



**KickStart – Washington State University (WSU) Research Study  
Milestone 11: Final Impact Evaluation Assessment Report**

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***Mobile Layaway and R2O: Bringing an Innovative Savings Solution to the Rural  
Poor for Small-Scale Irrigation Pump Purchases***

**23 June 2016**

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# **Mobile Layaway and Rent-to-Own: Bringing an Innovative Savings Solution to the Rural Poor for Small-Scale Irrigation Pump Purchases**

## ***Research Team - Milestone 3 Project Final Report***

**Baseline and End of Project Surveys with Cash, Rent-to-Own and Layaway Savings Options for Pump Purchases and a Control Group of Non-Buyers:  
Process and Results Highlights**

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## Acronyms

Base	Baseline Period (February - May 2015)
BBaseS	Buyers Baseline Survey
BEOPS	Buyers' End of Project Survey
Cash	Cash Pump Purchase Treatment
DID	Difference in Differences
ET	Enumeration Team
ETLC	Enumeration Team Leader and Coordinators
EOP	End of Project
EOPS	End of Project Survey (March - May 2016)
EOPTKTS	End of Project Layaway Survey
IRAD	International Research and Agricultural Development Unit
KSI	KickStart International
NBBaseS	Non-Buyers Baseline Survey
NBEOPS	Non-Buyers End of Project Survey
RA-DS	Rapid Appraisal - Demographic Survey
RT	Research Team
R2O	Rent-to-Own Pump Purchase Treatment
SES	School of Economic Sciences, Washington State University
TKT	Layaway Savings Pump Purchase Treatment*
WSU	Washington State University

\*TKT is the Kiswahili translation for drip by drip.

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**WSU Research Team: Final Report, June 2016**

## **Introduction**

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Washington State University (WSU) entered an agreement on 15<sup>th</sup> April, 2014 to provide research services to KickStart International (KSI). This report summarizes two of the three project phases implemented from April, 2014 through June 2016 while focusing on the “Research” Milestone 3 activities of 2016.

“Research” Milestone 1 was met by detailing the process and results of a Rapid Appraisal Demographic Survey (RA-DS) implemented in March-June 2014. “Research” Milestone 2 reported results on the “Buyers Baseline Survey (BBaseS)” and Non-Buyers Baseline Survey (NBBBaseS) of Money Maker Max Treadle and Money Make Max Hip pumps. The Baseline surveys were implemented in March-June 2015.

This report satisfies issues addressed by the WSU Research Team. It becomes part of the KSI’s Final Project Report to USAID- DIV. The latter will cover a more comprehensive list of issues to be addressed by KSI’s Marketing Team and others incorporated in the KSI/WSU sub contract and presented here.

1. Review of baseline data and end-line data for each indicator in the project as well as monitoring and evaluation process.
2. Comprehensive description of project implementation process including development impact and relevant implementation lessons.
3. Comprehensive cost-effectiveness analysis of the intervention compared to competing alternatives
4. Comprehensive social impact analysis of the intervention.
5. Potential pathways for future scale-up of the intervention
6. Number of direct/indirect beneficiaries impacted by the project – men versus women

Requests 3) and 4) will be responded to by Kick Start International’s marketing in the final report for USAID-DIV.

Interpretations of results are referenced, when possible, to explicit objectives for the research (KSI, USAID and WSU, 2014):

#1 - How do the two financing schemes (Mobile Layaway and Rent to Own) affect the take-up rates of MoneyMaker irrigation pumps (MoneyMaker Max and MoneyMaker Hip). The finance treatment comparisons should be made separately by type of pump if both are marketed. Layaway and rent to own will be compared to each other and to cash sales. What are the key

features of the financing schemes that matter?

#2 - Do these new financing schemes enable a different segment of farmers to invest in a pump compared to cash-only sales? In particular: do the new financing schemes enable higher adoption rates by women? Do they enable poorer farmers to adopt the pump?

#3 - Does the method of financing affect impacts on farm household wellbeing from owning/using a KSI treadle or hip pump? Are the impacts higher/lower among farmers who use a financing scheme to buy a pump compared to those who buy using cash? Are the impacts higher/lower for each financing scheme compared to households who did not take up a pump?

#4 - Use literature review and survey results to determine viability at scale of each financing mechanism and to determine how these mechanisms could break down barriers for asset acquisition for African women and poorest of poor farmers generally.

Appendices are attached electronically to assure access to the bulk of research materials and data. The Appendices contain supporting documentation including detailed numerical results from the End of Project survey (EOPS) and the End of Project Layaway Survey (EOPTKTS).

## Comprehensive Description of Project Implementation

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### Project phases

Washington State University's (WSU) International Research and Agricultural Development Unit (IRAD) collaborated with KickStart International (KSI) to design and implement the project entitled "Mobile Layaway and Rent-to-Own: Bringing an Innovative Savings Solution to the Rural Poor for Small-Scale Irrigation Pump Purchases". WSU undertook the three-phase research component of a broader KSI project to inform the funding organization, the United States Agency for International Development - Development Innovations Ventures, and KSI on the viability of three separate small scale irrigation financing methods:

- Cash purchase,
- Rent to Own (R2O), and
- Layaway (TKT)

**Phase 1:** The Rapid Appraisal – Demographic Survey (RA-DS) reported in Milestone 1 identified farmers in the study area who were part of agriculturally related organizations willing to participate with the WSU research team. During the RA-DS, the group leaders of these organizations were questioned about their members' gender, assets, risk of hunger, dominant food and cash crops and other pertinent information. Individuals within the organizations chose to participate with the WSU research team and were identified as interested candidates for August-December 2015 exclusive KSI marketing program to sell pumps by different finance schemes.

**Phase 2:** The baseline surveys of pump buyers and non-buyers reported in the WSU Research Milestone 2 report were implemented in three eastern Kenya counties: Machakos, Makeni and

Kitui during the period February – May 2015. The results from this phase activity was then provided to KSI whose job it was to develop a comprehensive marketing activity to these individuals without further involvement by WSU. The marketing activity was undertaken to assure as many sales as possible to each of the three treatment groups prior to the early rains in 2015.

**Phase 3:** Research during this phase addressed differences which may exist among three financing methods to purchase small scale irrigation systems; cash purchase (Cash), mobile layaway savings (TKT) and Rent to Own (R2O).

An additional component addressed differences between pump buyers and non-buyers. Milestone 3 reports on the individuals, both non-buyers and buyers during 2015 and through January 2016.

Unlike the RA-DS in Phase 1, which addressed farm group leaders, the Phase 2 BBaseS (2015) and Phase 3 EOPS (2016) and Phase 3 EOPTKTS (2016) questioned the same individual responders. These were families who had either purchased a KSI pump via Cash, registered to purchase via R2O, or were to be contacted by the KSI Marketing Team to register and purchase a pump using (Layaway-TKT). In addition, a non-buyers group was interviewed who did not benefit from either a treadle or hip pump purchase during the period of the surveys.

The “Baseline” survey (BBaseS and NBBBaseS) and the End of Project Survey (BEOPS and NBEOPS) contain a wealth of data including family health, nutrition, income, wealth and assets, and children’s educational , costs and returns for different enterprises, production on irrigated and rainfed cropland, and related farm information. These data allow longitudinal analysis spanning a 12 to 14 month period.

The “End of Project Layaway” survey (EOPTKTS), a one-time spot survey, was undertaken in February/March 2016. This was designed to help identify why so few of sixty-six potential “Layaway” (TKT) buyers actually took up this financing option prior to January 2016. This result was inconsistent with expectations generated during the Research Team’s work earlier in 2015. The EOPTKTS seeks to explain the low levels of participation by respondents who had previously committed to the purchase of equipment using the “TKT” finance treatment option.

The End of Project Survey (EOPS) undertaken during the period February - May 2016, interviewed the *same* individuals interviewed during a similar period one year earlier at Base. The primary objective of the EOPS was to track impacts of up to 11 months of pump use, or through one production period, depending on time of access to equipment.

### **Clustering and randomization of project participants**

Phase 2 and Phase 3 efforts were predicated upon the RT’s ability to identify and randomize groups, treatments and subsequently identify individuals. The following process was implemented to lay the foundation for meaningful results.

- Two hundred and fifty-six groups were contacted during the Phase 1 Rapid Appraisal-Demographic Survey in 2014. These groups consisted of 3,917 individuals, 67% of

whom were female and 33% male. From the 256 groups, 71 clusters were generated (Clustering Process and Randomization Procedures {CPRP} document Dropbox.com – Request sharing rights for access).

