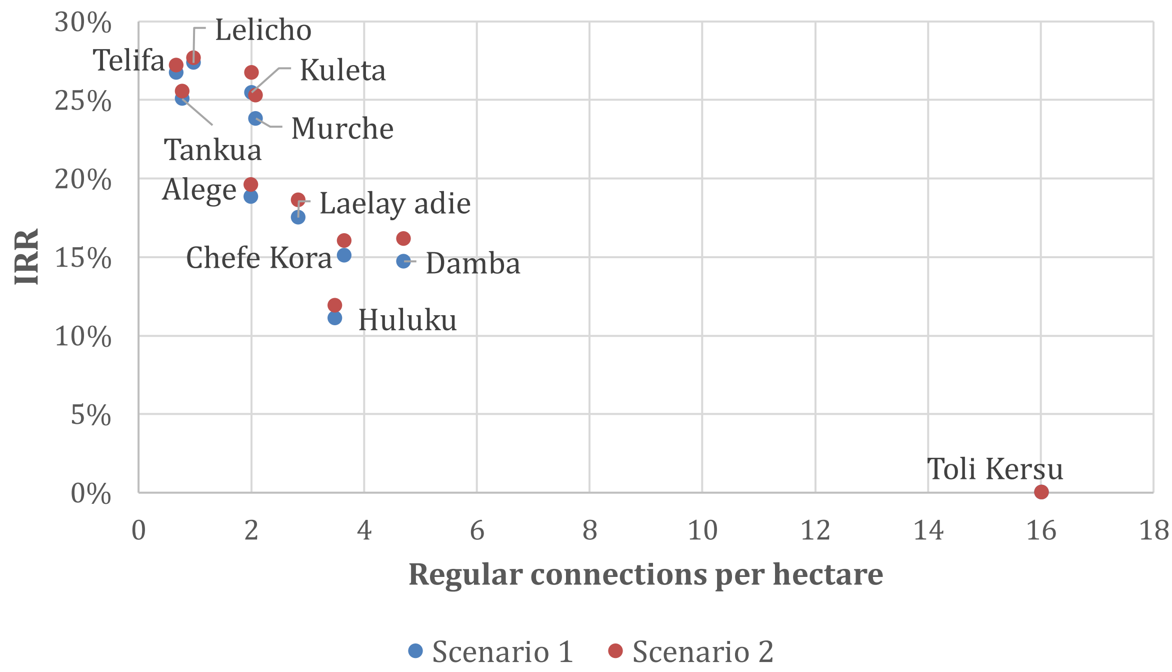


Figure 17: Comparing regular connections per hectare against IRR

From another perspective, the chart below shows the overall size of the irrigated area, and hence the potential demand, plotted against estimated IRR. All sites that have over 200 ha of irrigated land have estimated IRRs over 20%, and all below 200 ha have estimated IRRs below 20%.

