REEEP

IMPAQT Case Study

CASE STUDY: HEALTH, WEALTH AND SOLAR IRRIGATION IN KENYA

REEEP launched the pilot phase of its IMPAQT (Indicators for Multidimensional Prosperity Assessment, Quantification and Testing) project in 2015 together with the climate policy think tank Perspectives Climate Change, who have been working on climate change strategies for over fifteen years, and who have developed a unique way of quantifying and measuring the long-term impacts of climate change adaptation projects.

The methodology, called Saved Health/ Saved Wealth (SH/SW), works by applying standardised indicators to quantify long-term adaptation benefits to human health - in Disability Adjusted Life Years[1], or DALYs - and wealth - in USD - while considering uncertainties. We utilised an adapted, mixed version of this metric, for assessing our markets.

For IMPAQT, we first generated baseline BAU scenarios including expected climate-related damages, then analysed ex-post the initial market outcomes as measured by REEEP's Monitoring, Evaluation and Learning (MEL) systems. Finally, we created a scenario to predict impacts in the event of countrywide market scale.

The initial findings out of the SH/SW study of solar-powered irrigation in Kenya are particularly striking.

THE BACKGROUND

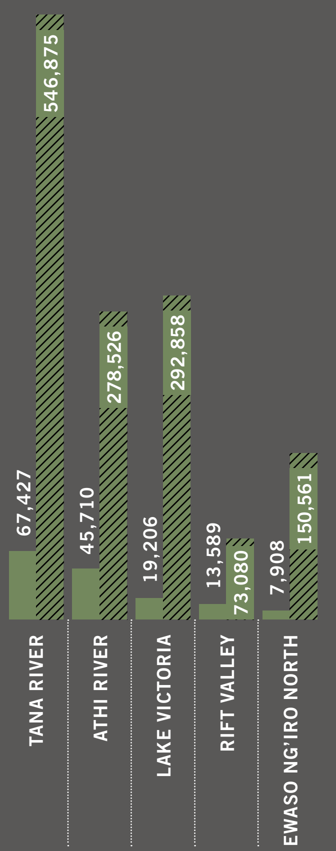
Agriculture is a central contributor to rural livelihoods, food provision and the economy in general in Kenya, accounting for 60% of foreign exchange and around a quarter of GDP. In the past two decades, increases in number and intensity of droughts and floods have affected personal wealth and food production in the country considerably. Between 1964 and 1984 Kenya experienced one famine cycle; from 2004 to 2009, it experienced five. These impacts are exacerbated due to comparably limited response and resource management capacity, as well as technology and infrastructure deficiencies.

To understand the vulnerability of Kenya's agriculture sector, it is necessary to consider the general climatic conditions, agricultural production patterns and irrigation potential. For most parts of the country, Kenya has two rain seasons: one with long-lasting rainfall from March to May; and short rain periods from October to December. Within the country, three types of land are classified according to the annual precipitation: Arid and semi-arid land (ASAL) (see map on next page), the medium rainfall zone, and the high rainfall zone.

More than 80% of Kenya is classified as ASAL; the remaining 20% is classified as medium to high rainfall zones. Most food and cash crops, as well as livestock, are produced in high rainfall zones under semi-intensive and intensive agricultural systems. The below graphic provides an overview of the irrigation potential in Kenya.

Source: *Ministry of Agriculture, Livestock and Fisheries, Republic of Kenya, 2015*

IRRIGATION POTENTIAL IN VARIOUS REGIONS IN KENYA



AREA DEVELOPED (HECTARES)

IRRIGATION POTENTIAL (HECTARES)

