POLICY BRIEF: ACHIEVING FOOD SECURITY IN KENYA THROUGH SMART SOLAR IRRIGATION

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ACRONYMS & ABBREVIATIONS

- SHF: SMALL HOLDER FARMER
- SWP: SOLAR WATER PUMP
- HH: HOUSEHOLD
- RBF: RESULTS BASED FINANCING
- SME: SMALL AND MEDIUM ENTERPRISES
- CGS: CREDIT GUARANTEE SCHEME
- LGF: LOAN GUARANTEE FUND
- NPV: NET PRESENT VALUE
- GDP: GROSS DOMESTIC PRODUCT
- MT: METRIC TONNES
- NTL: NIGHT-TIME LIGHT
- PAYG: PAY-AS-YOU-GO
- ROI: RETURN ON INVESTMENT
- SSA: SUB-SAHARAN AFRICA
- PV: PHOTO-VOLTAIC

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EXECUTIVE SUMMARY

Kenya has set a goal of reaching 100% food security in the country as part of the President's Big 4 Agenda, with irrigation as a key part of the solution. 11 million people are actively employed in primary production agriculture, with the majority of these (80%) in small holder farms of less than three acres. In the FY19/20 budget, several food security priorities were announced, including i) reducing over-reliance on rain-fed agriculture; ii) developing 85,000 acres under the National Expanded Irrigation Programme, and iii) increasing area under smallholder irrigation by 1,617 acres.

Solar water pump uptake is nascent but is primed to play a major role in agriculture in Kenya. In order to achieve the government's goals, solar irrigation must be part of the answer. With irrigation, a farmer can increase their production between 2 and 4 times, and their income between 2 and 6 times.[1] Whilst diesel pumps and large-scale irrigation programmes are common, fewer than 10,000 solar water pumps are purchased in Kenya annually. SWP's upfront costs are typically 2-3 times more expensive than a diesel pump. However, as they operate on sunlight (i.e. environmentally friendly), have reduced maintenance costs, and have a longer lifetime duration, SWP's costs to a farmer are less than half that of a diesel pump over their lifetime – and many current suppliers offer monthly payment terms to reduce the upfront cost. In addition, SWP can also penetrate the market faster thanks to their decentralized model. The uptake is not conditional on a few major programmes run by institutions; but instead it is a purchase decision made by farmers across Kenya.

To accelerate uptake of solar water pumps by farmers, government and other supportive actors need to invest in ambitious policy interventions. In this paper, we propose a set of investments for policymakers to consider, which have positive financial returns that could accelerate the uptake of SWPs and contribute to Kenya's food security agenda.

With multiple policy interventions combined, irrigation through solar water pumps will increase farmer income, food production, resilience, and reduce food imports – thus supporting the national Big 4 Agenda goals. In our 'multiple intervention' scenario, we expect farmer income to increase: 1.7 Million farmers will increase their daily income by an average of 177% by 2030, through better yields, planting of higher value crops; and selling produce off-season for higher prices. We expect national food production to increase significantly (from 23.2 Million MT in 2020 to 65.5 Million MT in 2030). We also expect imports of key staples to fall: currently 529 Thousand MT of maize is imported annually,[2] and this gap would be largely met.[3] Resilience would also improve – in any given year in Kenya there is a 40% chance of drought - and with a reliable pump, production can continue even when rains fail. All of these factors contribute to greater food production, resilience, and income for farmers.

1. The increase in production varies by crop; from 100% for maize and beans, 200% for cabbage and kales up to 386% for tomatoes
2. ITC Trade Map
3. Production of maize calculated based on the 'multiple intervention' scenario. The projected maize production in 2030 is estimated to reach 527 Thou

The graphs below illustrate the impact of the uptake of solar water pumps compared to the National Irrigation Program and the Big 4 Agenda.

INCREASE IRRIGATION

Under the National Water Master Plan 2030, the Government of Kenya aims to irrigate an additional 803,000 hectares by 2030.[4] Under the combined policy interventions, the land irrigated is projected to exceed the targets, by reaching 1.3 Million hectares. Currently 3% of arable land in Kenya is irrigated; well below the Sub-Saharan average of 7%. Under the interventions proposed in this brief, this could rise to between 7.5% and 22% of arable land (depending on the combination of interventions selected); whilst ambitious, this would still be well below Southern Asia (50%) or Eastern Asia (61%) regions.[5]

THE LAND IRRIGATED WILL EXCEED THE PROJECTED IRRIGATED LAND IN THE NATIONAL WATER MASTER PLAN

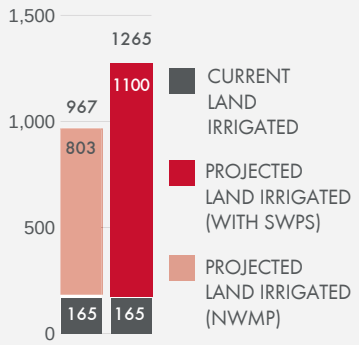


FIGURE 1: INCREASE OF LAND IRRIGATED UNDER COMBINED POLICY INTERVENTIONS (THOUSANDS OF HECTARES)

REDUCE FOOD INSECURITY

The Big 4 Agenda has set a goal to reduce the number of food insecure Kenyans by 50%. Around 3.1 Million Kenyans are currently food insecure.[6] Under the combined policy interventions, 6.8 Million Kenyans are likely to benefit from an increase of food production.

FOOD PRODUCTION WILL INCREASE 44% SUPPORTING THE AIM OF A 50% REDUCTION IN THE NUMBER OF FOOD INSECURE KENYANS

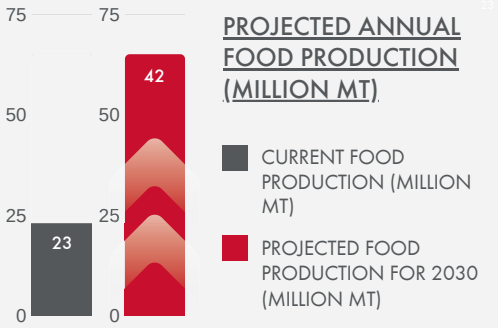


FIGURE 2: PROJECTED ANNUAL FOOD PRODUCTION DUE TO COMBINED POLICY INTERVENTIONS (MILLION MT)

INCREASE AGRICULTURAL GDP

The Big 4 Agenda aims to increase the proportion of GDP attributed to agriculture, by 48%. If all four interventions were chosen, the increase of food production due to solar irrigation will result in a 35% increase in the proportion of agriculture in Kenya's GDP in 2030[7] (from 26% of GDP to 35% of GDP).

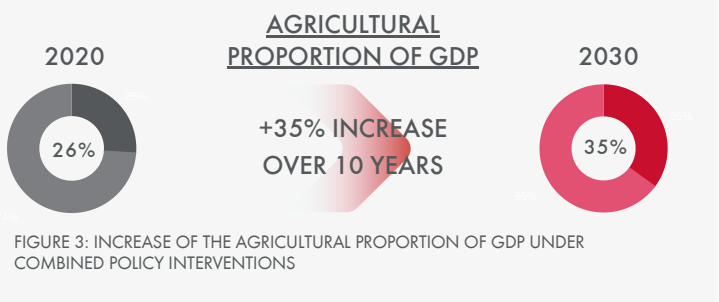


FIGURE 3: INCREASE OF THE AGRICULTURAL PROPORTION OF GDP UNDER COMBINED POLICY INTERVENTIONS

4. FAO, Irrigation market brief
5. World Bank figures
6. USAID, Food Assistance Fact sheet, 2019
7. Kenya's GDP is assumed to grow at 6% average rate per year until 2030

INCREASE SMALL HOLDER FARM INCOME

The Big 4 Agenda has set a goal to increase the average daily income of farmers by 34%. The expansion of irrigation will lead to higher yield and incentivize farmers to grow higher value crops. This will enable farmers to increase their income well above this target.

THE INCOME INCREASE WILL EXCEED THE OBJECTIVE OF 34% INCREASE OF SHF INCOME

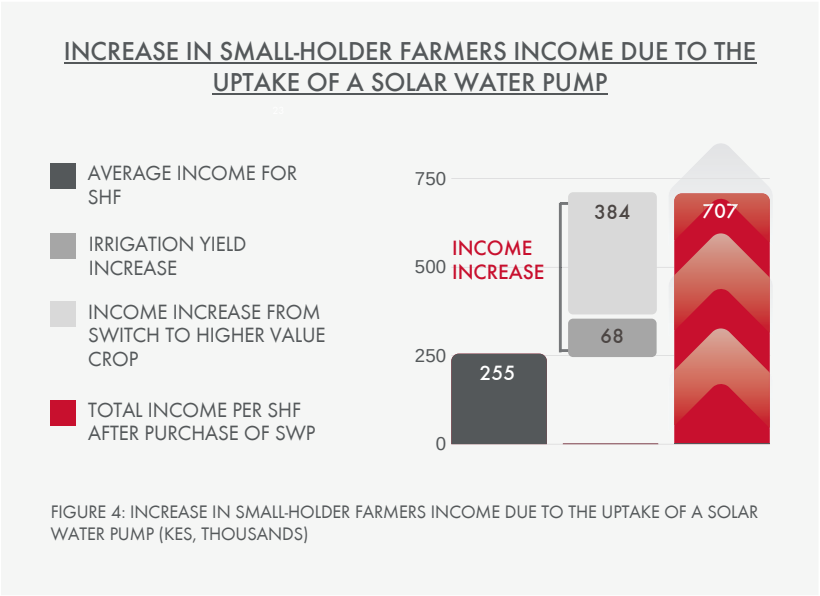


FIGURE 4: INCREASE IN SMALL-HOLDER FARMERS INCOME DUE TO THE UPTAKE OF A SOLAR WATER PUMP (KES, THOUSANDS)