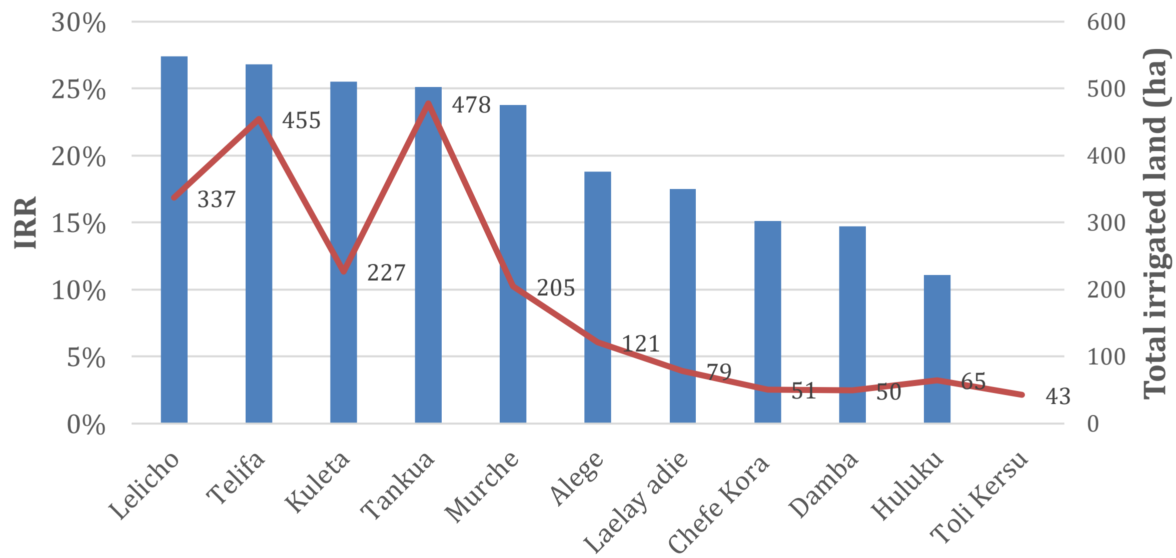


Figure 18: Total irrigated land vs IRR

Scenario 3 looks at the capital subsidy required (in this case implemented as RBF, which is becoming the normative model in the mini-grid sector) to make the project viable if all consumers were charged at the national grid tariff of $0.067/kWh. This subsidy improves the IRR to 21%, which is within the target range for investment.

It should be noted that even in the subsidized scenario, the sites Toli Kersu and Huluku are not financially viable as standalone projects, but the return for the aggregated projects overall works. Therefore, it is important to consider allowing a small number of developers to develop and operate multiple sites that work as a combined project, so as to have a type of cross-subsidization between sites as well as between the user segments.

Additionally, subsidy/grant funding should be considered only at the sites where no viable model can be established; commercial tariffs should be allowed at sites where this is workable. We believe that ETB 6/kWh (~ $0.18 per kWh), lower than national grid rates in many countries, is a very reasonable rate for productive uses, and, therefore, would be a very suitable model to enable agricultural and industrial development at minimum cost to the public.

This introduces an important policy discussion with MoWIE. Should sites such as Toli Kersu and Huluku be included as part of a project package and benefit from a cross-subsidization between sites? Certainly, the anchor tariff of $0.18/kWh in Scenario 1 is competitive and there is room to increase it sufficiently to achieve acceptable returns. Equally, structures such as RBF are common mechanisms to meet the same ends. However, the discussion will likely weigh on the competing goals of introducing commercially viable investment platforms for mini-grids, and the country's ambitious goals for universal electrification.

To provide some context we conducted some simple sensitivities for Scenario 1:

- If the tariff is increased to $0.30/kWh for anchor customers, then the project IRR improves to 30% from 17.6%.
- If Toli Kersu is removed from the portfolio and anchor tariff remains at $0.18/kWh, then Scenario 1's IRR would improve to 25.6% from 17.6%.

These modulations and their variable returns illustrate that multiple paths can be taken to achieve sufficient returns. The initial hypothesis considered was that the unsubsidized anchor tariff would range between $0.35 and $0.45/kWh. However, as the details of these pilots become more grounded, it is imperative that MoWIE and EEA continue to consider some level of subsidy if warranted.

5.3 Sensitizing Results for Irrigation

The above analysis considers successful agriculture sector intervention to stimulate irrigation practices to near-ideal levels. Annex 1 details these assumptions. This section of the analysis considers a less optimistic irrigation demand scenario.

The load for anchor irrigation customers is estimated to account for the bulk of the power requirement for these pilot sites. These anchor loads and the higher tariffs that can potentially be applied to them are the foundation of why the pilot sites are commercially viable. Therefore, in this portion of the study, we examine an alternative to the base case, wherein farmers do not fully adopt ideal irrigation practices. As Annex 1 illustrates, in this alternative case we assume an approximately 40% reduction in water usage for irrigation. These figures thus assume that farmers will not fully adopt irrigation recommendations and may serve as a proxy for a 'pessimistic case' adoption of anchor demand.

To factor for such anchor demand expectations, the tariff assumptions are amended, as shown in the table below. Since this case is illustrative of the sensitivity of irrigation, we only provide analysis for Scenario 1. All other variables such as connection fees and capital structure are held constant to the base case.

Table 21: Tariff used in low irrigation demand analysis

		Scenario 1
Business energy charge	ETB/kWh	6 ($0.18)
Irrigation (anchor) energy charge	ETB/kWh	10.23 ($0.31)

The increased tariffs help to offset the potential diminished demand from anchor customers and result in an estimated 15.0% IRR for the whole project.

Significantly, the CAPEX required for the power system will decrease substantially from $9.1 million to $5.8 million because of reduced PV ratings. Considering that the daytime load comes predominately from irrigation, the reduction in this load due to poor irrigation practices results in a lower PV rating in kWp. The battery rating is not affected as much, as the evening load, which is served by batteries, does not change.