161,840

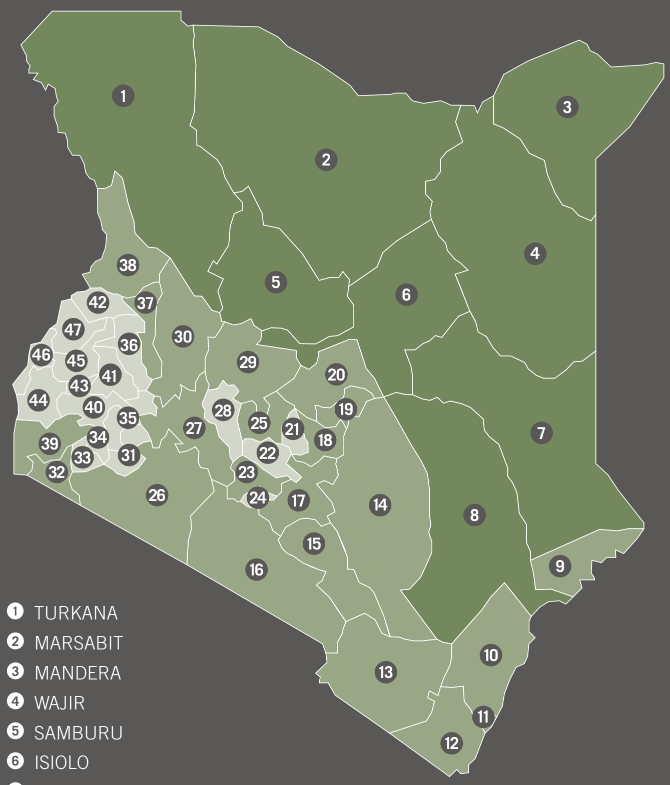
Total Area Developed

1,341,900

Total Irrigation Potential

MAP OF ASAL COUNTIES IN KENYA

Source: *Ministry of Devolution and Planning, Republic of Kenya, 2015*



1. TURKANA
2. MARSABIT
3. MANDERA
4. WAJIR
5. SAMBURU
6. ISIOLO
7. GARISSA
8. TANA RIVER
9. LAMU
10. KILIFI
11. MOMBASA
12. KWALE
13. TAITA TAVETA
14. KITUI
15. MAKUENI
16. KAJIADO
17. MACHAKOS
18. EMBU
19. THARKA NITHI
20. MERU
21. KIRINYAGA
22. MURANGA
23. KIAMBU
24. NAIROBI
25. NYERI
26. NAROK
27. NAKURU
28. NYANDARUA
29. LAIKIPIA
30. BARINGO
31. BOMET
32. MIGORI
33. KISII
34. NYAMIRA
35. KERICHO
36. UASIN GISHU
37. ELGEYO MARAKWET
38. WEST POKOT
39. HOMABAY
40. KISUMU
41. NANDI
42. TRANS NZOIA
43. VIHIGA
44. SIAYA
45. KAKAMEGA
46. BUSIA
47. BUNGOMA

KEY

- ARID COUNTRIES
- SEMI-ARID COUNTRIES
- NON-ASAL

Meanwhile, Kenya is experiencing more extreme temperatures and general declines in rainfall due to climate change. At the same time, there are indications that the ASAL zone is increasing.

Agriculture in Kenya is typically rain-fed with two growing seasons, and insufficient water distribution infrastructure for collection and storage has led to widespread inefficiencies in water resource management. Water scarcity is a growing problem as deforestation, erosion and droughts negatively impact watersheds. With these trends exacerbated by climate change, agricultural productivity – particularly of subsistence farmers – has become highly unpredictable, putting the country's food security at risk.

THE BASELINE

REEEP has been looking at market-based solutions for solar-powered irrigation systems in Kenya as part of our Powering Agrifood Value Chains project, and specifically via investments in two companies offering products in the country, Futurepump and SunCulture.

Whereas both companies are currently operating at regional level and in non-ASAL areas, REEEP expects both coverage and scope to grow as the companies expand and new entrants arrive in the market. We are looking toward a **countrywide expansion of the market for solar-powered irrigation.**

Smallholder farmers account for 75% of the agriculture sector in Kenya. These farmers face long-standing barriers in accessing food markets, credits and technology and are easily affected by volatile food and energy prices. These challenges limit their ability to increase production, and thus, to counteract pressures on food security, nutrition and poverty.