PROPOSED INVESTMENT STRATEGY

To achieve these goals, there are four investments proposed to increase production and smallholder income, which could dramatically scale up the solar water pump market. Once the market is at scale, it will continue to grow through increased income by smallholder farmers, and improved economies of scale for distributors and financiers. These investments are described as follows:

1. Subsidy to incentivize uptake: In areas with reliable water access, the single greatest constraint to SWP uptake is affordability. A 50% subsidy on solar water pumps would dramatically increase uptake by bringing SWPs within the reach of more SHFs. After five years, the subsidy could be removed, and the government would generate revenue from a much larger market.
2. Incentivize financial institutions to extend credit: To make SWPs widely affordable, they must be offered on Pay-As-You-Go credit; yet today credit is offered by the SWP distributors (who have limited finance) rather than financial institutions.[8] Today, each individual SWP company operates as its own financier, which creates operational complexity and raises the cost of finance. A risk-sharing mechanism would incentivize financial institutions to consider offering credit directly, thus increasing the amount of credit, and extending the payment period for farmers.
3. Support a wide scale awareness programme: Because SWPs are a relatively new technology in the Kenyan context, farmers often are unaware of their benefits; thus, each individual company has to educate farmers themselves. Leveraging government infrastructure and extension workers could dramatically improve awareness and accelerate SWP uptake, helping the market achieve scale more quickly.
4. Provide financial support for water access: Many parts of the country struggle with water supply; but without to access to water, irrigation is not possible. Incentives for appropriate local water access would increase the pool of farmers who could irrigate with a Solar Water Pump.

8. There are several advantages to decouple the distributors of SWP with financing. It allows debt investors to isolate the risk of customers non-payment from the risk of the company. It also allows companies to outsource financing to financial institutions that have greater experience in managing risks and larger balance sheet (Daniel Waldron et al, (2018), Taming the Strange Beasts: Servicing and the Future of PAYGo.

A county-level pilot using combined set of all four interventions, would be the most effective way to refine the roll-out and implementation approach. The projected impact of each intervention, against a 'base case', is provided below:

INTERVENTION	TOTAL UNITS OF SWPS SOLD IN NEXT 5 YEARS (ABSOLUTE VALUE)	TOTAL FOOD PRODUCTION IN 5 YEARS (MT, CUMULATIVE)	INCREASE OF SMALL-HOLDER FARMER INCOMES OVER 5 YEARS (KES, CUMULATIVE)
DESIGN A TARGETED SUBSIDY SCHEME FOR SMALL-HOLDER FARMERS AIMED AT PURCHASE OF SWPS (COST: 9.6 BILLION KES)	274 K UNITS SOLD	7.1 MILLION MT	622 BILLION KES
EXTEND RISK SHARING AGREEMENT TO FINANCIAL INSTITUTIONS TO ENABLE BETTER FINANCING OF SWPS (COST: 480 MILLION KES)	171 K UNITS SOLD	4.4 MILLION MT	388 BILLION KES
RAISE AWARENESS OF THE BENEFITS OF SOLAR IRRIGATION (COST: 318 MILLION KES)	119 K UNITS SOLD	3.1 MILLION MT	271 BILLION KES
PROVIDE FINANCIAL SUPPORT TO INCREASE ACCESS TO WATER SOURCES (COST: 2.8 BILLION KES)	154 K UNITS SOLD	4.0 MILLION MT	347 BILLION KES
BASE CASE – GROWTH WITHOUT POLICY INTERVENTIONS	103 K UNITS SOLD	2.7 MILLION MT	261 BILLION KES

FIGURE 5: IMPACT OF EACH POLICY INTERVENTIONS IN TERMS OF SWPS SOLD, TOTAL FOOD PRODUCTION IN 5 YEARS AND INCREASE OF SMALL-HOLDER FARMER INCOMES

INTRODUCTION

OBJECTIVE

This policy brief aims to show the positive business case for stimulating the growth of the Solar Water Pump (SWP) Market in Kenya. The policy brief has four main sections:

- Current Market and Constraints: A projection of the market size for SWPs for the period 2020 – 2030, including an assessment of the constraints to the market being able to scale.
- Policy Recommendations: The business case for a set of high priority policy interventions to increase uptake of SWPs, and thereby drive increased irrigation and food security.
- Aggregate Impact: An assessment of the impact of SWPs and these policy interventions on smallholder farmers (SHFs) yield and income over the period 2020 – 2030.
- County Roll-out: The projected uptake per county under a 'combined interventions' scenario, along with a deep dive on a selected county.

This policy brief highlights the impact, potential scale of opportunity, and policy recommendations for solar irrigation technologies in Kenya. This brief was commissioned by Mercy Corps AgriFin Accelerate (AFA) and was developed by Dalberg.

CONTEXT

Kenya has less than 5.5M hectares of arable land of which only 17% is suitable for rain-fed agriculture. This land currently supports 80% of the rural population.[9] Furthermore, productive crop areas are shrinking. To achieve national food security goals, SHFs, who produce 78% of Kenya's food,[10] need to embrace ways to increase yields and to increase the area under cultivation. Agriculture is also a backbone of the economy - accounting for 26% of Kenya's GDP directly and another 27% indirectly.[11]

However, today just under 3% of Kenya's arable land (<165,000 Ha) is irrigated with the rest relying on unpredictable rainfall to meet water needs.[12] Low levels of public and private investment in irrigation in the past have generally hindered its development in Kenya. Poor physical infrastructure and land tenure constraints have also contributed to low private sector participation.[13]

Reaching 100% food and nutrition security is a key priority for the nation of Kenya. The National Water Master Plan 2030 aims to increase the irrigated area up to approximately 970,000 hectares by 2030.[14] One of the President's flagship Big 4 Agenda projects is the irrigation programme at Galana Kulalu Food Security Model Farm, which aims to irrigate 10,000 acres for KES 7.3 Billion KES (approx. $7,300/acre; significantly more than solar water pumps).[15] The aim of programmes such as these as stated in the President's Big 4 strategy is to create a 34% increase in daily income for farmers; a 48% increase in agriculture sector contribution to GDP, and a 50% reduction in the number of food insecure Kenyans by the end of the Big 4 Agenda.

9. 2030 Water Resources Group. Agricultural and Irrigation opportunity in Kenya, 2016
10. DFID. Agricultural Productivity in Kenya, 2018
11. FAO 2020. The Agriculture Sector in Kenya, 2019
12. DFID. Agricultural Productivity in Kenya, 2018
13. FAO. Kenya: Irrigation Market Brief, 2015
14. Ibid
15. President.go.ke – Big 4 Agenda projects – stated targets

The solar water pump can play a critical role in improving the incomes and resilience of rural households while unlocking environmental benefits. Solar water pumps have the potential to increase yields two to four-fold depending on crop and climate.[16] Solar water pumps also expand seasonal growing cycles and mitigate periods of low or irregular rainfall.[17] Off-cycle planting with SWP generates additional income, hence creates greater general resilience for farmers by creating more wealth. This provides households with increased and more predictable disposable income to pay for other outgoings and save for emergencies, thereby reducing vulnerability to risks.[18] With more stable income flows, farmers can progress up the "agricultural productivity ladder", making further investments in machinery, inputs and technology. However, affordability, limited awareness, and unreliable water access remain critical barriers to the uptake of solar irrigation technologies in Kenya. Accelerating the uptake of SWPs could create a large impact on yield, income, and contribute to addressing the food security challenge in Kenya. To do so, the aforementioned barriers need to be addressed, and government as well as donors have a significant role to play.

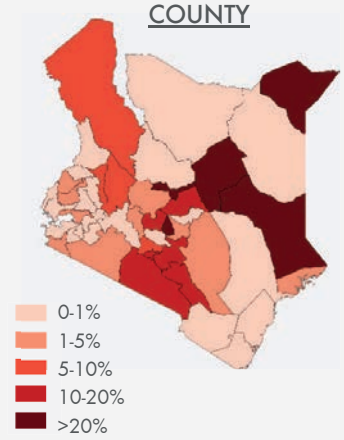


FIGURE 6: IRRIGATED LAND PER COUNTY IN KENYA

CASE STUDY: DAVID MUTUGA

David Kirubi Mutuga is a full time farmer who owns 3 acres, 1 cow and 17 rabbits. He is cropping cabbages and potatoes. Before purchasing a solar water pump, David was using a petrol generator and was fetching water manually for his agricultural and domestic activities. Thanks to his solar water pump, he significantly increased the irrigation of his farm with 2500L of water per day.

David improved the yield of his farm (from 80 bags of potatoes to 120). He is now able to use water during dry season. David also increased his income by ten times. During dry season one cabbage is worth KES 50, while in rainy season it is worth KES 5. David is also reporting an increase of KES 40,000 for potato cropping. Because he is not using a petrol generator anymore, he is saving roughly KES 500 per week in petrol costs.

METHODOLOGY

This paper aims to demonstrate the value of various policy interventions to accelerate the uptake of SWPs. To do so, we have estimated the difference between baseline uptake and the estimated uptake with various policy interventions, then calculated the estimated impact in terms of food production, yields, resilience, and farmer income. The assessment utilizes data on income distribution at a sub-location level (for 6000+ unique regions across Kenya), off-grid data based on nighttime lighting (NTL) from satellite imagery, water access availability per source (e.g. borehole, well, tank, etc.), and crop data from the Ministry of Agriculture and the Food and Agriculture Organization. A number of industry players were also interviewed to understand the most significant bottlenecks faced, and to understand what could drive uptake and thus impact for smallholder farmers.