Table 22: Capacity and financial outcomes per site for low irrigation demand case

	IRR	NPV	Est. PV Rating (KWp)	Est. Battery Rating (KWh)	Power System CAPEX	Distribution CAPEX	Distribution $ / Connection
Toli Kersu	0%	(2,307,992)	140	290	282,612	143,147	208
Chefe Kora	11%	(104,133)	81	48	108,712	110,431	597
Huluku	0%	(634,310)	104	113	162,573	104,302	462
Alege	12%	(173,372)	193	129	265,229	109,120	453
Damb	11%	(89,496)	80	48	107,847	82,864	351
Tankua	32%	829,642	767	64	846,837	122,978	331
Telifa	34%	910,444	730	64	807,923	83,938	273
Kuleta	32%	410,727	364	64	417,748	69,105	152
Laelay adie	22%	21,325	126	32	148,688	82,372	371
Murche	29%	249,979	266	48	305,643	89,286	209
Lelicho	35%	1,444,863	1,093	97	1,209,607	101,910	310
Average	N/A	N/A	359	91	423,947	99,950	338
Total	**15%**	**1,187,695**	**3,945**	**999**	**4,663,419**	**1,099,454**	**3,715**

To assess the general sensitivity of the anchor tariff in this diminished irrigation case, we considered a \$0.40/kWh anchor tariff, again under Scenario 1. The IRR is increased to 25% with a \$0.40/kWh anchor tariff from 15%, where the anchor tariff was set to \$0.18/kWh.

It should furthermore be noted that agriculture practices are seasonal and depend on the region, crop, timing of planting, etc. ; the model in this respect uses averages to approximate the typical demand over a certain period. We recommend additional work be undertaken to add a layer of detail to this analysis in collaboration with ATA, which we have already begun. This collaboration has allowed us to get a better sense of the viability of the agriculture model in specific locations/areas, which also include the actual capacity of available of water resources.

6 Conclusion and Next Steps

This pre-feasibility report provides commercially viable mini-grid investment opportunities in Ethiopia. The specific sites selected represent a unique dynamic in the Sub-Saharan landscape. Each site has a concentration of farmers that are already performing productive use activities, albeit with the use of diesel generators. Furthermore, as part of a larger program, the ACCs present ample opportunity for scale. The farmers have a reasonably higher relative level of income because of higher price points for irrigation dependent on horticulture products; this helps to greatly alleviate potential concerns about capacity and ability to pay for electricity tariffs. Lastly, consistent with the trend across the continent, off-grid systems such as mini-grids are now a key part of Ethiopia’s national electrification strategy.

The potential financial returns from mini-grid investment are compelling. Looking at the most conservative scenario -Scenario 1 with an anchor customer tariff of $0.18/kWh – we estimate that the investor can expect an IRR of 17.6% without a subsidy. This includes one site, Toli Kersu, that is a substantial drag on returns, and several others that are expected to have IRRs over 25%. Removing Toli Kersu from the portfolio would immediately improve the IRR to 25.6% from 17.6%. Alternatively, with a 43% RBF facility and reduced $0.06 tariffs across the customer spectrum, the sites would collectively provide an IRR of 22.5%.

There are two competing dynamic factors that largely govern returns within the context of the pilot sites. First, there is a strong and positive correlation between the amount of land that is expected to be irrigated and financial returns. Intuitively, this makes sense since the anchor loads are what attract investment to these sites. Conversely, the more household connections present at the sites, the more depressed the returns are. This is a function of the reality that households pay subsidized tariffs and have very low consumption numbers. Thus, they typically offer a poor return to connection. Such dynamics are why developers do not invest in a single site, but instead a package of sites.

It also bears noting that the authors of this report have endeavored to design an investment portfolio that is commercially viable without a public subsidy; this is not a common scenario for rural communities in the continent, and the concentration of irrigation farmers allows for such discussion. However, subsidies are common features for mini-grids in Africa. Should further due diligence result in somewhat less optimistic returns, subsidies are a variable that the Government of Ethiopia should be amenable to.

Potential PPP business models have been referenced in this study, but have not been explored in detail. This relative omission is purposeful. The authors do not believe that anchoring a particular viewpoint or design beyond the general designs that the government has forwarded will serve further negotiations constructively.