- Clusters were dispersed by topography and geography. Highlands, rivers and plains areas offered topographical barriers to information transfer between clusters which was minimized. Spatially, a distance > than 15 kilometers between treatments has been achieved in all but a few cases.
- Derivation of clusters, allocation of groups to clusters, treatments, breakout by county of clusters, identification of treatments groups and group leaders occurred. This was a multi-step process; a summary is provided here.
  - Each case (represented by a Group Leader), from the Rapid Appraisal-Demographic Survey (RA-DS) Dropbox was introduced to Google Earth utilizing EarthPoint software (<http://www.earthpoint.us/Default.aspx>).
  - Locations associated with the EarthPoint data (latitude and longitude demarcations) were visually reviewed in Google Earth and prepared for clustering.
  - Each group leader (case) and a subset of data associated with each leader, was introduced into a new spreadsheet for cluster generation utilizing Google Earth as a visual foundation tool.
  - Each case was allocated to one of seventy-one clusters across the three counties. The qualitative allocation is based upon physical topography and spatial dispersion of cases across the three counties. (Example from the CPRP, Cases 102 93, 103, 96 fall into Cluster 1).
  - Each cluster was assigned a treatment number, 1, 2 or 3, sequentially across all clusters ([1, 2, 3][1, 2, 3] [1, 2, 3][1, 2, 3], etc - See column A of the CPRP).
  - Each Case was allocated a randomly generated value to allow sorting by Cluster and subsequently by Treatment and/or County.
  - Cases were sorted according to random values from low to high identifying associated Cluster and Treatment affiliations.
  - Treatments were color coded for visual identification
  - Sorting by Treatment provided information necessary to select the “sales opportunity set” associated with each Treatment. Sales were to be generated by the KSI sales force based on this opportunity set. The sales which were subsequently made became the framework for the sample population or in this case a census of buyers in the Buyers Baseline Survey (BBaseS) and the Buyers Baseline End of Project Survey (BEOPS).
  - Clusters were then selected by choosing for each of the three treatment groups sequentially. Selection was made after reviewing topographical barrier space or a physical distance greater than 15 kilometers from each other. Those which were less than 15 kilometers apart from each other were rejected from participation.

From the 3,917 potential buyers', sales volume was anticipated to exceed statistical minimum sample size requirements.

### **Team building, training and coordination with county administration**

The WSU research team was reassembled for the Phase 3 field activity in February, 2016 to

implement the EOPS. Three of four Kenyan research associates who had worked on the Phase 1 and Phase 2 activities returned to implement the EOPS. The team met on Day 1, debriefed and translated the EOPS questionnaire into Kiswahili on Day 2, and departed for activities in Machakos County on Day 3. This rapid progress was facilitated by successful team building and training during the previous two phases. This team continued data collection, field activities, data analysis and input of data into MS Excel into the month of May, 2016.

As part of the research agreement with the Kenya National Commission on Science and Technology, introductions and authorization to undertake research for the duration of the project was received from County Commissioners, County Directors of Education, and County Directors of Agriculture in Machakos, Makueni and Kitui Counties. In line with the NACOSTI agreement, copies of results of the RA-DS had been hand delivered to the administrative units in 2015 after report completion. The BBaseS results, detailed in the Research Team's Milestone 2 report, were delivered to each administrative unit in April 2016. The final report will be presented to the administrative units by KickStart International after submission

### **Development and discussion of descriptive statistics and frequencies**

Three primary surveys were undertaken during the three phases of the project

- Rapid Appraisal-Demographic Survey (RA-DS)
- Baseline Survey (Base)
- End of Project Survey (EOPS)

The EOPS followed closely and was built upon the foundation of earlier works undertaken in Phase 1 and Phase 2.

### **Data input and validation**

Data was collected in thirty-nine districts from farmers at locations,

1. Household sites,
2. Group meeting locations, and
3. Markets nearby where they were going to be on the day of the interview.

Data collected on-site was then introduced into a rigorous data input and validation process which included:

- ✓ Entry into Excel files consistent with questionnaires
- ✓ Codes assigned to variables
- ✓ Incremental sampling of the data undertaken to identify the prevalence of remaining errors or omissions
- ✓ Delivered to the WSU partners for a third review utilizing a second incremental sample, followed by an aggregate data analysis run for mins/max.
- ✓ Provided final evaluation for cleanliness and validity of the data set by PI and Co-PI.
- ✓ Final physical and mechanical checks of data set undertaken
- ✓ Final review for consistency across relationships and variables

- ✓ Survey instruments and data sets uploaded for DropBox cloud access by WSU for researchers and stakeholders. (Dropbox.com – Request sharing rights for access)
- ✓ Data analyzed using Microsoft Excel and IBM Statistical Package for the Social Sciences (SPSS)
- ✓ Data disaggregated to undertake special analysis projects

### Shortfall in TKT and statistical implications

Despite 67 households expressing an interest in the TKT mobile savings finance option at Base, only eight of households purchased pumps by this scheme by EOP. This was the foremost challenge to fulfilling research objectives of the project. Although this small subsample weakened statistical significance of impacts by finance scheme, many useful conclusions were generated. Reasons behind this shortfall are discussed later in this report.

Multiple regression analyses of survey data were weakened by small subsamples and by a relatively short time period between the BaseS and EOPS; nonetheless, t-tests and descriptive narrative were able to identify important lessons for KSI in design of TKT and for targeting of MoneyMaker (MM) pumps in general. The bottom line is that the RT was able to develop considerable quantitative and descriptive information in this report at minimal cost.

**Table 1: Phase 2 and phase 3 projected versus actual participation by individuals**

Action Taken	Cash Treatment Group	Rent to Own (R2O) Treatment Group	Layaway (TKT) Treatment Group
Identified, purchased or committed to purchase	KSI Projected 90	KSI Projected > 100	RT Identified 67
Participants who purchased	59	68	8

### Implementation lessons

- Geographic and topographic selection for this type of effort is an integral part of this genre of research project and must be provided adequate time and resources to be completed during Phase 1.
- Physical location of respondents needed to participate in a longitudinal study of this nature, involving expected purchase of technology, may not be known to the marketing group.
- Meetings held at locations away from the buyer’s household require less effort to generate greater participation but are subject to long waits both for the enumeration team and the respondents who may be waiting in a que for unsustainable periods of time.
- GPS readings of group meeting locations, nearby villages, and/or homesteads of respondents must be developed in the first stages of this type of research activity. This may be a separate, distinct activity and may require several weeks to generate, dependent upon scope of the research project.
- GPS locations should be mapped via Google Earth and EarthPoint or another similar mechanism. Being able to arrive within meters of an anticipated meeting location is value added to the RT’s efforts and to the Marketing Team as well

- The institutional infrastructure to undertake these activities may not be available but must be created to ensure timely completion of surveys.

### County characteristics and population of interest

**Table 2** displays basic county information from both secondary and primary data sources on the target counties of Machakos, Makueni and Kitui. Kitui is the most remote in terms of distance from Nairobi and also is the most arid. Kitui lagged Makueni and Machakos in household wealth and displayed more hunger incidence as reported in the Phase 1 RA-DS survey.

**Table 2: Characteristics of Eastern Kenya Counties**

County Name	Population	Rural	Poor	Literate	Estimated Farm Households	Groups Interviewed
	2009	%	%	%	No.	
Machakos	1,098,584	48	59.6	69.7	79,098	132
Makueni	884,527	88.2	64.1	72.7	117,023	63
Kitui	1,012,709	86.2	63.5	74.8	130,943	61
Total	2,995,820				327,064	256

#### Sources:

Phase 1 Rapid Appraisal Demographic Survey (RA-DS)

Populations from (<http://www.scribd.com/doc/36672705/Kenya-Census-2009>)

% Rural from (<http://fs12.formsite.com/ICTAuthorityKE/OpenData2014/index.html>)

% Poor from Open Data Kenya (<https://www.opendata.go.ke/Poverty/Poverty-Rate-by-District/i5bp-z9aq>)

World Bank (<http://data.worldbank.org/country/Kenya/>)

Kenya Open Data <https://www.opendata.go.ke/Counties/County-Urbanization-Kitui/747f-z33c>

Maize, beans and cassava are the most important staple food crops in all three counties. Cash crops, including cotton, coffee, and fruit, are found in favorable agro-climatic niches. Farmers keep cattle, goats and donkeys in all three counties. Machakos County is adjacent to Nairobi and offers residents greater opportunities for seasonal off-farm employment.