16. Efficiency for Access Coalition. Solar Water Pump Outlook 2019: Global Trends and Market Opportunities, 2019
17. Ibid
18. Ibid

CURRENT SOLAR IRRIGATION MARKET & CONSTRAINTS

There is high potential for small holder farmer-led irrigation to be a route to increasing food resilience in Kenya. 97% of Kenya's agriculture is rain-fed with just 3% of arable land irrigated.[19] This makes Kenyan farmers highly susceptible to climate change and climate variability including seasonal rainfall and increased frequency and intensity of extreme weather and climate events such as droughts.

Additionally, a rapidly growing population exacerbates Kenya's food security situation. For instance, due to Kenya's slowing production growth, the country will need to increase maize supply by 27% over 2016-2022 to satisfy its 2022 domestic needs.[20] Kenya, currently imports 29% of its maize, 82% of its wheat, and similarly 82% of its rice[21] – the three most popular staples. As a result, the country faces an increasingly challenging task to feed its rapidly growing population. High competition over limited water resources and a need to consider the environmental sustainability of agricultural investment mean water-efficient, advanced irrigation systems are increasingly in demand.[22]

KENYAN IRRIGATION LANDSCAPE

The current market for solar irrigation products is nascent and structured around both public and private players, with significant potential to scale. Currently, irrigation development is led by the private sector and by smallholder irrigation schemes with particular emphasis on sustainable development. The private sector has spearheaded irrigation development in areas close to urban centers for local vegetables and high-value horticultural produce for the export market.[23]

Several international development agencies run limited technical cooperation programs on distributed solar systems; however, the existing incentives from these programmes are targeted more broadly at solar home systems rather than solar water pump irrigation. A non-exhaustive table of major players in the irrigation space is highlighted below.

OVERVIEW OF KEY ACTORS (NON EXHAUSTIVE)

SWP SUPPLIES	Futurepump, GRUNDFOS, SunCulture, D&S DAVIS & SHIRTLIFF	Key activities in the private sector focus mainly on distribution, delivery of irrigation solutions and technology, equipment maintenance, as well as extending credit to farmers to purchase a SWP.
FINANCIAL INSTITUTIONS	EQUITY, abc, KWFT, Rafiki, JUHUDI KILIMO, Century Bank	Financial institutions provide loan products to farmers, including asset financing. However, these institutions rarely extend financing to small-holder farmers due to the default risks. Juhudi Kilimo recently launched one of the first credit facilities for solar irrigation in Kenya
REGULATORY BODIES	Ministry of Agriculture, Livestock, Fisheries and Irrigation, Kenya Agricultural Research Institute, KVDA	Government-led, multi-stakeholder platforms to facilitate private sector collaboration aimed at increased sustainable water access focused on ground water management, industrial water use efficiency & surface water quality management
IFIS/ DONORS	Food and Agriculture Organization of the United Nations, JICA	Development agencies and non-profits tackle a wide range of issues including funding for irrigation projects and water management solutions

FIGURE 7: MAP OF KEY ACTORS IN THE KENYAN IRRIGATION LANDSCAPE

19. 2030 Water Resources Group. Agricultural and Irrigation opportunity in Kenya, 2016
20. Agricultural Sector Transformation and Growth Strategy. Towards Sustainable Agricultural Transformation and Food Security in Kenya 2019-2029, 2019
21. US Dept of Trade. Kenya Country Commercial Guide, accessed 2019. Export.gov
22. FAO. Kenya: Irrigation Market Brief, 2015
23. Ibid

There are a wide range of solar water pumps available in the market: electric-only, diesel, solar water pumps, human-powered manual pumps and wind-powered water pumps. This policy brief will focus on solar water pumps (SWPs) that have a lower cost of operation that the other options available in the market, as well as their ability to operate off-grid across Kenya. In addition, SWPs can unlock environmental benefits due to no ongoing emissions, and a longer product lifetime.

CONSTRAINTS TO SOLAR WATER PUMP UPTAKE

Three major constraints slow the uptake of solar irrigation: (i) Affordability, (ii) Awareness and (iii) Water Access:

AFFORDABILITY

Affordability remains one of the greatest challenges to growing the market for solar water pumps. Of the 2 Million off-grid rural households with access to water in Kenya, 800,000 cannot afford a pump – even if payments are made over multiple years and a large proportion of income is allocated to this.[24] A study of the Kenyan solar water pump market found the lack of smallholder financing for irrigation was a key obstacle to solar water pump sales.[25] SHFs cite price as the most important driver of whether or not to purchase, when selecting a pump.[26]

AWARENESS

Despite solar water pumps being available in the market for a number of years, awareness of solar technology, and specifically its use to power water pumps, remains limited in many markets. In East Africa, although 64% of solar water pump customers had owned a solar lighting product before purchasing a solar water pump, 57% of this 'well informed' segment did not know solar technology could be used for irrigation. Furthermore, awareness of the spectrum of modern irrigation solutions, and the full extent of the potential benefits of irrigation, also remains limited.[27] The consequence of this is that each company individually has to educate consumers on the existence, benefits and use of these technologies. This adds to the complexity and costs of operations as most of these consumers are typically located in rural areas and are hard to access. One local water pump distributor currently spends 10% of the sales price on marketing and consumer education (much higher than other durable goods). Given the low level of awareness in the market, there is a high level of marketing and education expense required for first movers in the market to influence consumers to pay; and much of the return on this investment could be captured by their competitors. A government-led awareness campaign for all market players will therefore generate a positive externality, expanding the market for everyone.

WATER ACCESS

Solar water pump reliance on nearby access to water (e.g. borehole, river, dam, well) presents a significant constraint to its uptake. In Kenya, the majority of irrigation is currently by surface water (87% of current hectares under irrigation),[28] but there could be a significant increase in sustainable groundwater usage for irrigation. Aktchenko (2014) estimated that between 173,000 and 447,000ha could be irrigated, sustainably, using ground water in Kenya (up from 20,000ha).[29] The expansion of access to groundwater is a critical factor if the area under irrigation is to be increased and the uptake of solar water pumps is to be accelerated. The average cost of digging a borehole of 150 meters is USD 16,800 – far beyond the affordability of a SHF household.[30] Expanding groundwater access requires significant coordination between national and county governments to ensure sustainability.[31]

24. See annex for full assumptions. Payments made over 18-30 months and 30% of income dedicated to repayments.
25. Solar World Congress. Accelerating Solar Water Pump Sales in Kenya: Return on Investment Case Studies, 2017.
26. Efficiency for Access Coalition. Solar Water Pump Outlook 2019: Global Trends and Market Opportunities, 2019
27. Ibid
28. FAO, Aquastat database, most recent figure (2010)
29. Ibid
30. FAO. Kenya: Irrigation Market Brief, 2015
31. This constraint is incorporated in the assumptions when calculating the addressable market of SWPs

RECOMMENDATIONS FOR POLICY INTERVENTIONS

The adoption of policy incentives will, in the short to medium term, promote the uptake of solar irrigation products in Kenya. The massive scaling of solar irrigation technologies could make a significant contribution to Kenya's food security goals. Irrigation also features strongly in the government's Agriculture Sector Transformation and Growth Strategy (ASTGS).

An 'average' SHF household's disposable income is expected to rise by 177% with the purchase and appropriate use of solar water pumps, although there is wide variation based on the usage, crops grown, and additional choices made (e.g., switching to higher value crops). This increased income can go towards further investments in the farm, as well as towards improvements in the household's financial stability and quality of life (e.g., school fees, medical expenses) and savings that would enhance the household's resilience to shock.

There is a strong case for policy / development partner interventions to accelerate the uptake of SWP. Given the challenges identified, we explore several policy interventions. The interventions fall in three major categories:

- Increasing the affordability of solar irrigation technologies
- Raising awareness of solar irrigation products among SHFs
- Increasing reliable water access for SHFs

For policy intervention options under these categories, we have assessed the potential impact on food production, SHF income, estimated the cost of implementation, and assessed the impact and return on each intervention.

INTERVENTION 1: DESIGN A TARGETED INCENTIVES & SUBSIDY SCHEME

DESIGN A TARGETED INCENTIVES / SUBSIDY SCHEME FOR SMALL HOLDER FARMERS FOR PURCHASE OF SWPS

Affordability remains one of the greatest challenges to growing the market for solar water pumps, with a small pump costing the equivalent of about 6–12 months of income for a typical small holder-farming household.[32] Government support for a targeted subsidy program could incentivize distribution.[33]

A targeted subsidy scheme of 50% of the cost of an approved SWP system, would enable SHFs to increase yields whilst unlocking benefits (increased SHF income) of KES 622 Billion over 5 years. This incentive scheme has been projected as KES 1,950 per household per month and is expected to increase the uptake of SWP 2.7 times over base case. The financial incentive would be a temporary measure applied per solar water pumping system, aimed at expanding the market to a self-sustaining level; at which point economies of scale could continue to reduce the cost for consumers. It is anticipated that the government would re-apply taxes from Year 6 onwards. Due to increased market share for SWPs, the government would be able to recover funds initially dedicated to the subsidy scheme through taxation after year 5.

To note, the global uptake of solar products has been largely driven by subsidies that have effectively stimulated development and attracted private investors. Subsidies were able to effectively stimulate development of solar and attract private investors, enabling a price reduction from $3 per watt in 2000, to $0.4 per watt less than 20 years later.[34]

EXPECTED IMPACT

A targeted subsidy scheme is expected to increase uptake of SWPs by 274,000 units while unlocking benefits of 7.1 Million MT of food production over 5 years. A cumulative increase in SHF income of 622 Billion KES is also estimated.