According to USAID, inadequate and deteriorating food security increased the number of malnourished children by 20% between April 2013 and July 2014. In addition, the choice of food consumption is also limited, which also leads to malnutrition. Today, 45% of the population are classified as poor, the majority being small-scale farmers.

In our baseline scenario, irrigated land in Kenya reaches about 4% of the national surface due to the lack of appropriate technology for smallholder farmers. Most smallholders use treadle irrigation systems if at all, as modern petrol or diesel pumps are unaffordable. These systems are time-consuming and require a high level of physical labour, which can lead to health problems, and are also recognised in the baseline.

Utilising FAO data on crop varieties, yields and price trends, we can apply SH/SW methodology to assess baseline wealth losses; health losses based on a frequency distribution of food supply with its nutritional values in terms of energy (in kcal), fat and proteins and related life years in DALYs. As literature and calculations on this topic are limited, the calculation relies on publically available data. The results are preliminary, as obviously key factors other than the nutritional situation might also have significant impact on health. However, the assumption serves as good indication to estimate the relation between malnutrition and life years lost or lived with disabilities. We hope to improve our understanding of how health losses result from malnutrition as we continue investing in agrifood value chains.

GENERAL BASELINE PARAMETERS

PARAMETER	VALUE	SOURCE
Project country	Kenya	REEEP
Project region/community	Various	REEEP
Project start year	2014	REEEP
Total project area in ha	58.3	REEEP Monitoring, Evaluation and Learning (MEL)
PLT (project lifetime in years)	10	REEEP
POP0 (population in start year)	603	REEEP MEL (# farms) and World Bank 2016 (avg. household size)
PGR (population growth rate per year)	0.0%	REEEP MEL
WPCB: Baseline Income (USD/p.c./y)	1,111	REEEP MEL
IGR: Income p.c. growth rate (%/y)	3.2%	World Bank 2016
CCloss,t: Percentage of income/health projected to be lost due to climate change in year t (excludes savings due to autonomous adaptation).	1.0%	Local values and if not available national or regional values (default: 1% due to climate change
LE: Life expectancy at birth	61	Default value
FSD: Food supply deficit (kcal/cap/day)	135	Default, Kenya, deficit of undernourished pop.
CCdeaths: Population that dies because of climate change in DALYs per year and per capita	0.068	Calculated, based on global analysis
CCdisab: Population that has disabilities because of climate change in DALYs per year and per capita	0.034	Calculated, based on global analysis
DW: Average disability weight; the disability weight is a weight factor that reflects the severity of the disease on a scale from 0 (perfect health) to 1 (equivalent to death);	0.5	DWs for different diseases can be found in WHO (2004)
AA: Autonomous adaptation	10%	Default value

BASELINE CALCULATION: SAVED WEALTH

$$WLC_{PLT} = \sum_{(y=0)}^{PLT} POP_0 \, (1 + PGR)^y \; * \; WPC_B \; (1 + IGR)^y \; * \; CC_{losst} \; * \; (1 - AA)$$

BASELINE CALCULATION: SAVED HEALTH

$$HLC_{PLT} = \sum_{t=0}^{PLT} POP_0 \, (1 + PGR)^t \; (CC_{deaths} + CC_{disab} * DW) \; * \; (1 - AA)$$

The baseline calculations represent discounted summations over the project lifetime of expected climate-related damages to health and wealth of the affected population. A full explanation of the methodology behind Mixed Saved Health/Saved Wealth will be included in the full REEEP IMPAQT report to be published in late 2016.

Thus we can calculate that the roughly 600 farmers and their family members are facing wealth losses due to yield decrease of more than **USD 70,000** over 10 years, and more than **600 DALY** losses due to insufficient food supply.

*An Agro-Solar Irrigation Kit (ASIK) (**Credit**: Sunculture)*

THE TECHNOLOGY; THE PRODUCT; THE MARKET

As part of Powering Agrifood Value Chains, REEEP selected and invested in two companies – Futurepump and SunCulture – to act as market catalysts and investigative partners into the solar-powered irrigation sector generally, and Kenyan market specifically.