### Application of results

The conclusions of the BaseB, BaseN and EOPS apply to the farm households in each County. These include 130,943 farm households in Kitui, 117,023 in Makueni, and 79,098 in Machakos. With an average of six persons per household, the conclusions will apply to a population base of about two million people in the three Counties. Of these two million, those individuals or families who have access to water, and who purchase, access or rent and then utilize the small scale irrigation tools provided, should be considered direct beneficiaries. Secondary and tertiary beneficiaries would number in the hundreds of thousands. These begin from the base of almost 4,000 possible participants identified during the research project who subsequently had knowledge of the technology and access to the KSI marketing team members in the Counties. Cautiously, one could generalize conclusions to other African locations which share characteristics similar to the surveyed counties.

## Descriptive Statistics for Selected Results

### Household, demographic and location results

**Table 3** introduces the general background of potential respondents who were members of the 256 groups contacted. The total membership was 3,917 of which 67% were female members and 33% male. From this number, sales opportunities existed with 116 female group members and 78 male group members. This suggests about a sixty/forty female to male ratio.

**Table 3: Groups and gender of participant pool**

Gender	Potential Buyers	
RA-DS Identified groups*	76	
Population of members in groups contacted	3,917	
	Number	%
Female Group Members Identified	2589	67.0
Male Group Members Identified	1265	33.0
Female Sales Opportunities	116	59.8
Male Sales Opportunities	78	40.2

\* Rapid Appraisal-Demographic Survey – Phase 1

Interestingly, the married couples, on a percentage basis were more likely to be treadle and/or hip pump purchasers (see **Table 4**).

**Table 4: Marital status of respondents in BaseS**

Marital Status	BBaseS (%)	NBBuyers (%)	BEOPS (%)	NBEOPS (%)
Married	84.5	73.5	81.7	72.3
Unmarried	7.2	2.9	8.6	6.4
Divorced/Separated	1.0	4.4	8.6	17
Widowed	7.1	19.1	1.1	4.3
N	97	68	117	47

### Characteristics of pump purchaser and children

**Table 5** reports that there were few families who did not have male and female household members. Few male or female single parent households appeared to be interested in the irrigation technology. The result implies that the KSI marketing team should not target single-parent households. The results of **Table 5** indicate that households with two adults and younger children were more likely to buy KSI Money Maker pumps.

**Table 5: Frequency of household types in BaseS**

<b>Household Status</b>	<b>BBaseS</b>	<b>NBBuyers</b>
Male and Female Adults	38.7	35.3
Female adult only	2.6	2.9
Male adult only	1.5	0*
Male adult and children < 14 yrs old in the household	0.5	0*
Female adult and children < 14 yrs old in the household	.5	2.9
Male and female adults and children < 14 yrs old in the household	56.2	58.8
N	97	68

\*/ None reported

**Table 6** shows that in each category of education the spouse of the respondent had a similar education level, except for University.

**Table 6: Percentages of respondents' and spouses' level of education**

<b>Education level</b>	<b>Respondent</b>	<b>Spouse</b>
Primary	58%	53.5%
Secondary	34%	36.6%
College	6.2%	9%
University	1%	9%

There was an approximate 60/40 split between female and male respondents in the Baseline who were buyers compared to an 80/20 split for non-buyers. In each case, perhaps due to the poor rainfall during the project, there were increases from Base to EOP in those who had small savings. These differences moved from 36% to 40% for buyers and from 43% to 22% for non-buyers.

**Table 7: Percent for selected variables for buyers and non-buyers of pumps at baseline (Base) at April-June 2015 vs. end of project (EOP) at March-May 2016**

<b>Survey Activity</b>	<b>Gender</b>		<b>Access to adequate water to irrigate</b>	<b>Household Savings</b>	
	<b>Female Respondents %</b>	<b>Male Respondents %</b>		<b>&lt; 15,000 KS (%)</b>	<b>&gt; 15,000 KS (%)</b>
BBaseS	59.8	39.8	80	36	31
BEOPS	60.0	40.0	65.8	40	29
NBBaseS	80.9	19.1	76	43	16
NBEOPS	74.5	25.5	48.9	21	15

## Discussion of medians for land use and pump utilization

### Land use

**Table 8** presents medians for several key variables related to crop production and to use of MoneyMaker irrigation pumps. Medians are preferred over means because they are less vulnerable to being skewed upward by a handful of very high values. Readers' attention is directed to the horizontally adjacent columns showing Base and EOP. This presents the desired "before and after" impact of pump ownership and use. Irrigation should permit producing more crops and more valuable crops. Pump buyers expanded Money Maker Pump (MMP) irrigated ac/household of food crops from a median of 0.13 to 0.25. Marketed irrigated ac/household expanded similarly. The zero Base gross revenue (GR) for MM irrigated food crops is an artifact of medians. It means the bottom 50% of households' GR from these crops was reported as zero. As expected, the quantities are smaller because semi-arid eastern Kenya produces relatively little non-food crops like cotton, coffee and tea. Sisal was the exception as it tolerates arid conditions.

The entries of N/A (non-applicable) for Non-Buyers (NB) are expected. This group lacked pumps and would not be expected to produce crops under treadle or hip pump irrigation. The data show that eastern Kenya farmers in the sample area continued to produce rainfed food crops at similar levels at Base and at EOP. Producing food more efficiently on irrigated cropland possibly released some labor to continue producing dryland food.

As expected, NB's acreages of rainfed food crops changed little from Base to EOP. A slight increase in this group's production of non-food crops was probably associated with improved precipitation at EOP.

### Pump utilization

Among buyers at EOP, 63% of households chose hip pumps and the remainder treadle pumps. **Table 8** reports *median* time spent by households was zero at Base with both types of pumps. This is inconsistent with the nonzero median acres of MMP irrigated land at Base reported below. However, our data show there are means for each of these cases which are positive and negate the concern associated with the 0 median in this case. If one extends this rationale to other BBaseS and NBBBaseS medians one can discern benefits which are apparent over period between Base and EOP.

**Table 8: Comparison of medians of selected variables at baseline (BBase) vs. End of Project (BEOP) for buyers and non-buyers**

<i>Money Maker Pump (MMP) irrigated food crops</i>	<b>BBaseS</b>	<b>BEOPS</b>	<b>NBBBaseS</b>	<b>NBEOPS</b>
<i>Total acres of MMP irrigated food crops</i>	0.13	0.25	NA	NA
<i>Marketed acres MMP irrigated food crop</i>	0.12	0.25	NA	NA
<i>Gross revenue, marketed MMP irrigated food crops (KSh/yr.)</i>	0.00	20,000	NA	NA
<b><i>Rainfed food crops</i></b>	<b>BBaseS</b>	<b>BEOPS</b>	<b>NBBBaseS</b>	<b>NBEOPS</b>
<i>Total acres, rainfed food crops</i>	2.50	3.00	2.75	2.50

<b>(Table 8 Cont.)</b>				
<i>Total acres marketed rainfed food crops</i>	2.50	3.00	2.00	2.50
<i>Total gross revenue rainfed food crops (KSh/yr.)</i>	10,000	20,000	2,330	10,500
<b><i>Rainfed non-food crops</i></b>	<b><u>BBaseS</u></b>	<b><u>BEOPS</u></b>	<b><u>NBBaseS</u></b>	<b><u>NBEOPS</u></b>
<i>Total acres rainfed non-food crops(ac)</i>	0.00	0.50	0.00	0.125
<i>Total acres marketed rainfed non-food crops</i>	0.00	0.25	0.00	0.125
<i>Total gross revenue rainfed non-food crops (KSh/yr.)</i>	0.00	8,000	0.00	2,000
<b><i>Marketed livestock and off-farm earnings</i></b>	<b><u>BBaseS</u></b>	<b><u>BEOPS</u></b>	<b><u>NBBaseS</u></b>	<b><u>NBEOPS</u></b>
<i>Gross revenue marketed livestock and livestock products (KSh/yr.)</i>	0.00	0.50	0.00	0.125
<i>Household off-farm earnings (KSh/yr.)</i>	36,000	96,000	30,000	60,000

An increase in time spent by households using a pump on 3.00 acres of total rainfed food crops at EOP compared to 2.50 acres at Base is expected. An increase is normal as families become more familiar with the equipment and better appreciate its benefits. **Table 9** shows EOP sample households' median hours/year of pump use increased to 144 and 124 for treadle and hip pumps, respectively. This is a substantial investment by families in strenuous activity in frequently hot weather. It is expected that non-buyers would not be irrigating and that data for pump use would be not applicable (N/A).