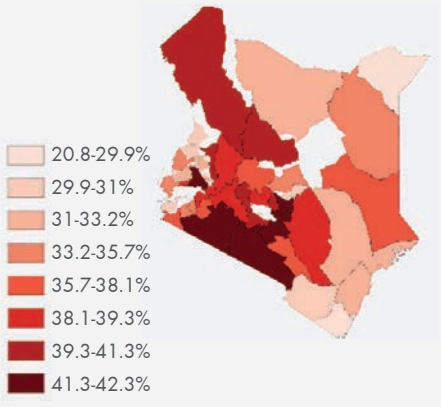


FIGURE 8: PERCENTAGE OF OFF GRID, RURAL HOUSEHOLDS WITH WATER, PER COUNTY THAT ARE LIKELY TO PURCHASE THE SWPS AFTER A SUBSIDY SCHEME

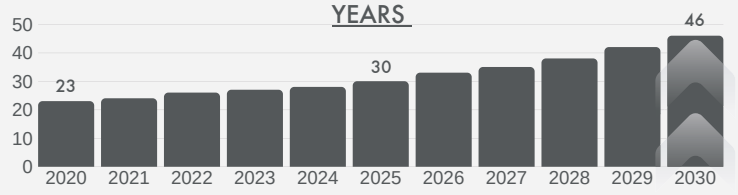


FIGURE 9: PROJECTED AVERAGE ANNUAL YIELD INCREASE IN FOOD PRODUCTION OVER 10 YEARS UNDER THE SUBSIDY SCHEME (MILLION MT)

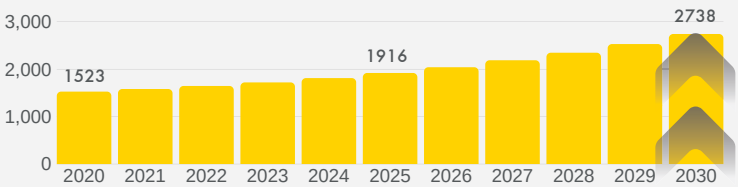


FIGURE 10: PROJECTED AVERAGE ANNUAL INCREASE IN AGGREGATED SHF INCOME UNDER THE SUBSIDY SCHEME (BILLION KES)

32 .The Human Account, 2019; Dalberg analysis
33. Efficiency for Access Coalition. Solar Water Pump Outlook 2019: Global Trends and Market Opportunities, 2019
34. Power for All. Investor Position Paper: Unlocking Private Capital for Mini-Grids in Africa, accessed 2019

ESTIMATED COST

The expected cost of implementing the targeted subsidy scheme is KES 9.6 Billion over five years compared to KES 622 Billion increase in small-holder farmer's income.

IMPLEMENTATION CONSIDERATIONS

The targeted subsidy scheme should adhere to smart subsidy design principles outlined below:

- Target specific areas: Testing the subsidy in one county, and then expanding once the approach is refined, would reduce the risk of the subsidy not being provided in a timely fashion, or its implementation being tied up in red tape. There will be natural variation in the specific target market in different regions of the county.
- Design a market-based solution: The scheme should utilize and support the further development of existing private input supply networks, rather than supplant them with state-controlled distribution systems or mass government purchasing. This enhances the efficiency of input delivery as well as increases the likelihood that the scheme has a sustained impact after its termination.
- Link to payment by the customer: Payment subsidy is paid on a monthly basis and is only paid if the customer also pays their share of the cost. This incentivizes good credit management and follow-up practices from the solar water pump distributor. Over time the farmer will see the increase in yield and be continually educated about the benefits of irrigation. If the farmer stopped paying, the equipment would be returned to the distributor.
- Define a clear exit strategy: The scheme should ensure it has a credible time limit on the support offered (e.g. five years, which could be rolled out county by country in partnership with distributors.) SHFs have the opportunity to be subsidized for one solar water pumping system; after which we expect the increase in yields to cover the cost of a replacement or additional pumps.

This subsidy could be financed by government or donors; organisations like the World Bank have already shown interest in supporting the roll out of similar products, such as those for solar home systems.

CASE STUDY: INDIA

To enhance farmers' financial and water security, the Indian government launched a subsidy scheme to promote the installation of three different components – commissioning of grid-connected solar power plants, installation of stand-alone solar water pumps and solarization of grid-connected pumps The subsidies covered between 50%-70% of total cost and are aimed at the installation of standalone water pumps to replace diesel powered agricultural plants, and solarization of grid connected pumps. Farmers are required to pay only 40% of the cost of the standalone solar pump, with only 10% paid upfront. New installations of solar water pumps rose by 108% CAGR, from 1,055 units in 2012 to 41,479 units by November 2018.[35]

CASE STUDY: TOGO

In March 2019, Togo became the first government in Africa to introduce a subsidy programme for solar energy payments. The government awarded BBOXX (Joint Venture with EDF Group) a tender to provide solar home systems for 300K households. The government awarded a similar contract to Soleva in August 2019. Government will issue monthly vouchers to households with a BBOXX or Soleva system, which covers the cost of the system – household only has to pay the cost of energy consumption.[36] <20% of the rural population currently has access to electricity, the scheme aims to achieve 100% electricity access by 2030.[37]

FIGURE 11: CASE STUDY ON TARGETED SUBSIDY

35. Efficiency for Access Coalition. Solar Water Pump Outlook 2019: Global Trends and Market Opportunities, 2019
36. Reuters, Togo subsidizes off-grid solar to extend electricity access to all, 2019
37. BBOXX, BBOXX Receives First Ever Government Subsidy, 2019

INTERVENTION 2: INCENTIVIZE FINANCIAL INSTITUTIONS

INCENTIVIZE FINANCIAL INSTITUTIONS TO EXTEND CREDIT TO SHFS FOR SWPS

The credit market for SMEs in Kenya is currently constrained by high interest rates and a risk-aversion to lending to SHFs, thus limiting access to much needed financing. Increasing access to finance for farmers through a 50:50 loss sharing scheme would increase the supply of corporate finance in the space and accelerate the growth of the solar water pump market.[38]

A risk-sharing scheme on loans for SWP could incentivize banks and MFIs to provide credit for this purpose, or to allocate funding from their existing agriculture credit guarantees towards SWP purchase. Current repayment rates in the industry are around 85-90%. This intervention has been modelled as the government (and/or donors) shares the cost of defaults 50:50 with the financier. Bringing in external finance allows greater capital into the industry and the repayment term length to be extended from 30 to 36 months, thus bringing down the monthly cost to the SHF by 20% and increasing uptake.

EXPECTED IMPACT

The risk-sharing scheme is expected to increase the number of SWPs over base case reaching 171,000 units over 5 years. This increase in uptake is expected to result in increased food production to 4.4 Million MT by 2025, and a KES 388 Billion increase in SHF income.Whilst the figures are based on affordability constraints, to mass scale SWPs in Kenya, far greater financing will be required than can be provided by the distributors themselves – so linking with financiers will be essential.

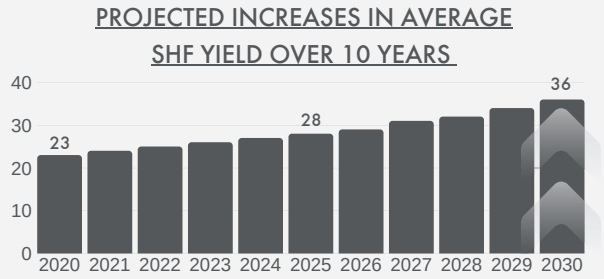


FIGURE 12: PROJECTED AVERAGE ANNUAL YIELD INCREASE OVER 10 YEARS UNDER THE RISK-SHARING SCHEME (MILLION MT)

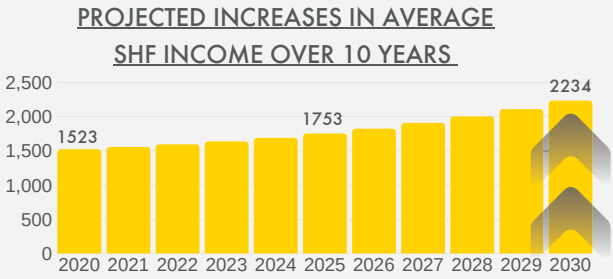


FIGURE 13: PROJECTED AVERAGE ANNUAL INCREASE IN SHF INCOME UNDER THE RISK-SHARING SCHEME (BILLION KES)

ESTIMATED COST

The expected cost of running a risk-sharing scheme is KES 480 Million over five years compared to KES 388 Billion increase in small-holder farmers income.

38. Efficiency for Access Coalition. Solar Water pump Outlook 2019: Global Trends and Opportunities, 2019

IMPLEMENTATION CONSIDERATIONS

- Ensure product quality: To mitigate against potential loss arising from sub-standard pumps, and to help with de-risking for financial institutions,[39] it is vital that pumps bought by consumers are appropriate long-term investment. This can be ensured by requiring pumps bought from loaned funds are high quality (e.g., those with GOGLA certification as an industry standard for all imported and locally manufactured pumps).
- Link first to a pilot: At present, distributors provide their own financing to customers, to support the pay-as-you-go model. Banks are reluctant to lend to SHFs; and this is made more difficult by the need for a close relationship between originator of the loan (i.e., the distributor) and the financier – for example, if the SWP is not correctly serviced by the distributor, then default rates will rise. A supported upfront pilot will be needed to confirm the operational challenges of financiers providing the funds for the SWP
- Use a range of financial services platforms: Given the local expertise to understand county-level agricultural risk, the financiers could be MFIs, banks with significant agricultural expertise, or innovative platforms (e.g., crowdfunding). Simply aiming for a single national bank may not be the most effective way to launch.
- Provide the financing to the SHF, not the SWP company: To scale, SWP distributors will need to focus on their own specific elements of the value chain – such as originating new business, and SWP maintenance. If financing is provided to the SHF (for use for purchasing a SWP), then they can build credit history, and a relationship with the financial institution themselves.