SunCulture designs and sells an Agro Solar Irrigation Kit (ASIK), which is a fully-integrated system combining solar pumping technology with a high-efficiency drip irrigation system, as well as an agronomic-based financial support model (called agricultural extension services); Futurepump is behind the basic and low-cost Sunflower solar powered irrigation pump (no irrigation system) combined with an end-user finance that allows for flexible payments. To read more about these technologies visit **www.reeep.org/powering_agrifood**

Compared with treadle pumping, solar powered irrigation systems can withdraw deeper groundwater with less labour. From an environmental perspective, solar powered irrigation systems produce far less GHG emissions than petrol or diesel powered pumps. Increased access to water allows poor smallholder farmers to improve food security during cultivation in the dry season, as well as creating extra income by cultivating high value vegetables and fruits.

*Farmers using the Sunculture ASIK (**Credit**: Sunculture)*

THE IMPACT

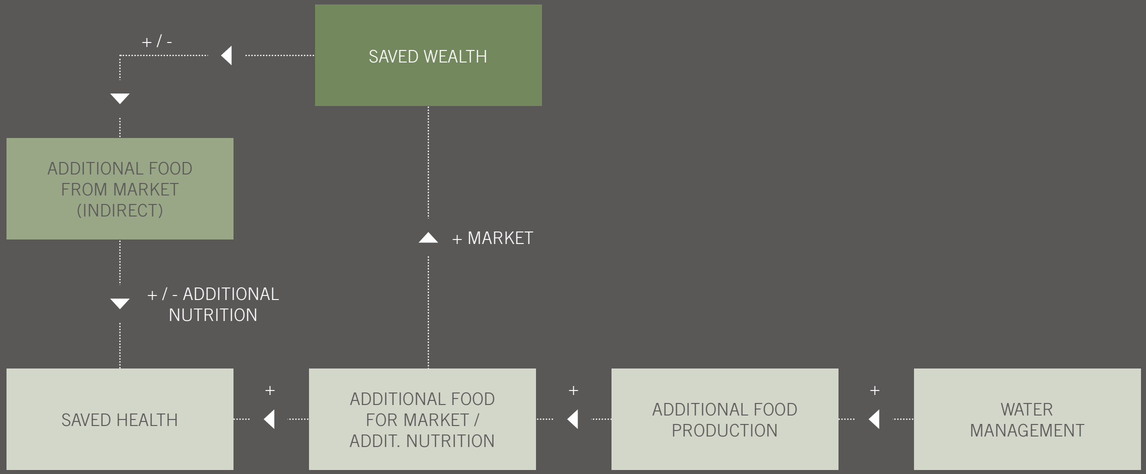
In calculating the wealth and health benefits related to the additional yields of these technologies, we considered three different scenarios: First, the current rollout of around 90 systems in Kenya makes our basic scenario. The second and third are essentially extrapolations of the original results based on a larger number of beneficiaries and hectares of irrigated farmland. Futurepump and SunCulture offer different products with variations in specific outcomes and coverage; however, the SH/SW results are considered jointly.

The methodology, which will be released in the second half of 2016, allows us to analyse the volume of expected additional yield due to the technology. The methodology also considers the negative impacts of additional irrigation, such as salinization of soil, waterlogging yield decreases and a default for irrigation water potentially missing at other areas.