**Table 9: Median treadle and hip pump usage on an annual basis**

<b>Utilization</b>	<b>Survey</b>			
	<b><u>BBaseS</u></b>	<b><u>BEOPS</u></b>	<b><u>NBBaseS</u></b>	<b><u>NBEOPS</u></b>
<b>Treadle Pump</b>				
Ave. hrs./day	0.00	3.00	NA	NA
Ave. hrs./day	0.00	3.00	NA	NA
No. months/year	0.00	4.5	NA	NA
Total hrs. and days/year	0.00	144/18	NA	NA
<b>Hip Pump</b>	<b><u>BBaseS</u></b>	<b><u>BEOPS</u></b>	<b><u>NBBaseS</u></b>	<b><u>NBEOPS</u></b>
Ave. hrs./day	0.00	2.00	NA	NA
Ave. hrs./day	0.00	3.00	NA	NA
No. months/year	0.00	4.00	NA	NA
Total hrs. and days/year	0.00	124/15.5	NA	NA

During the period when the project was being implemented, buyers and non-buyers were experiencing difficult rainfall conditions with over 70% of non-buyers responding that rainfall was below normal until the short rains of 2016 when normal or above normal rainfall patterns predominated. This, without question, resulted in making the marketing team's efforts more difficult and may have been the determining factor in its inability to meet the sales needed reach minimum sample size levels. In addition, the poor rainfall conditions and short period for the farmers to use their newly acquired irrigation equipment had an impact on data generated during the survey period. In addition, it is likely that safety-first requirements for minimum food consumption may have restricted the households' willingness to market crops which were produced during the short-rains which ended in January 2016 in the project area.

**Table 10** presents the median rainfall for 2014 (recalled in 2015 at Base), rainfall for 2015 at Base, and rainfall for 2016 at EOP. The latter result captures perceptions of the short rains which ended in January of 2016.

**Table 10: Median rainfall estimates across recent cropping cycles**

Rainfall	2014–Prior yr. recall % of Respondents	2015 Current at Base % of Respondents	2016 – Short Rains Current at EOP % of Respondents
Normal	34.0	23.7	43.2
Above Normal	8.4	3.4	35.3
Below Normal	57.6	72.9	21.6
N	262	262	142

Estimates of *mean* rainfall by respondents by year are presented in **Table 11**. This data supports the aggregated medians presented in **Table 10**. Mean rainfall in 2014, among both buyers and non-buyers was perceived to have been below normal. This was the same case in the 2015 long rains but more non-buyers were affected by the below normal rains during this period. In October, 2015 the short rains provided relief to 78% of the buyer respondents and 78 % of the non-buyers. The October 2015-January 2016 short rains mark a transition to above normal rainfall. Had the project been able to assess the impact of pump utilization after the end of the 2016 long rains in the June – August period, the RT would have expected to see increased income and higher wealth indications. Safety first concerns would have diminished from improved food inventories allowing sales to expand. This, of course, assumes that the 2016 long rains were successful in making the maize and/or other staple crop.

**Table 11: Mean rainfall estimates by respondents across recent cropping cycles**

Rainfall	2014 (Prior Year Recall)		2015		2016 – Short Rains	
	BBaseS %	NBBaseS %	BBaseS %	NBBaseS %	BEOPS %	NBEOPS %
Normal	23	25	37.6	23.5	35.9	57.4
Above Normal	4.1	1.5	10.3	2.9	42.4	21.3
Below Normal	71.9	73.5	52.1	73.5	21.7	21.3
N	194	68	194	90	92	47

Comparing **Tables 10, 11 and 12** illustrates that poor 2014 and 2015 rainfall led to below average maize production among those interviewed. This created a barrier for the marketing team trying to sell pumps. It also created a challenge for the RT in interpreting irrigation area and pump utilization data.

Conditions during the period when individuals could have utilized their treadle or hip pumps to their greatest advantage did not occur until the short rains in the final quarter of 2015 into January 2016. There was little access to water for irrigation during 2014 and 2015 from any of the sources normally available. Measureable, positive change to income, from increasing treadle or hip pump irrigation, would likely not have occurred until the short rains were over in

January 2016. Emerging from a two-year drought, households may not have been willing to sell recently produced crops due to fear of future shortage threatening family food supplies. The necessity to secure the households' consumption needs before entering the market to sell any surplus would need to be assessed carefully. This could only have been monitored by extending data collection beyond the EOPS. This was impossible due to the effective final report deadline by early-June 2016.

The results presented in **Table 12** show that maize production increased by EOP in line with the earlier discussion on rainfall presented in **Tables 10 and 11**. **Table 12** reports that a cumulative 72.8% of respondents reported "Average", "Slightly above average", and "Much above average" maize production in the EOPS. This represents maize production during the 2015-January 2016 short rains.

**Table 12: Maize production**

<b>Maize Production</b>	<b>Baseline</b>	<b>End of Project</b>
Much below average	62.1	13.1
Slightly below average	22.2	14.6
Average	10.3	21.9
Slightly above average	1.5	25.5
Much above average	1.5	24.8
N	261	137

### **Health and nutrition**

Drought continued to affect families into the second half of 2015 with households subject to shortages as reported in **Table 13 and Table 14**. The relationship is evident among individuals who experienced food shortages. While the number of respondents was small they are shown to have experienced a deteriorating condition between Base and EOP. Own farm production shortfalls increased during the research period leading to more respondents experiencing lack of funds to purchase food as production shortfalls continued to exacerbate the challenge to food security.

**Table 13** reports the combination of production shortfalls and lack of money to buy food decreased over the period (Condition 3: 93.8% respondents at Base declining to 77.3% at EOP) while at the same time the challenge became more apparent in both shortfalls and lack of money classifications. Both of these conditions were reported to have increased (deteriorated) from Base - Condition 1: 6.3% to 18.2% at EOP and Condition 2: zero% to 4.5%. This explains why Condition 3: seemingly improved; there were both more respondents who were experiencing food shortages and the impact had led to greater shortfalls and more respondents no longer having money to buy food but the combination of both was no longer as important to the family as the "shortage" of production or the "shortage" on money to buy food. This continued up until the short rains broke the drought in the fourth quarter of 2015.

**Table 13: Percentages of respondents reporting having experienced food shortages**

<b>Reason for Experiencing Food Shortage</b>	<b>BBaseS</b>	<b>BEOPS</b>
1. "Own Farm" production shortfall	6.30	18.2
2. Lack of money to buy food	0.00	4.50
3. "Own Farm" production shortfall and lack of money	93.8	77.3
N	16	22

Sixteen respondents surveyed during the 2015 BaseS and 22 during the 2016 EOPS reported that they were affected by hunger on an annual basis across years. The proportions presented in **Table 14** suggest that almost two-thirds of families "must" reduce meals or "miss" preferred meals at times. It seems reasonable to suggest that hunger occurs during periods when poor harvests occur and crop inventories are depleted.

Over three quarters reported that the family regularly experiences hunger. The data collected at baseline represented responses that were given during a period of short rainfall, see **Table 10 and Table 11**, corresponding too much below average maize production (see **Table 12**). Whether perception of the hunger over *longer* periods of time is correlated with rainfall and maize production cannot be determined definitively from the data set, but this seems reasonable from the results in **Tables 10-14**.

**Table 14: Percent of respondents reporting hunger**

<b>Hunger Indicator</b>	<b>Baseline Survey</b>
Family regularly experiences hunger during any week of year	78.7 %
Household must reduce meals/day during the year	62.0 %
Preferred meals are missed during the year	63.1 %

The median number of times that the respondent is ill each year was two at Base for buyers and three for non-buyers. The non-buyers appeared to be ill more times per years but for shorter periods of time and less severe.

**Table 15: Median responses to illness of family members**

<b>Illness Indicators</b>	<b>BBaseS</b>	<b>NBBaseS</b>
Number of times each year that respondent is ill	2	3
Family member is too sick to work during each sickness period (Days)	7	4
Child is unable to work or attend school due to illness each year (Days)	14	12
Days children 5 < are sick each year	5	4
Days children, => 10 yrs <=14 yrs, are unable to work or attend school due to illness each year	3.5	3
Estimated total days children are unable to work or attend school due to illness each year.	17.5	12

## Micro finance, credit utilization and savings

Micro finance across Kenya is growing through the use of MPESA but can also be observed in the level of participation in savings clubs. In just a few years, MPesa has penetrated the most remote markets in Kenya. Furthermore, 87.6% of the respondents reported membership in a “Merry-Go-Round” savings club (see **Table 16**).

The Kenya cell phone market is moving toward saturation even in remote locations. Anyone can borrow a phone to use MPesa but over time will create the environment necessary where cell phones are in almost every pocket. As this process evolves so will the expansion in smart phone usage and the benefits which flow from conducting economic activities online. The use of treadle and hip pumps should provide part of the revenue necessary to benefit from this landmark technology.