CASE STUDY: NIGERIA

Nigeria's Loan Guarantee Facility (LGF) is one of the oldest operating LGFs in developing economies started in 1977 with 60 per cent funding from the Nigerian Government and 40 per cent from the Central Bank of Nigeria (CBN). The fund provides guarantees for loans to agricultural producers and processors. The model allows the farmer to jointly apply for a guarantee together with the lending bank. The CBN also manages the system. This fund has very favorable terms and conditions, with 75 per cent coverage of the principal in case of default plus reimbursement of interest up to a level matching the interest income from non-due loans. The daily operations are under the CBN.[40] Findings reveal a positive and significant relationship between this model, and the agricultural sector development evaluated by the sustained rise in its contribution to GDP.[41]

FIGURE 14: CASE STUDY ON RISK-SHARING

39. Certifications or pre-qualification of products are critical to manage one part of risks for banks (i.e., product failing, hence SHF not benefiting from it and not getting extra income to replay
40. IFAD. Results-based Financing for Energy Access, How to Design and Implement Projects: Lessons from the Field, 2018
41. Billy, Akaninyene Orok. The Impact of Agricultural Credit Guarantee Scheme Fund for Agricultural Sector Development in Nigeria, 2016

INTERVENTION 3: CONDUCT A TARGETED AWARENESS AND EDUCATION CAMPAIGN

CONDUCT A TARGETED AWARENESS AND EDUCATION CAMPAIGN OVER THE NEXT FIVE YEARS TO RAISE AWARENESS OF BOTH THE SHORT-TERM AND LONG-TERM BENEFITS OF SOLAR IRRIGATION PRODUCTS AMONG SHF

Despite solar water pumps being on the market for a number of years, awareness of solar technology, and specifically its use to power water pumps, remains limited. Convincing farmers of the value of the technology requires time, with more education needed on how the product works and in particular how it can benefit their farms.

A variety of interventions, e.g., integrating SWPs technical operation and benefits in curriculum for government extension workers, funding radio campaigns – particularly directed at those stations with a large small holder farmer audience (e.g., Radio Citizen or Radio Jambo, and regional radio stations e.g., Kameme FM, Kass FM), including demonstrations and education materials on SWPs operations and benefits in regional and national agricultural shows, and working with county level agricultural officers to sensitize local SHFs on the benefits of SWPs could drive up awareness and accelerate uptake of SWPs.

EXPECTED IMPACT

We expect a much swifter uptake towards the total addressable market; realizing the levels projected in seven years rather than ten. This would include those within reach of water and those who can afford a pump.

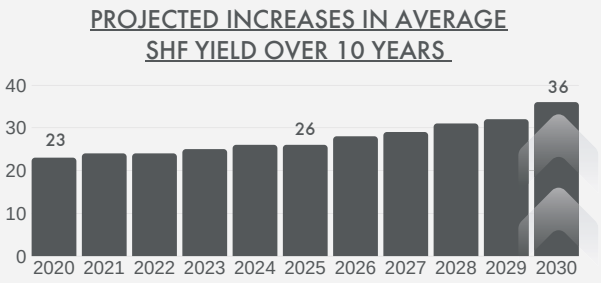


FIGURE 15: PROJECTED AVERAGE ANNUAL YIELD INCREASE OVER CURRENT FOOD PRODUCTION UNDER A TARGETED AWARENESS AND EDUCATION CAMPAIGN (MILLION MT)

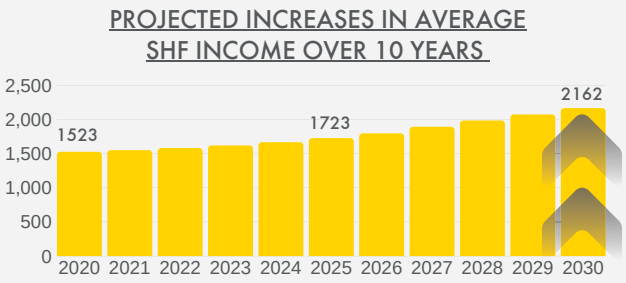


FIGURE 16: PROJECTED AVERAGE INCREASE IN INCOME OVER CURRENT INCOME LEVEL, UNDER A TARGETED AWARENESS AND EDUCATION CAMPAIGN (BILLION KES)

ESTIMATED COST

The expected cost of implementing the government-led awareness-building campaign is KES 318 Million over five years (inclusive of payment for large-scale awareness campaigns) compared to KES 271 Billion increase in income for small-holder farmers.

IMPLEMENTATION CONSIDERATIONS

- Consider partnerships with private sector players: There are far fewer government extension workers than is optimal (currently a ratio of 1000 farmers to one extension worker). Many private companies also hire extension workers for particular areas and value chains (e.g., other inputs providers, or major off-takers). There could also be an opportunity to add content to existing digital training platforms (e.g., iShamba, iCow, or Arifu).
- Ensure product quality: To mitigate against negative consumer experience and to build trust, it's vital that consumers are educated on which pumps will be an appropriate long-term investment (e.g., by adopting GOGLA certification as an industry standard for all imported and locally manufactured pumps).

INTERVENTION 4: PROVIDE FINANCIAL SUPPORT FOR INCREASING ACCESS TO APPROPRIATE WATER SOURCES

PROVIDE FINANCIAL SUPPORT FOR INCREASING ACCESS TO APPROPRIATE WATER SOURCES

In Kenya, an estimated less than 29% of SHF households[42] have reliable water access for irrigation. Increasing water access has the potential to both increase SHF household resilience to variable weather and stimulate the uptake of solar irrigation equipment.

The government has an important role in increasing access to water sources through funding critical water access infrastructure, particularly digging of wells and boreholes, and construction of dams and water pans. Reliable water access will drive uptake by increasing the total addressable market for solar irrigation technologies. Solar water pumps can also help Kenya reach its water access objectives, provide more affordable and effective ways for smallholder farmers to tap into water for domestic and productive use, in addition to increasing the resilience of the national food system.

EXPECTED IMPACT

Increasing reliable water access by 25% is estimated to increase SWP uptake to 154,000 over five years. Projected increase in SHF income and yield is outlined below.

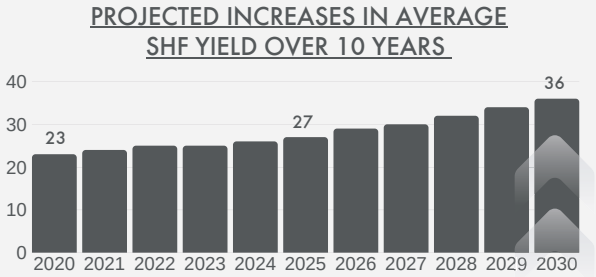


FIGURE 17: PROJECTED AVERAGE ANNUAL YIELD INCREASE OVER CURRENT FOOD PRODUCTION WITH RELIABLE ACCESS TO WATER (MILLION MT)

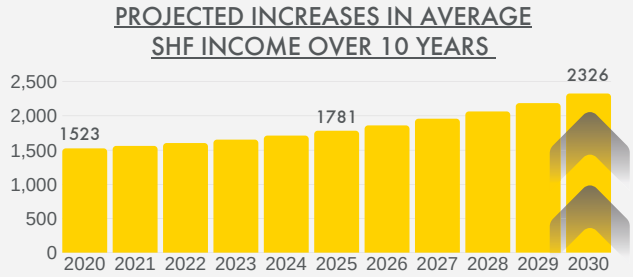


FIGURE 18: PROJECTED AVERAGE ANNUAL INCREASE IN SHF INCOME OVER CURRENT LEVEL WITH RELIABLE WATER ACCESS (BILLION KES)

ESTIMATED COST

The estimated cost of providing direct financial support for water access (e.g., the digging of boreholes and construction of water storage infrastructure) is estimated to be KES 2.8 Billion over five years compared to KES 347 Billion increase in small-holder farmers income.

42. Figures based on data collected from the 2009 Census. A more in-depth analysis could be performed based on ground water and surface water data

IMPLEMENTATION CONSIDERATIONS

A major consideration is ensuring that the design of the financial incentive scheme adheres to the design principles of a smart subsidy.

- Targeting specific farmers to promote pro-poor growth: Testing the subsidy in one county for a specific group of farmers and then expanding once the approach is refined, would reduce the risk of the subsidy not being provided, or its implementation being tied up in red tape
- Market-based solutions: The scheme should utilize and support the further development of existing private input supply networks. This enhances the efficiency of input delivery as well as increase the likelihood that the scheme has a sustained impact after its termination; as well as supporting the up-scale of effective market-based water access schemes
- Developing an exit strategy: The scheme should ensure it has a credible time limit on the support offered (the current approach assumes that the water access incentives are provided in the first year, to maximize benefits over time)

Another consideration is the need to institute a national water management strategy to ensure sustainability and to prevent depletion. Given the various steps that need to be met to complete this particular intervention, it is important to acknowledge that implementation could be challenging and would need to be rooted in the local context for increased water access. Several challenges could limit the implementation such as managing the stock of irrigation equipment and ensuring access to remote population.[43] However, its impact on national food security and on both SHFs income are potentially extremely high.