There are risks that potential developers should be particularly sensitive to, as with all investments. From a power demand perspective, the likelihood of irrigation farmers transitioning from diesel to electricity is an important assumption. Similarly, this study has assumed irrigation practices as recommended by the FAO; the ATA has indicated an interest in supporting farmers in their adoption of such best practices, and even potentially implementing more centralized systems that are frequently found in large commercial farms. Significantly stunted adoption of such irrigation practices will have a negative impact on both the frequency and volume of irrigation and thus on energy demand. Beyond these contextualized risk factors, investors should conduct their own country-level risk assessments. The financial analysis has attempted to account for this by providing an irrigation demand reduction of 40% from the base case assumption. Under this set of assumptions, Scenario 1 will need an unsubsidized anchor tariff of between $0.30/kWh and $0.40/kWh to achieve an IRR of over 20%.

Going forward, a program has been developed to support the potential pilot investment sites that Veritas Consulting will be supporting under the cooperation and supervision of MoWIE. This will include substantially deeper assessments of site level demand dynamics for the anchor customers, support for EEU and EEA in the development of tariff guidelines, support in streamlining the investment process, and the identification of potential donors to de-risk these pilots while concurrently defining a scale-up pathway. It is expected that a series of private developer workshops will be held, and, in the interests of assuring qualified developers have access to these workshops, both MoWIE and institutions such as the African Mini-grid Developers Associations (AMDA) will play a convening capacity.

ANNEX 1

The financial results for these pilots can be particularly sensitive to substantial deviations in the assessed demand for irrigation and what actual demand will ultimately be. At this stage of the pre-feasibility assessment, detailed and site-specific water requirements from farmers is not available. Therefore, some generic data is used.

The financial model deployed incorporates water usage assumptions for a number of crops based on the various growth stages of each crop, and assuming drip irrigation. It should be noted that these water requirements are based on 'best practices' for these crops, and do not consider the specific locations that the crops are grown.

In terms of assessing the energy requirements related to providing the amount of water required, monthly averages are incorporated rather than the actual amount of water required each month. This is done because: a) this will depend on exactly when a crop is planted; and b) the timing of the revenue matters less than the annual total for the revenue assessment.

We have taken into consideration the estimated annual rainfall and deducted this from the water requirement, again on a monthly basis. Overall, we believe this illustrates a relatively accurate picture of the expected outcomes. The table below provides the base case water requirements applied to the model.

Table 23: Farmer business models – base case

Farmer Business Models - Base Case										
		Crop:	Average	Tomato	Onion	Mango	Avocado	Banana	Onion & Tomato (50/50)	Banana+ Avocado (50/50)
BASE CASE SCENARIO										
Water requirement	Early growth	m3/acre/day	6.3	4.0	8.0	8.0	8.0	4.0	6.0	6.0
	Flowering	m3/acre/day	8.5	8.0	8.0	10.0	10.0	7.0	8.0	8.5
	Maturation	m3/acre/day	12.0	10.0	6.0	18.0	18.0	10.0	8.0	14.0
	Production	m3/acre/day	12.0	10.0	6.0	18.0	18.0	10.0	8.0	14.0

The table below provides the irrigation assumptions applied to the alternative case in which irrigation uptake is substantially diminished. Irrigation practices vary from region to region and from site to site. These reduced demand assumptions are based on interviews with agriculture experts in the region and subsequent assessments from the Veritas team. The goal of this exercise was to ascertain what the mimum irrigation use, and thus demand for power, would resemble after technical support to support the farmers adopt better irrigation practices.

Table 24: Farmer business models - Alternative case

Farmer Business Models - Base Case		Crop:	Average	Tomato	Onion	Mango	Avocado	Banana	Onion & Tomato (50/50)	Banana+ Avocado (50/50)
ALTERNATIVE CASE - Tier 2 irrigation (40% reduction)										
Water requirement	Early growth	m3/acre/day	3,8	2,3	5,1	4,2	4,2	3,5	3,7	3,85
	Flowering	m3/acre/day	5,4	5,1	5,1	5,5	5,5	6	5,1	5,75
	Maturation	m3/acre/day	6,8	6,5	3,7	9,7	9,7	5,5	5,1	7,6
	Production	m3/acre/day	6,8	6,5	3,7	9,7	9,7	5,5	5,1	7,6
REDUCTION IN IRRIGATION LEVELS										
Water requirement	Early growth		39%	43%	36%	48%	48%	13%	38%	36%
	Flowering		36%	36%	36%	45%	45%	14%	36%	32%
	Maturation		43%	35%	38%	46%	46%	45%	36%	46%
	Production		43%	35%	38%	46%	46%	45%	36%	46%