### Access to MPesa and other finance opportunities

Familiarity with MPesa and experience with Merry-go-round savings groups will work together over time to provide the resources necessary to take more loans while being assured to be able to pay-back the loan. Surprisingly, 65.8% of the respondents answering this question said they used MPesa to purchase their pump. Given contract requirements, this would include all R2O or TKT sales through either the vendor or KSI marketing agents. Informal discussions with respondents revealed that many of them used Merry-Go-Round” savings clubs to purchase their most expensive assets.

**Table 16: Access to and utilization of MPESA and credit**

Response	Response	
	Yes (%)	No (%)
Familiar with MPesa	98.5	1.5
M-Pesa used to purchase your pump	65.8	34.2
Could have purchased w/o access to MPesa	68.4	31.6
Household members took loans, borrowed cash or received in-kind transfers	56.7	43.3
Member of “Merry-Go-Round” savings club	87.6	12.4

### Attitudes

Attitudes regarding the environment, education and information sources influence technology adoption and can modify the state of knowledge and access to technology. **Table 17** reports 81% of the respondents said they had attended educational sessions to improve their ability to produce crops. The most popular source of information on production and marketing was government extension services at 53.9%. The total of 15.6% of respondents who received information via cell phone is encouraging considering the short period of time that this technology has been available compared to radio and extension.

In the context of the small scale irrigation tools, by far the most important source for information is the vendor, 65% (see **Table 17**). This result identifies a major challenge to acceptance R2O and TKT. Cash sales are made directly from a vendor but this is not the case for

R2O or TKT which are the result of interaction between KSI marketing and the potential buyer. 65% of the owners rely on the vendor as their most useful information source but neither R2O nor TKT buyers have a direct seller/buyer relationship with a vendor at purchase. It may be difficult for the latter to access important information on product improvement, operation, maintenance. New technology information which could improve utilization may not be available to the TKT and R2O buyer if there is no formal link with the vendor until a challenge arises.

**Table 17** confirms that a diverse set of media sources and organizations are used by farm households to access information. The transition to cell phones and now toward smart phones will transform access to information. These new information communication technologies should be utilized to link vendors with participants who have purchased via R2O or TKT. Attitudes toward accessing information this way are changing rapidly empowering participants, who are already proud of their new mobile phone use, to gather and share information.

**Table 17: Exposure to Agricultural Education and Extension**

**Agricultural education sessions and reception of information**

	Yes (%)	No (%)
% of respondents who attended educational sessions on better methods for growing crops	81.2	18.8
<b>Received the most useful information on agricultural production and marketing from (Type of communication Technology Tool):</b>	% <sup>1</sup>	N
Cell Phones	14.6	19
Government Extension Services	53.9	70
Radio	22.3	29
Pump Vendor	3.8	5
TV	2.3	3
Internet	3.1	4
<b>Received the most useful information on small scale irrigation from (Type of Communication Technology or Median):</b>	% <sup>1</sup>	N
Cell Phones	1.3	2
Government Extension Services	20.6	32
Radio	10.3	16
Pump Vendor	65.2	101
TV	1.9	3
Internet	.6	1

<sup>1</sup> Percentage of those responding yes to receiving information through a type of communication media/organization or individual.

**Women’s empowerment and small scale irrigation**

Women make up over 67% of the 3,900 members of the 256 groups that were contacted during Phase 1. Among potential buyers, the breakdown was approximately 60% female and 40%

male. Marketing to women and low resource producers was listed as KSI’s second explicit objective for the research (KSI, USAID and WSU; 2014). Consequently the RT devoted considerable attention to understanding the role of women in the household decision making structure. **Table 18** presents the results of this inquiry.

What is striking about the responses associated with this section are that in each, except one, women are making the decisions that are not made jointly at rates many percentage points higher than their male counterparts. With the exception of “primary responsibility to pay for inputs, bought in the market, which are for use on any irrigated plot” this result holds true. In the latter case, males were identified as the main decision maker by 22.8% of the respondents and 22.2% of the time female respondents were making the decisions; the remainder, 55%, reported decisions were made jointly. Strong pluralities of decisions were made jointly or “Both Equally” in 12 of the 14 decisions listed in **Table 18**. Women were reported to be making over 30% decisions in response to 7 of the 14 questions. These are italicized in bold print in **Table 18**. In the “Leadership” category, 40% or more of the decisions are made by women. These findings should inform KSI’s attempts to target women producers in its attempt to provide treadle and/or hip pumps to the population.

**Table 18: Decision making and labor allocation in the household**

<i>Function</i> <i>By whom are decisions in the household made and labor allocated?</i>	Mainly husband or adult male	Mainly wife or adult female	Both Equally
<b>A. Production (Any type of Irrigation–pump/buckets/other</b>	N (%)	N (%)	N (%)
Who makes decisions about what non-vegetable crops are to be grown under irrigation?	13(12.6)	26(25.2)	64(62.1)
Who makes decisions about what vegetables crops are to be grown under irrigation?	24(14.0)	52( <b>30.2</b> )	96(55.8)
<b>B. Resource Control</b>			
Who has primary decision-making power over the use of productive resources and assets such as land, agricultural inputs and/or credit?	40(17.4)	69(26.5)	151(58.1)
<b>C. Income Control</b>			
1.1. Who has primary control over revenue generated from irrigated crops which were subsequently sold in the formal market?	12(7.3)	36(21.8)	117(70.9)
Who has primary control over revenue generated from irrigated crops which were subsequently sold to neighbors?	13(7.8)	47(28.3)	106(63.9)
Who has primary control over revenue generated from MM pump produced crops which were subsequently sold in to individuals from close-by villages?	11(11.1)	27(27.2)	61(61.6)
Who has primary responsibility to pay for inputs, bought in the market, which are for use on any irrigated plot(s)?	41( <b>22.8</b> )	40(22.2)	99(55.0)
<b>D. Leadership</b>			
In your household, who takes leadership in organizations that are related to irrigation?	40(16.3)	101( <b>41.1</b> )	105(42.7)
In your household, who takes leadership in other organizations, open to participation by both women and men, which are designed to generate monetary income?	28(11.0)	104( <b>41.6</b> )	122(24.4)

<b>(Table 18, Continued)</b>			
In your household, who takes leadership in other organizations, open to participation by both women and men, which are designed to generate/create social benefits but not monetary benefits?	28(11.0)	109( <b>42.8</b> )	118(46.3)
<b>E. Time Expenditure or Savings</b>			
Who in the family allocates the most time, on an annual basis, to the production of <i>irrigated crops</i> ?	35(19.3)	73( <b>40.3</b> )	73(40.3)
Who in the family allocates the most time, on an annual basis, to the production of <i>irrigated cash</i> crops?	38(21.6)	67( <b>38.1</b> )	71(40.3)
Who in the family allocates the most time, on an annual basis, to the production of <i>irrigated staple food crops</i> ?	21(18.3)	42( <b>36.5</b> )	52(45.2)
Who in the family controls the money generated from sales of crops grown and sold which required use of the treadle/hip pump for irrigation?	16(15.5)	27(26.2)	60(58.3)

## Statistical Comparisons of Household Wellbeing of Moneymaker Pump Users<sup>1</sup> versus Pump Non-Users: End of Project

The third research objective asks: “Are the impacts higher/lower for each financing scheme compared to households who did not take up a pump?” That question is addressed in the following section. This section statistically examines the precursor: Were household impacts higher or lower for *all* pump users, regardless of finance method used, versus those who did not irrigate.

**Table 19** presents 1-tailed t-test comparisons of means of pump users versus pump non-users for 16 wellbeing variables at EOP. One-tailed tests are used so that the alternative hypothesis implies irrigation improves wellbeing. As conventional, the null hypothesis ( $H_0$ ) is specified so that its rejection implies tentative acceptance of the theoretically desired alternative. For the hunger example,  $H_0$ : Proportion hungry for irrigators at EOP > Proportion hungry for non-irrigators at EOP. **Table 19** reports this null is rejected at the 0.05 level so one may tentatively accept the desirable alternative that irrigators’ family hunger is less at EOP. This corresponds with the reported proportions hungry of 0.104 (about 10%) for irrigators (pump users) versus 0.243 (about 24%) for dryland farmers (pump non-users) (see data columns 2 and 3, row 4 in **Table 19**).

The nine results where the accepted alternative hypotheses imply that irrigation improved household wellbeing, *and* are explained by normal economic theory, are superscripted “+” in the Altern (Alternate) Hypothesis column. These include rows 3, 4, 5, 6, 7, 8, 9, 10 and 15; however, rows 7, 8 and 10 fail statistical significance. Rows 7 and 8 both relate to net revenue for *rainfed* food crops where improvement in net revenue would not be expected.