CASE STUDY: SRI LANKA

The government of Sri-Lanka launched a national agro-well programme in the late 1990s in conjunction with donors, supporting construction of ~50K wells in the country's Dry Zone by 2000. Starting in 2000, government provided subsidies for micro-irrigation systems (pump, filter, drip irrigation). One surprising finding was that based on a representative survey of pump users conducted after the subsidy scheme was conducted, 72% of pump users had invested their own resources in the pump, and just 25% benefited from the subsidy. The authors concluded that the subsidy programme had helped upscale the technology, by encouraging a larger, broader community to self-finance.[44]

FIGURE 19: CASE STUDY ON FINANCIAL INCENTIVES FOR WATER ACCESS

43. 2030 Water Resource Group, Agricultural & Irrigation Opportunity, 2030 WRG Roundtable #3, Moving towards Solutions
44. Mechanizing Water Lifting through Pumps (2019); A Case Study in Sri Lanka; IWMI & CGIAR Working Paper 188 p30

ADDITIONAL ENABLING INTERVENTIONS

ADDITIONAL ENABLING INTERVENTIONS

The major interventions proposed above could significantly stimulate the market in a relatively short period of time. There are other interventions that would create a better enabling environment overall, but not be sufficient in themselves to drive uptake. These include the following:

KEY CONSTRAINT	INTERVENTION
AFFORDABILITY	• Streamline exemptions processing: A single point of contact at each government agency (Ministry of Energy, Ministry of Agriculture, Kenya Revenue Authority) would speed up processing time, reduce paperwork within government, and reduce the management overhead required to process these exemptions • Removal of remaining taxes: VAT, Import Duty, & Railway Development Levy comprise ~8.5% of the total cost of a pump, which could be removed • Subsidy for local manufacture of components: Some parts of the kit are suitable for local manufacture (e.g., piping). However, for the majority, the sub-scale nature of the specialist manufacturing required (e.g., solar panels), means this would only be feasible once the market was at scale
AWARENESS	• Publicized government endorsement: To educate farmers of the benefits of solar water pumps • Quality approval: Maintaining a quality mark for water pumps (e.g., based on GOGLA certification) could ensure that as the market increases in size, it is not poorly functioning pumps which are purchased (which would reduce willingness of farmers to invest).
WATER ACCESS	• Enact a comprehensive water management policy: Coordinating amongst the various actors is key to ensure that the available water is used effectively • Digitize and make water table data and borehole location public: Allowing farmers an understanding of the depth that a borehole would be required; would allow them to make a more informed decision on how to source water for irrigation

FIGURE 20: ENABLING INTERVENTIONS, TO SUPPORT BROADER UPTAKE

FUNDING OF THE INTERVENTIONS

These interventions aim to be achieve positive financial returns for government investment over time. The initial investment could be paid for in the following ways:

- Reallocation of subsidies: Kenya spends 9.0bn KES ($89m) annually on input subsidies[45] A percentage of the funds allocated to the subsidy scheme could be reallocated to fund a subsidy scheme for the purchase of SWPs targeting SHF
- Paid for out of the national budget: Significant funds have already been allocated to advance the Big Four pillar of food security. In FY19-20 the annual Kenyan budget for the Big 4 Agenda was 450.2bn KES, and within this agriculture/food security was allocated 55.97bn KES.[46] Irrigation was given a specific budget within this of 7.9bn KES, for support to ongoing projects. The government could capitalize on these funds to drive irrigation as a high ROI investment.
- External funding: Expanding food security and small holder output aligns with donor interests; furthermore, similar programmes have benefited from donor funding (e.g., the KOSAP programme to expand solar home systems in Kenya)

45. Birch 2018
46. Kenyan Budget 2019-2020

AGGREGATE IMPACT

The combined policy interventions will result in significant impact in terms of market growth, yield, income and food security and resilience.

IMPACT OF MARKET GROWTH

Each policy intervention will boost the uptake of SWPs. A 50% subsidy scheme will have the largest impact on the uptake of SWPs driven both by new customers that could afford SWPs and customers that are now willing to spend on a SWP. Implementing credit financing will contribute to a 20% decrease of the cost of a SWP, therefore increasing the uptake of SWPs. By supporting 40% of the costs of irrigation equipment (and thus boosting water access), the government can play a significant role in driving uptake for SWPs over the next ten years. Finally, the awareness campaign will speed up the increase of uptake over time.

CUMULATIVE UPTAKE OF SWPS IN KENYA FOR EACH POLICY INTERVENTION (NO OF HHS)

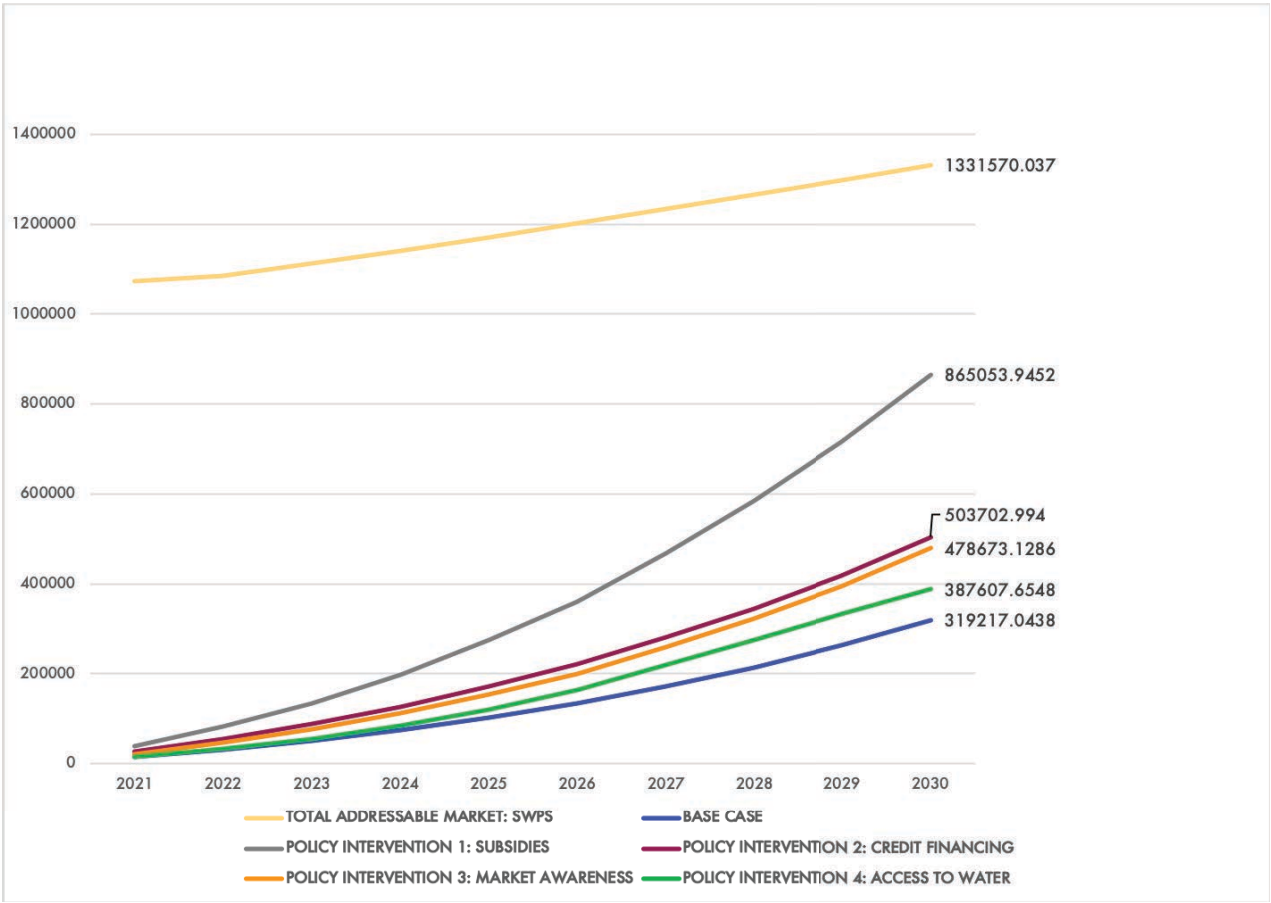


FIGURE 21: CUMULATIVE UPTAKE OF SWPS IN KENYA FOR EACH POLICY INTERVENTION (NO OF HHS)

Figure 22 illustrates the cumulative impact of several policy interventions. Due to projected cannibalization, the uptake of SWPs under cumulative policy interventions will not equal to the sum of individual policy interventions. For instance, implementing a subsidy scheme and facilitating credit financing do not translate to an entirely additive number of customers that purchase SWPs due to diminishing returns.