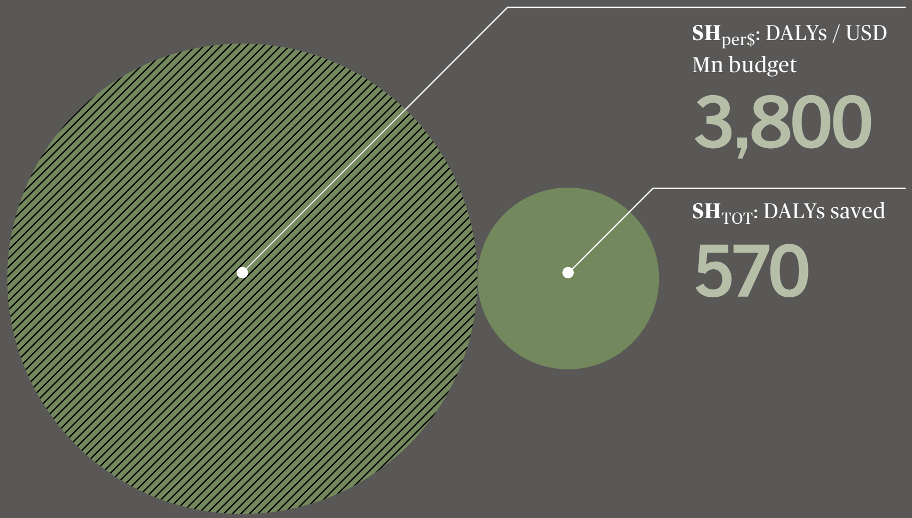
The methodology assumes additional yields are used first by farmers to address their own nutritional undersupply first, before selling the remaining crops to the market.

As a result, the calculation provides a positive outcome for all quantified indicators. For the health benefits, almost all DALY losses from the baseline can be avoided through the significantly increased yields due to the irrigation systems. Theoretically, 100% of the malnutrition in the baseline could be avoided through additional production. However, as a conservative approach, methodological parameters limit the 100% avoidance of malnutrition, which reflects uncertainty regarding the nutritional values of consumed crops from additional production or the market. Nevertheless, the project would result in around **570 DALYs** saved over the 10-year lifetime of the technology among a project population of 603 individuals, representing about **3,800 DALYs per invested million USD**.

MODEL TO ESTIMATE SH/SW



TOTAL HEALTH BENEFITS OF THE PROJECT INTERVENTION OVER THE PROJECT LIFETIME



The economic value of the remaining food sold on the market can be derived by applying the average market price of the respective crops over the last five years. Hereby the economic benefit can significantly exceed the climate change induced wealth losses in the baseline. This is a valid assumption as also the sustainable development benefit of the project intervention beyond the climate related part is considered.

We found that total economic benefits are considerable. Over 10 years of project lifetime, a total of more than **USD 13 million of wealth benefits** can be achieved with only about USD 150,000 program investment (deployed at the time of calculation – total investment amounts to USD 1.5m). This is mainly due to the threefold (and as much as sixfold in some instances) increase in productivity, meaning that almost 95% of additional food is not required for consumption but ready for sale. Thus the wealth benefits of **USD 90 per invested USD** are very high. The relative wealth benefits per person – compared to the average income in the baseline – are also considerable.

The second scenario is extrapolated to cover the project target number of 1400 farms and the full deployment of USD 1.5 million investments across both companies. The third scenario represents a simplified estimation of the irrigation potential for the whole of Kenya, based on Kenyan government assessments of irrigation potential and constant parameters. Although transposing target market parameters (such as crop types, farm sizes and environments etc.) onto other areas of the country is insufficient for a proper analysis, the calculations nevertheless give an indication of the order of magnitude of the benefits in a country-wide program.

In Scenario 2, one can expect up to **USD 123 million** of economic benefits and more than **5,000 DALYs** saved over 10 years. Within Scenario 3, one could expect economic benefits of about **USD 280 billion** for the country[2]. DALYs would reach **3.7 million** over 10 years representing a tremendous contribution to Kenya's health and wellbeing and increasing food-security tremendously.

As compared to our baseline of climate-related damages, the market is expected to address challenges due to adaptation deficit and climate change impacts more than sufficiently (see above). Regarding health, more than 93% of the losses and disabilities due to malnutrition and food deficit can be avoided. In case the general food market provides sufficient variety, even 100% could be possible.

Regarding wealth benefits, the additional food produced and sold on the market exceed the wealth losses in the baseline by several orders of magnitude.