Greater net income from irrigation suggested student enrollment increases might be permitted by making tuition and school uniforms more affordable, but the results were not significant.

<sup>1</sup> Users and non-users of pumps are not identical to buyers and non-buyers because 14 buyers had not used their pumps by EOP and two non-buyers had used a pump that had been given to them by World Vision.

This is to be expected due to the very short period during two very poor rainfall years (see **Tables 10 and 11**) when most production would be retained for home consumption. *Non-food* crops like coffee, tea, and cotton are not common in semi-arid eastern Kenya. Consequently, the weakly significant results in rows 13 and 14 should not be given great importance. No definitive theory was identified for the influence of irrigation on off-farm earnings. On one hand, by using labor more efficiently to produce food, some household members might be liberated to work off the farm. But theory could equally predict that with irrigation family members could produce more value on the farm rather than by working in the weak off-farm unskilled labor market in Kenya. Available data did not permit the RT to favor one theory over the other.

**Table 19: One-tailed t-test comparisons of means of pump users versus means of pump non-users for 16 wellbeing variables at end of project survey**

Variable	Mean or proportion users	Mean or proportion non-users	Alternative Hypothesis (H <sub>A</sub> ), 1-tail test	Accept H <sub>A</sub> 1-tail test	p - level 1-tail (reject H <sub>O</sub> ) & S. <sup>2</sup>	Theory for H <sub>A</sub>
1. Primary students (PS)	2.2	2.3	Mean PS: pump users > mean nonusers	No	0.400, NS	Lower budget constraint for utility max.
2. Secondary students (SS)	1.6	1.5	Mean PS: pump users > mean nonusers	No	0.264, NS	Lower budget constraint for utility max.
3. Ac cropland 2015 (AcCr)	2.12	2.26	Mean AcCr pump: users > mean nonusers <sup>+</sup>	Yes	0.001, S at 0.01 ***	Profit max
4. Proportion Hungry	0.104	0.243	Mean Proportion hungry: users < nonusers <sup>+</sup>	Yes	0.012; S at 0.05 **	Utility max
5. Net Rev/ Ac irrig. crops, KSh	46,933	4,039	Net Rev/ Ac irrig. Crops: users > nonusers <sup>+</sup>	Yes	0.0001; S at 0.01 ***	Profit max
6. Net Rev/Farm irrig. crops, KSh	15,849	762	Net Rev/Farm irrig. Crops: users > nonusers <sup>+</sup>	Yes	0.00000009, S at 0.01 ***	Profit max
7. Net Revenue/ ACRE for Rainfed Food Crops, KSh	359	1,854	Net Revenue/ ACRE for Rainfed Food Crops: users < nonusers <sup>+</sup>	No	0.264, NS	High opportunity cost of labor for users
8. Net Revenue/FARM for Rainfed Food Crops, KSh	6,957	7,528	Net Revenue/FARM for Rainfed Food Crops: users < nonusers <sup>+</sup>	No	0.450; NS	High opportunity cost of labor for users
9. Wealth/FARM, KSh	452,408	243,946	Wealth: users > nonusers <sup>+</sup>	Yes	0.004; S at 0.01 ***	Reinvestment of profit in farm assets
10. Acres irrigated using Bucket	0.234	0.243	Acres irrigated using Bucket: users < nonusers <sup>+</sup>	No	0.462, NS	High opportunity cost labor

<sup>2</sup> For the 1-tailed test, the null hypothesis is that one mean > or < the other mean. Rejecting this null implies that means are ranked with a reversed inequality for the alternative hypothesis. Significance (S) declines progressively from 0.01, 0.05, and 0.10 levels. These levels are denoted by \*\*\*, \*\* and \*, respectively. NS denotes not significant at the lowest 0.10 level.

<b>(Table 19 Continued)</b>						
11. Total acres rainfed food crops	4,417	2,740	Total acres of rainfed food crops: users < nonusers	No	0.0007, S at 0.01 ***	Uncertain
12. Total gross revenue rainfed food crops (KSh/yr)	34,959	25,346	Total gross revenue rainfed food crops: users < nonusers	No	0.067, S at 0.10	Uncertain
13. Total acres rainfed non-food crops	0.55	0.198	Total acres rainfed non-food crops: users > nonusers	Yes	0.06, S at 0.10	Uncertain
14. Total gross revenue rainfed non-food crops (KSh/yr)	28,700	4,745	Total gross revenue rainfed non-food crops: users > nonusers	Yes	0.07; Significant at 0.10	Uncertain
15. Gross revenue marketed livestock and livestock products (KSh/yr)	62,801	19,148	Gross revenue marketed livestock and livestock products: users > nonusers <sup>+</sup>	Yes	0.068, S at 0.10	Profit max
16. Household off-farm earnings (KSh/yr)	151,840	137,389	Household off-farm earnings: users > nonusers	No	0.306, NS	Uncertain

## Statistical Comparisons of Household Wellbeing of Moneymaker Pump Purchasers Who Used Specified Finance Methods versus Non-Irrigators at End of Project

This section statistically tests results pertaining to the third research objective: “Are the impacts higher or lower for each financing scheme compared to households who did not take up a pump?” **Table 20** presents statistical answers to this question for the same 16 household wellbeing variables included in **Table 19**. The explanation of and justification for 1-tailed t-tests remains the same. No theories are listed for alternatives to the null hypotheses as in **Table 19**. The prevailing theory, although not listed in **Table 19**, is that pump use and irrigation, regardless of finance method, should improve wellbeing relative to dryland farming. Wellbeing means or proportions are presented for:

- a) Non-users
- b) Cash pump purchasers
- c) R20 purchasers and
- d) TKT purchasers.

For acres of cropland (Ac cropland) 2015, Proportion Hungry, Net Revenue per acre (Net Rev) and per farm for Irrigated crops (Irrig. crops), all three finance options show better wellbeing than non-irrigators at the strong 0.01 level. Cash has better point estimates for Ac cropland and TKT for Proportion Hungry, but R20 is slightly stronger over Cash for Net Rev per acre and per farm for Irrig. crops. Results for TKT are weaker because fewer than ten households purchased equipment using this finance/treatment method. Irrigation would be expected to have less effect on rainfed crops and rows 7, 8, 11 and 12 fail to show poor significance across finance

methods. As introduced earlier, non-food crops are not common in semi-arid eastern Kenya.

Results for rows 13 and 14 fail significance for Cash and R20; it is not applicable (N/A) for TKT due to a small sample size. Wealth for cash purchasers at KSh 675,378 easily has highest superiority over non-irrigators and is significant at the 0.01 level. R2O and TKT lack statistically significant superiority over non-irrigators. The significance across finance methods is erratic. Gross revenue from livestock is weakly superior for cash relative to non-irrigators and fails significance for the other two finance methods. Off-farm earnings are statistically superior at the 0.01 level for cash compared to non-irrigators, but for R2O and TKT lacked statistical significance. A plausible explanation may be that higher off-farm earnings, at a mean of KSh 204,267, permitted cash households to pay cash for their irrigation pump. An alternative explanation may be that cash buyers had more opportunities to generate wealth due to more of them having access to the equipment during the long rainy season in 2015. On the other hand, R2O and TKT purchasers showed statistically weaker off-farm earnings when compared to non-irrigators.

Taken collectively, the results in **Table 20** show that cash purchasers had the highest household wellbeing advantages over non-irrigators. Cash pump purchasers had the highest and most significant net revenue advantage from irrigated food crops. Moreover, cash pump purchasers experienced significantly less hunger, were significantly wealthier, had significantly greater nonfarm earnings and irrigated less cropland with a bucket. The results show R2O purchasers were in second place for wellbeing compared to Cash.

Layaway results should be regarded cautiously since this subsample contained only eight households. As a result, TKT (layaway) results were not expected to be substantially revealing given the few sales that occurred among treatment participants. All t-tests for TKT households lack statistical power as a result of small sample size. TKT households earned more net revenue from rainfed crops and irrigated more acres with a bucket than other types of households. TKT pump purchasers were less wealthy and earned the least from non-farm sources compared to the other households. Only a small number of households used the layaway micro-credit scheme to purchase MoneyMaker pumps. This issue was addressed in a follow-up Layaway survey undertaken to assess why so few of potential buyers in this treatment purchased equipment. Lack of money and shortness of payback period were the most common responses but others were perceived as equally important by other potential buyers. The results of this data analysis are introduced in **Table 20**.