CUMULATIVE UPTAKE OF SWPS UNDER COMBINED POLICY INTERVENTIONS (NO. OF HHS)

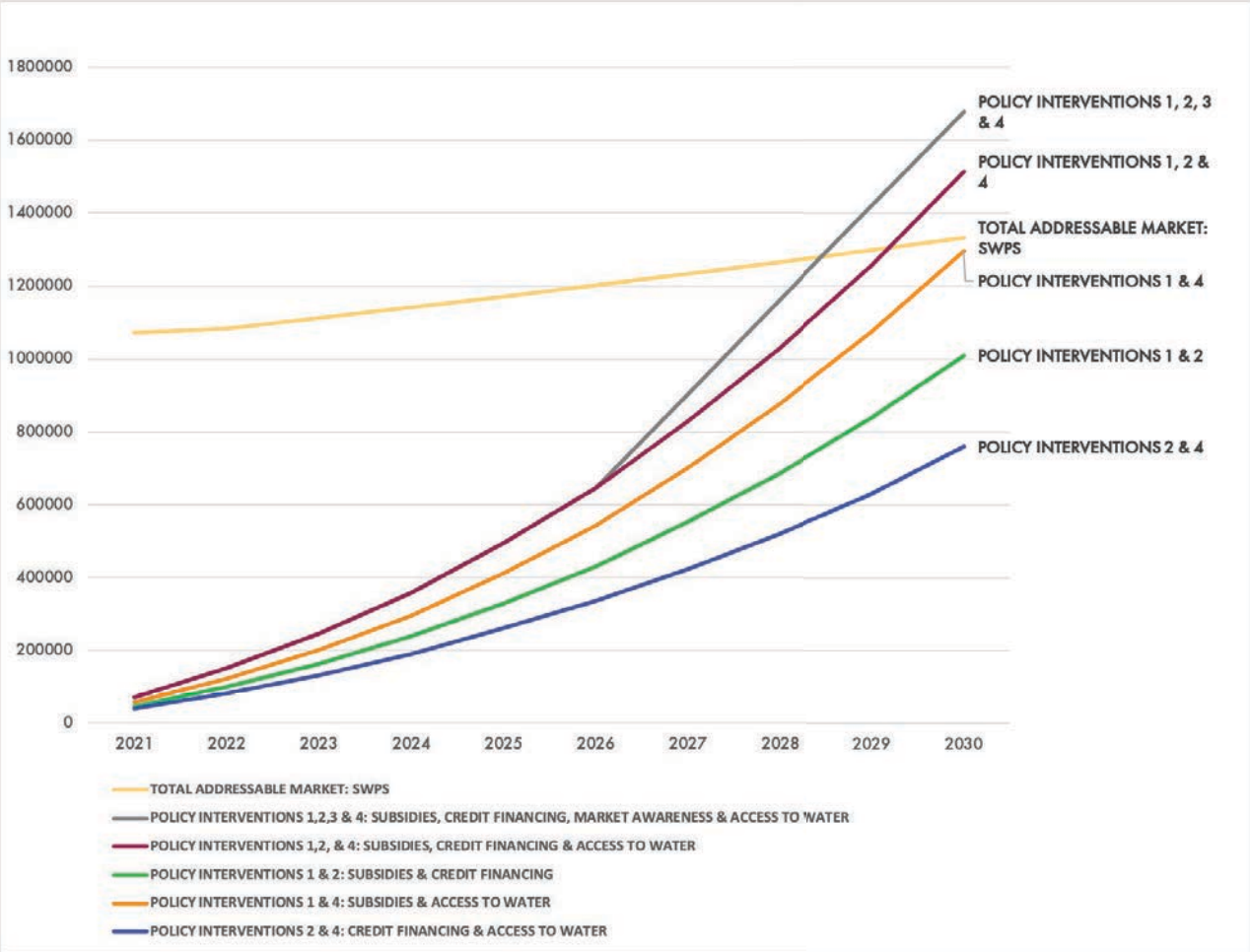


FIGURE 22: CUMULATIVE UPTAKE OF SWPS UNDER COMBINED POLICY INTERVENTIONS (NO. OF HHS)

IMPACT IN TERMS OF YIELD AND INCOME

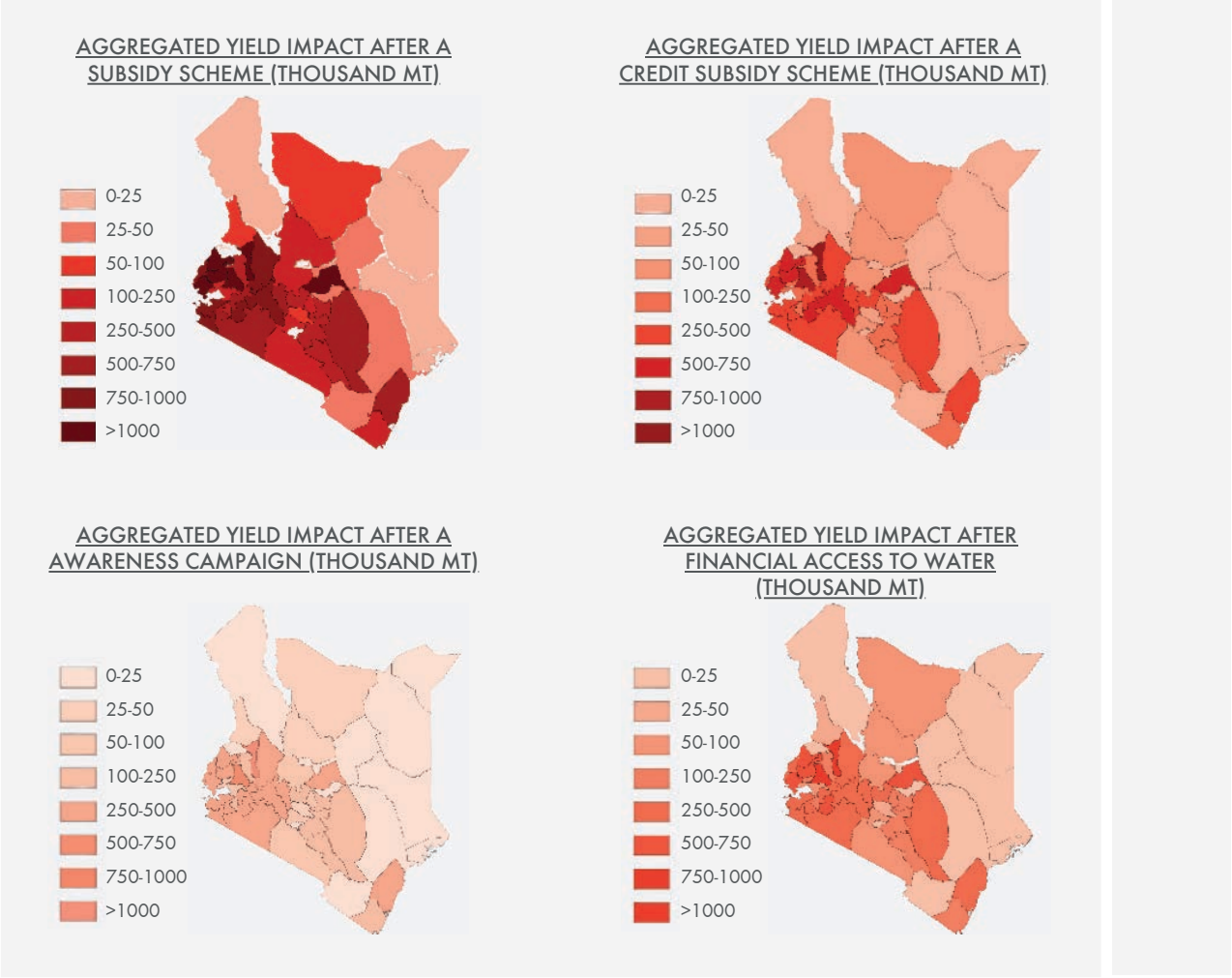


FIGURE 23: AGGREGATED IMPACT IN TERMS OF YIELD PER COUNTY UNDER COMBINED POLICY INTERVENTIONS 1,2,3 AND 4 (THOUSAND METRIC TONS)

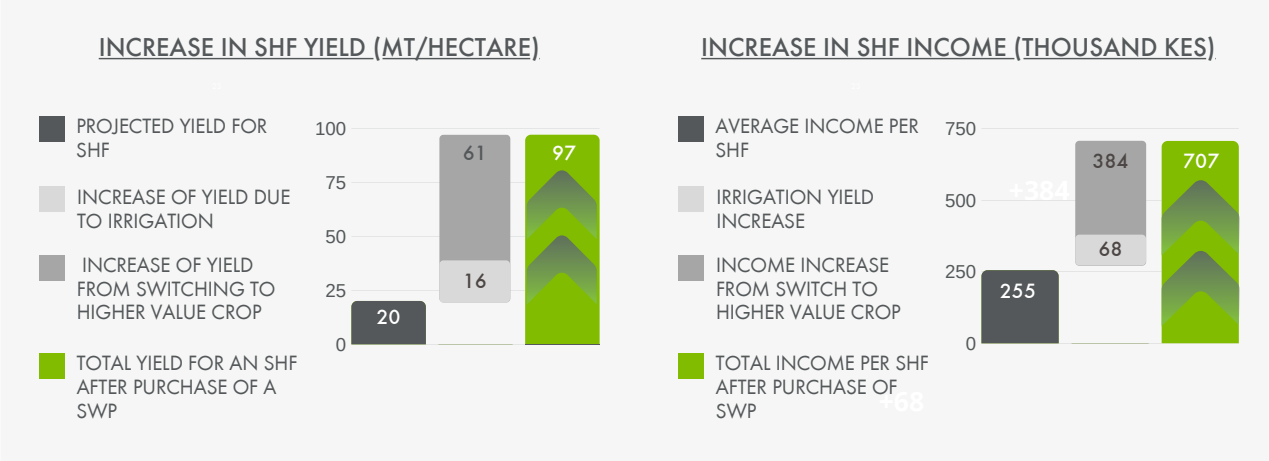


FIGURE 24: BREAKDOWN OF THE MAIN DRIVERS OF YIELD (MT/HECTARE) AND INCOME INCREASE (THOUSAND KES) FOR SMALL-HOLDER FARMERS IN KENYA

IMPACT IN TERMS OF FOOD SECURITY AND RESILIENCE

Between 1998 and 2011, five major droughts affected from 2.2 Million to 3.8 Million Kenyans. The costs for the Government of Kenya and international humanitarian aid have been significant, reaching up to 43.7 Billion KES in 2009 (USD 432.5 Million).[47]

Under the combined policy interventions, the uptake of SWP will contribute to increased resilience. With a better mitigation of drought shocks, farmers can build their reserves, therefore contributing to a greater income increase over time.