TOTAL WEALTH BENEFITS OF THE PROJECT OVER THE PROJECT LIFETIME

13.42m
Total wealth benefits

$90
Wealth benefits per 1 USD invested

18,600%
Saved wealth in relation to climate change losses in the project lifetime

Credit: Sunculture

TOTAL WEALTH AND HEALTH BENEFITS OF THE PROJECT INTERVENTION IN SCENARIO 2 AND 3 OVER THE PROJECT LIFETIME

SAVED WEALTH
USD saved

123m Scenario 2

280bn Scenario 3

SAVED HEALTH
DALYs saved

5,200 Scenario 2

3.7m Scenario 3

TOTAL ECONOMIC BENEFITS ARE CONSIDERABLE. OVER 10 YEARS OF PROJECT LIFETIME, MORE THAN USD 13M OF WEALTH BENEFITS CAN BE ACHIEVED WITH ONLY ABOUT USD 150K IN PROGRAM INVESTMENT

Next Steps

The solar-powered irrigation sector in Kenya clearly provides phenomenal sustainable development return on investment, in terms of wealth and health benefits, at rates of up to 90 to 1.

The sector, which is close to, but not yet ready for, commercial levels of investment, also represents a vast store of opportunity for progress toward climate and development goals. These goals are expressed in the Paris Agreement and Intended Nationally Determined Contribution (INDC) of Kenya, and the Sustainable Development Goals (SDGs).

90 to 1

Return on investment rates that can be achieved through investing in the solar-powered irrigation sector in Kenya

SDG'S AND TARGETS ADDRESSED BY THIS MARKET:

Goal 1
End Poverty in all its forms everywhere

Targets:
1.1, 1.2, 1.5

Goal 2
End hunger, achieve food security and improved nutrition and promote sustainable agriculture

Targets:
2.1, 2.3, 2.4

Goal 6
Ensure availability and sustainable management of water and sanitation for all

Targets:
6.4

Goal 7
Ensure access to affordable, reliable, sustainable and modern energy for all

Targets:
7.2

Goal 8
Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all

Targets:
8.4, 8.5

Goal 13
Take urgent action to combat climate change and its impacts

Targets:
13.1, 13.2

Goal 17
Strengthen the means of implementation and revitalize the global partnership for sustainable development

Targets:
17.3, 17.5

*A Sunflower solar irrigation pump in Kenya (**Credit**: Futurepump)*

For Kenya, with its relatively low carbon intensity, emissions mitigation is not a pressing priority, nor does mitigation figure prominently in Kenya's INDC; however, the potential for CO_2 emissions avoidance – vis-à-vis an agricultural development pathway in which the energy to power irrigation is powered by hydrocarbon-based technology, such as diesel fuel – is nonetheless significant, REEEP continues to work on developing a robust scenario predictor of potential avoided GHG emissions for the sector, which should be released by the end of 2016.

Of course, the market for clean irrigation represents tremendous potential both for furthering Kenya's INDC objectives toward climate adaptation and resiliency, as well as making progress toward seven SDGs (see figure on left).

One of the great challenges of the ambitious post-2015 development agenda lies in quantifying, measuring and understanding the numerous inter-linkages among the 17 Goals and 179 Targets (not to mention the current proposed basket of 230 indicators to assess them). Through the IMPAQT program, REEEP is hoping not only to improve evidence-based cost benefit analyses in decision making and uncover entry points for mobilising private finance, but also to pilot practical solutions to the indicator multiplicity challenge.

***Credit**: Sunculture*

Footnotes

1. A Disability Adjusted Life Year (DALY) is a standard metric for quantifying the burden of disease from mortality and morbidity. Essentially, a DALY is on lost year/years of "healthy" life, and represents the sum of years of life lost due to premature mortality and years lost due to disability.

2. Secondary effects such as dropping market prices due to a potential oversupply of the food market are not considered in this simplified scale-up model.

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INVESTING IN CLEAN ENERGY MARKETS

This document contains preliminary results. The information contained therein is subject to change before final publication in late 2016

Cover image: The Ewaso Nyiro River, Kenya (Credit: NASA)