**Table 20: One-tailed t-test comparisons of wellbeing means of pump non-users to pump users<sup>3</sup> who purchased pumps by specified finance methods: End of Project Survey (EOPS)**

Variable	Non-users Mean or proportion	Cash Mean or propor.	R2O <sup>4</sup> Mean or propor.	TKT <sup>5</sup> Mean or propor.	Cash p-level, 1-tail (reject H <sub>0</sub> ) & S <sup>6</sup>	R2O p-level 1-tail (reject H <sub>0</sub> ) & S	Layaway(TKT) p-level 1-tail (reject H <sub>0</sub> ) & S
1. Primary students (PS)	2.3	2.25	2.26	1.5	0.400, NS	0.047, S at 0.05	0.037, S at 0.05
2. Secondary students (SS)	1.5	1.9	1.56	1.2	0.062, S at 0.10	0.04, S at 0.05	0.114, NS
3. Ac cropland 2015 (AcCr)	2.27	4.92	4.036	3.07	0.007, S at 0.01	0.02, S at 0.05	0.318, NS
4. Proportion. Hungry	0.243	0.05	0.17	0	0.0013; S at 0.01	0.170, NS	0.000006, S at 0.01
5. Net Rev/Ac irrig. crops, KSh	4,039	44,850	54,524	19,800	0.001; S at 0.01	0.0000454, S at 0.01	0.117, NS
6. Net Rev/Farm irrig. crops, KSh	762	16,216	17,603	6,100	0.0006, S at 0.01	0.00005, S at 0.01	0.054, S at 0.10
7. Net Revenue/ACRE for rainfed food crops, KSh	1,854	-2,460	259	12,391	0.088, S at 0.10	0.278, NS	0.157, NS
8. Net Revenue/FARM for rainfed food crops, KSh	7,528	1,720	8,293	22,144	0.145; NS	0.440, NS	0.111, NS
9. Wealth/FARM, KSh	243,946	675,378	316,984	174,725	0.004; S at 0.01	0.98, NS	0.117, NS
10. Acres irrigated using Bucket	0.243	0.0374	0.1875	0.458	0.00007, S at 0.01	0.176, NS	0.251, NS
11. Total acres rainfed food crops	2.740	4.33	4.69	3.286	0.014, S at 0.05	0.007, S at 0.01	0.284, NS
12. Total gross revenue rainfed food crops (KSh/yr)	25,346	33,402	34,490	42,643	0.142, NS	0.123, NS	0.104, NS
13. Total acres rainfed non-food crops	0.198	0.75	0.5	0.5	0.127, NS	0.166, NS	N/A
14. Total gross revenue rainfed non-food crops (KSh/yr)	4,745	88,000	15,957	0	0.204; NS	0.103, NS	N/A
15. Gross revenue marketed livestock and livestock products (KSh/yr)	19,148	116,777	26,830	18,778	0.08, S at 0.10	0.142, NS	0.484, NS
16. Household off-farm earnings (KSh/yr)	137,389	204,267	122,757	89,750	0.076, S at 0.01	0.308, NS	0.054, S at 0.10

<sup>3</sup> Users and Nonusers of pumps are not the same groups as Buyers and Non-buyers of Pumps because 14 buyers had not used their pumps by EOP and two Non-buyers had used a pump that had been given to them by World Vision.

<sup>4</sup> R2O is rent to own. The farmer takes possession of the pump immediately after a down payment and may keep it as long as his/her rental payments are current.

<sup>5</sup> TKT is laying away savings by MPesa. When the full price of the pump is laid away, the farmer is entitled to collect his/her pump.

<sup>6</sup> For a one-tailed test, the null hypothesis is that one mean > or < the other mean. Significance (S) means this null is rejected and that the alternative hypothesis, namely that means are ranked with a reversed inequality, may be tentatively accepted. Significance is reduced progressively from 0.01 to 0.05 to 0.10 levels. NS denotes failure to reject the null at the 0.10 level.

## Multiple Regression Analyses of Impacts of Moneymaker Pump Use on Selected Household Wellbeing Measures (Brief Summary)

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The previous t-tests of impacts of irrigation on household wellbeing are limited by not controlling for confounding factors which could have changed household wellbeing between Baseline (B) and End of Project (EOP). These include weather, physical location, farm size and other factors. Multiple regression computes marginal changes in the dependent wellbeing variable associated with one explanatory variable while other explanatory variables are held constant.

Two multiple regression approaches were attempted: Differences in differences (DID) and panel data regression (Abadie, 2005; Angrist & Pische, 2008; Bertrand et al., 2004; Card and Krueger, 1994). The unit of observation was the household interviewed at *both* baseline and EOP. Matching of households, in both non-irrigators and irrigators groups, over the two surveys was a key design of this research.

### Difference in differences analysis

Difference in Differences (DID) analysis, developed in the 1990's, is the most modern technique to show "before and after differences" in a dependent variable like household income or hunger after some "intervention" such as adoption of irrigation, passage of new legislation, or political upheaval. It does so by utilizing a control group, in our case non-irrigators, who went through the Base to EOP period experiencing the same weather and other external forces. Including the control group requires merging the buyers and non-buyers data sets. DID also enters a set of "control variables" relevant to the wellbeing measure. These variables control for possible confounding. In our case, these included gender of respondent; low, normal or high rainfall; Kitui, Makueni, or Machakos county of residence; traditional family of male & female adults with children under 14, education of respondent secondary or higher, main occupation of household is farming, possession of adequate water to irrigate cropland, use of Hip pump, household savings greater than KSH 15,000, total annual off-farm earnings of household members and household wealth. Separate DID equations were estimated for nine household wellbeing factors: (1) number of primary students, (2) number of secondary students, (3) number of college and university students, (4) cropland ac planted last year, (5) hungry any week in year (yes/no; binary), (6) reduce meals any day in year (binary), (7) consume less preferred meals in year (binary), (8) net revenue/ac of food crops and (9) net revenue/farm of food crops. Six of these variables, (1), (2), (4), (5), (8) and (9) were also included in the t-tests reported in **Tables 19 and 20**. Unfortunately, the DID regression was not feasible due to technical statistical reasons when finance scheme was added as a control variable.

It should be stated at the outset that the DID literature emphasizes that it works best when (a) the intervention shows a pronounced break between before and after and (b) the sample size is relatively large. Neither of these conditions applied to our data. Regarding (a), only one year elapsed between Base and EOP due to project term limitations. This limited the amount of time for experience with the pumps to accumulate and for their full effects to be realized. Indeed for most buyers, they would have only seen large improvement in their wellbeing after the final set of data had been collected as discussed earlier in the report. Also, different households used the

pumps to varying degrees during this short period. Regarding (b) our sample with complete data included only 96 pump users (“irrigators”) and 70 non-users (“non-irrigators”). In contrast, some DID analyses contain more than 1,000 observations. Our small sample was constrained by the ability of KSI to market equipment as effectively as had been hoped. As discussed above, this was likely due to drought conditions that affected household’s ability to buy pumps, and also their ability to access water for irrigation from 2014 up to the short rains in the four quarter of 2015.

In light of these limitations, it was not surprising that a limited number of statistically significant relationships emerged at 0.01, 0.05, or 0.10 levels.  $R^2$ 's, showing “goodness of fit” were low ranging from 0.037 for number of primary students to 0.435 for acres of cropland. Net revenue per farm from food crops was the only wellbeing variable with a statistically significant difference from baseline to EOP. Net revenue per farm from food crops was also positively and significantly correlated with farming as principal occupation and savings exceeding KSh 15,000. Attention to farming on a full-time basis and adequate savings to purchase inputs improves farm profit.

Wellbeing variable (6), hungry any week of the year, was significantly related with education greater than secondary and savings greater than KSh 15,000. Both these coefficients were negative as predicted by theory; in other words, greater education and savings reduced hunger. Number of primary students was positively and significantly related to savings exceeding KSh 15,000. Greater savings plausibly made school related costs more affordable. No other wellbeing variables displayed significance with the control variables. The category, “greater than KSh 15,000 savings” was most frequently significant. Education equal to or greater than secondary school ranked second. Savings and education are frequently significant in the technology adoption literature.

A complete matrix of DID results with coefficient estimates, standard errors of coefficients, significance levels, and  $R^2$ 's is included in the online appendix. The appendix also includes a table of theoretically expected coefficient signs for several explanatory variables for several possible dependent variables. The range of variables differs slightly from the lists above.