The increase of resilience due to SWP was calculated based on the expected probability of a drought in Kenya per year estimated at 40% and the expected impact on agricultural land usage projected at 30%.[48]

In a given year, the average farmer is expected to lose 12% of of their crop due to drought. Under a severe drought a farmer can lose their entire crop. SWP will therefore play a key role in reducing shocks for farmers.

40% EXPECTED PROBABILITY OF A DROUGHT IN KENYA

30% AVERAGE IMPACT OF DROUGHT ON AGRICULTURAL LAND USAGE

FIGURE 25: INCREASE OF FOOD PRODUCTION DUE TO RESILIENCE (%)

In addition to increased resilience, the national food production will increase significantly (from 23.2 Million MT in 2020 to 65.5 Million MT in 2030). Imports of key staples are likely to drop, based on local production. Currently 529 Thousand MT of maize is imported annually[49], and this gap could be largely met.[50] This will contribute to savings in import bills on food.

The increase of food production will enhance the basis for other sectors including food exports and processing. A consistent supply of raw materials will be the basis for developing sustainable processing and stronger exports.

47. Bartel and Muller., Economics of resilience to drought, Kenya analysis, 2018
48. Ibid
49. ITC Trade Map
50. Production of maize calculated based on the 'multiple intervention' scenario. The projected maize production in 2030 is estimated to reach 527 Thousand MT

COUNTY ROLL OUT

On the right are listed the counties with the largest projected uptake of solar water pumps over 10 years under the combined policy interventions.

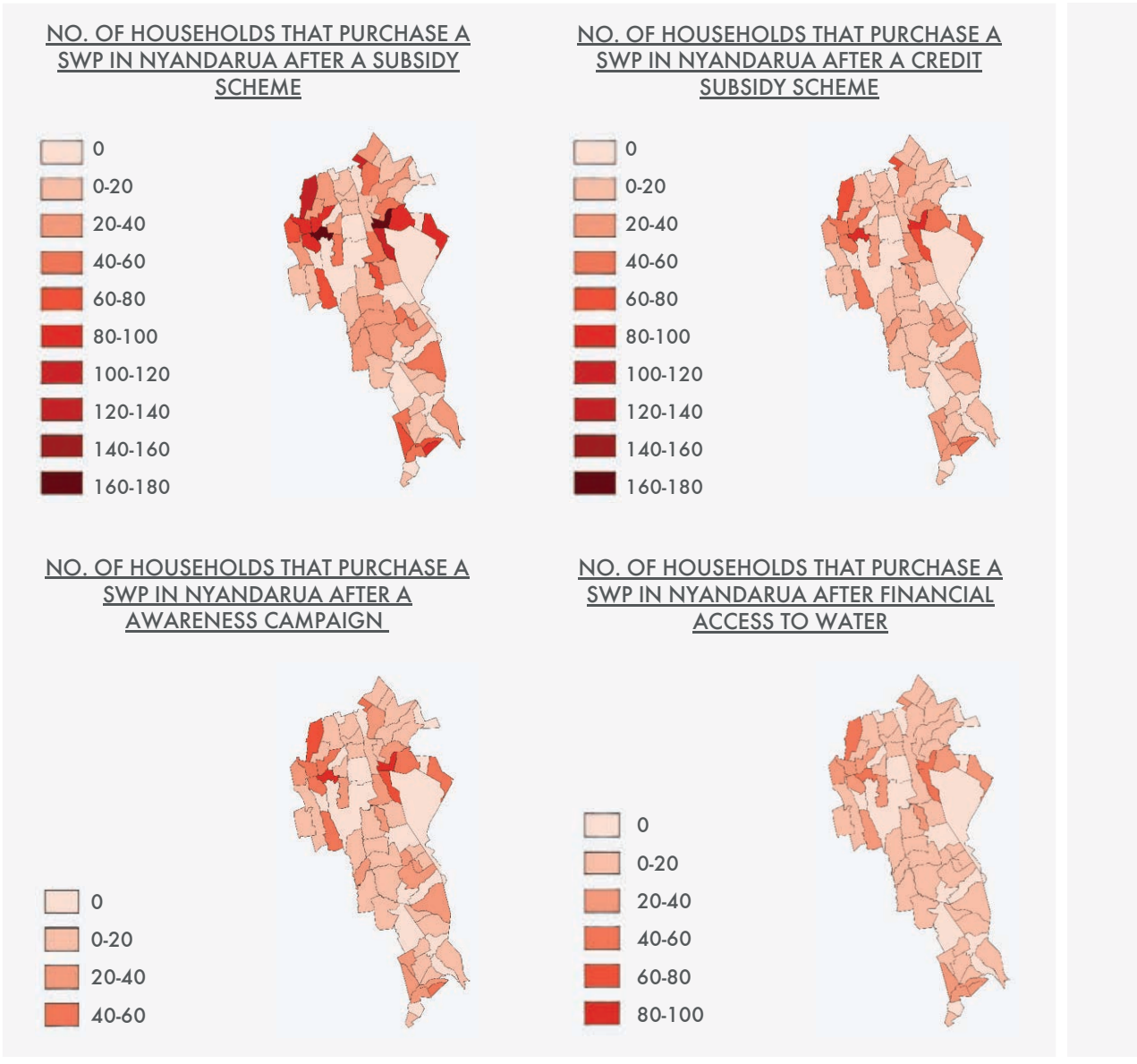
COUNTY	UPTAKE FIGURES UNDER COMBINED POLICY INTERVENTIONS OVER 10 YEARS (UNITS)
NANDI	96K
MERU	75K
SIAYA	70K
KAKAMEGA	64K
BUNGOMA	64K

FIGURE 26: PROJECTED UPTAKE PER COUNTY IN KENYA

Several criteria need to be taken into consideration for the prioritization of county-roll out, such as local political priorities, and on the ground relationships. Nyandarua is one county where this could make a significant impact, and the potential impact is shown below at a sub-location level. There is a strong argument to pick a single county first and pilot the especially given the strength of Kenya's devolved system of government.

A combined set of policy interventions is most likely to lead to successful implementation (e.g., a locally managed subsidy, along with additional capital inflow from a financial services partnership, and an awareness campaign about the programme).

FIGURE 27: MAP OF NYANDARUA SWP USAGE, AT SUB-LOCATION LEVEL, BASED ON COMBINED INTERVENTIONS BEING ENACTED (POLICY INTERVENTION 1, 2, 3, 4 COMBINED)



APPENDIX

FIGURE 28: LIST OF ASSUMPTIONS USED IN THE MODELLING

ASSUMPTIONS	VALUE	SOURCE
% of HHs off grid or with unstable connection to the grid in rural areas	79%	Satellite data – night time light. Dalberg Research proprietary data
% of HHs with access to water	29%	Household Census data, 2009
% increase of HHs connected to the grid over time	2%	Assumption based on World Bank Development Indicator
% of urbanization rate	4%	CIA World Factbook
% of small-holder farmers in rural area	89.4%	Kenya Randomized Rural Household Survey
Lifetime value of a solar water pump (years)	5	Data collected through stakeholder interviews with the main producers of solar water pumps in Kenya
Replacement rate of a solar water pump (%)	80%	Data collected through stakeholder interviews with the main producers of solar water pumps in Kenya
% of income dedicated to a solar water pump	30%	Data collected through stakeholder interviews with the main producers of solar water pumps in Kenya
Monthly payment for a solar water pump (KES)	KES 3,900 for a solar water pump with battery KES 3,100 for a solar water pump without battery	Data collected through stakeholder interviews with the main producers of solar water pumps in Kenya
Product mix (%)	80% for a solar water pump with battery, 20% for a solar water pump without battery	Data collected through stakeholder interviews with the main producers of solar water pumps in Kenya

ASSUMPTIONS	VALUE	SOURCE
Average duration of a loan (months)	30 months for a solar water pump with battery18 months for a solar water pump without battery	Data collected through stakeholder interviews with the main producers of solar water pumps in Kenya
% of taxes on a solar water pump (after existing tax exemptions)	8.5%	Data collected through stakeholder interviews with the main producers of solar water pumps in Kenya
Extension of loan duration due to credit financing (months)	36 months for a solar water pump with battery 24 months for a solar water pump without battery	Conservative estimate based on existing industry payment terms
Cost of a market awareness campaign (%)	3.5% of the product cost	Data collected through existing marketing spend by producers of solar water pumps in Kenya
Cost of increasing access to water (USD)	Boreholes (16,800 USD), Wells (6,500 USD), Water ponds (2,000 USD)	FAO Irrigation Brief, World Bank: ten steps guide towards cost-effective boreholes, Farm ponds for climate resilient rainfed-agriculture, data on farm ponds
Crop production per county and livestock distribution (%)	% distribution per county	Ministry of Agriculture, Livestock, Fisheries and Cooperatives
Breakdown of switching customers (%)	13% using diesel before and 87% using rain-fed agriculture	Data collected through stakeholder interviews with the main producers of solar water pumps in Kenya
Average irrigated acreage per farm with a solar water pump (Ha)	.69	FAO, Kenya Irrigation Market Brief, 2015
Density of cattle (head/Ha)	.70	FAO Stat, FAO, Livestock sector brief (2005)
Expected probability for a drought (%)	40%	Horn of Africa natural probability and risk analysis, Bartel and Muller (2007)
Impact on agricultural land usage (%)	30%	Horn of Africa natural probability and risk analysis, Bartel and Muller (2007)

ASSUMPTIONS	VALUE	SOURCE
% of ha farmers growing staple crops switching to cash crops (%)	50%	Assumption
Yield increase (%)	194% (Average % between all the crops)	FINTRAC, FAO Stat, Water Irrigation Group, Bosire et al (2016), Meat and Milk production and the associated land footprint
Income increase (%)	177%(Average % between all the crops)	National Horticulture Information System, M-farm

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