### **Regression with panel data**

Panel data regression is an older technique where observations on the same entities, in our case farm households, are observed over two or more time periods ([http://www.indiana.edu/~wim/docs/10\\_7\\_2011\\_slides.pdf](http://www.indiana.edu/~wim/docs/10_7_2011_slides.pdf)). The data set also includes a set of explanatory variables. There is no control group.

Results from the panel data regression are similar to those for DID. Cropland acreage, hungry any week of the year (and its duplicates) and net revenue/farm from food crops again show the most statistically significant relationships. The category, “greater than KSh 15,000 savings” was again the strongest explanatory variable. The DID and panel data approaches are methodologically different, and there were minor differences in the included variables, so comparisons should be made with caution. Readers with greater interest in the panel data results are referred to the online “Appendix 3” showing estimated coefficients, standard errors, and significance levels for each explanatory variable for each wellbeing regression.

## Pathways for Future Scaling-up of the Intervention

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The authors consulted extensive literature on agricultural technology adoption in other regions of Kenya and other African countries to attempt to ascertain how different financing mechanism could break down barriers to asset acquisition (Gitau et al., 2015). This literature review summary was included in the Milestone II report and is repeated here. Two of the three eastern Kenyan counties in this research were populated by dominantly rural households, all three possessed mainly poor households solely dependent on farming. On the positive side, from 70 to 75 percent of the counties' populations were literate. This shows the potential that farmers could understand how to operate and care for new agricultural equipment like KSI's small scale irrigation equipment. The authors believe this KSI-WSU research might be generalized to Kenya's Kwale and Tharaka agro-ecological zones because they are similar to the eastern counties (Kenya Food Security Group, 2015). Truly arid regions such as Turkana, Laikipia and Isiolo are mainly inhabited by pastoralists rather than farmers. This makes them poor candidates for the study's results.

Some factors might discourage layaway savings elsewhere in Africa. Mobile banking has not been as successful everywhere in Africa as in Kenya. For instance, Somalia's agricultural ventures are discouraged by the political instability of the country. Islamic rules against paying any form of interest on loans could inhibit use of R2O in Arabic countries in North Africa (Savin, 2012). The eastern Kenya results will be difficult or impossible to duplicate in most Saharan and southern African countries that experience arid and/or desert conditions. The mobile layaway and R2O financing schemes will not overcome a genuine lack of water (Kirui et al., 2013).

Mobile layaway and R2O financing could be beneficial to women by permitting them to expand their asset base. Women were very active in the farm groups surveyed in the RA-DS. The percent of women ranged from 63 in Makueni to 82 in Kitui (Young et al., 2014).

Based on a popular brochure, KickStart International (2015) asserts 93% of women feel empowered after buying the pump. Women empowerment by the Kick Start project has tripled the number of students attending schools, 28% of children in the communities using pumps can attend private schools, an increase from 9%. These exceptional benefits are also attributed to the fact that women control 36% of the household income generated through irrigation. Communities embracing the technology experience a claimed doubling in the income per household KickStart International (2015).

Literature from other countries reveals that certain variables have a consistent positive effect on financial innovation and agricultural technology adoption. These include higher education, exposure to extension programs which teach farmers how to use the new technologies, and adoption of other financial innovations. These relationships are shown by studies in Kenya and Nigeria (Owuor, 2009; Omonoma, 2010). The age range 21-49 years has higher technology adoption rates. KSI's Rent-to-Own and Layaway financial options, as well as Cash Purchase, may facilitate adoption by a broader range of households. In Ethiopia, which shares agro-

climatic conditions with Kenya, microfinance credit, access to extension services, and shorter distance to the nearest road and/or market positively influenced adoption of irrigation (Liverpool, 2010; Goshu, 2012). Ethiopia possesses extensive agricultural lands. Malawi has greater availability of water and land which may contribute to its higher adoption of human-powered pumps. Higher share of off-farm income, participation in farmers' self-help groups, and contact with extension services were shown to promote adoption of pumps and similar technology in Madagascar, Tanzania, and Malawi (Moser, 2006; Kabunga, 2011; Mohamed, 2008; Amudavi, 2009).

From the literature review, the authors believe Kick Start pump technology has strong potential to alleviate poverty and enhance food insecurity in Africa, especially due to an increased empowerment of African rural women. However, households must be able to afford the pump and hoses as a lump sum purchase or over time through layaway or rent-to-own. The authors believe there are niches in the agricultural population throughout Africa under current economic growth trends that can afford this investment.

## **Important Reasoning for Respondents to Adopt KSI Pumps**

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One hundred-ninety four of the surveyed respondents in the BaseS were potential buyers of human-powered irrigation pumps (Young et al., 2015). Of these, 59 indicated an interest in cash purchase, 68 in rent to own, and 67 in TKT-layaway savings. As a control group, another 68 households in the same locations as the respondents, who had neither purchased a pump nor who were interested in doing so, were surveyed. The baseline surveys asked for considerable information about access to water, production of food, non-food crops, livestock, and household wellbeing. The wellbeing measures included family nutrition, family health, children's enrollment in education, farm income from various enterprises, and household wealth. General farm management information elicited use of credit, land allocation to different crops, irrigation intentions, revenues and costs of rainfed or irrigated crops, labor utilization and exposure to agricultural education and remoteness from public services was also elicited. The bulk of this information is included in the on-line appendices.

During March-April 2016 the RT team conducted End of Project (EOP) surveys of the *same* farm households among both pump buyers and non-buyers. The EOP surveys used a subset of identical questions from the Baseline. By the EOP, among 168 respondents, only eight (8) had used the layaway finance treatment to acquire pumps, with the remainder using cash and rent to own to acquire pumps. This implies an attrition of 59 households who intended to use layaway to purchase pumps to those who actually did so. Finally, in May 2016, 43 households who had expressed an interest in layaway at baseline, but had dropped from the program or had yet to receive their pump by the time the EOPS was undertaken, were surveyed to learn more about their inability to complete the purchase.

The Base, EOP, and Layaway surveys all contained a number of self-classification questions. We believe the answers to these can assist KSI in targeting future pump promotion. Qualitative responses from participants also aid in the interpretation of quantitative results.

## Reasons for Purchasing a Pump

**Table 21** reveals that economic reasons dominated plans for purchasing a pump in the Baseline survey. These included “Increase income,” “Enable to irrigate larger parcels,” “Inexpensive,” “No operational costs,” “No costs involved,” and “Easy to pay.” These six reasons accounted for 53% and 57% of the first and second most important reasons, respectively.

A second grouping of “important” reasons related to ease of use and efficiency in use of water and labor. The EOP results showed 49% of buyers considered the ability to irrigate larger parcels as the most important reason for purchasing their irrigation pump. When compared with the Base result of 16% one might conclude that use of the equipment allowed respondents and their family members to more clearly recognize the benefits of bringing more land of irrigation. At Base increasing income was seen to be the major motivating factor for purchase. This may be related to marketing efforts which emphasize profit through intensification that can generate surplus production which can be sold after food security concerns have been met. This compares to only 4 percent responding that increased income was the most important reason for purchasing the pump, down from 17 percent in the Baseline. The expectations thus become intertwined and related as more knowledge is gained on the use of the equipment. Both security issues and efficiency issues tend to promote the interest in irrigating more land, especially when poor rainfall is putting the home at risk for shortages. Some 18% indicated reasons such as planting vegetables or caring for livestock. Home gardens and water near the homestead for livestock were important reasons for using the irrigation equipment when water was available. But there were many respondents who used their pumps for multiple purposes such as watering their chickens and making bricks for their homes along with producing the mortar for sealing their homes against weather. For those using the pumps there were very important additional benefits which fell into this grouping. The multiple purposes category was the second “Most Important” reason for purchasing a pump. This can be interpreted to mean that if the first most important reason for a respondent to purchase a pump was to irrigate more land than his/her second most important reason for the purchase may fall in the multiple-purpose category while the third may be income related. The multiple-purpose category should be an important category to consider when developing sales messages.

**Table 21: Respondents’ most important reasons for purchasing a Money Maker pump**

Important Reason	1 <sup>st</sup> and 2 <sup>nd</sup> Most Reasons for Purchase			
	1 <sup>st</sup> Most Important Reason (Respondents)	(%)	2 <sup>nd</sup> Most Important Reason (Respondents)	(%)
<b>Baseline:</b> Increase income	33	17%	38	20%
EOP: Increase income	4	4%	12	11%
<b>Baseline:</b> Enable to irrigate larger parcels	35	18%	29	15%
EOP: Enable to irrigate larger parcels	54	49%	12	11%
<b>Baseline:</b> Ease to use	32	16%	24	12%
EOP: Ease to use	14	13%	3	3%

<b>(Table 21, Continued)</b>				
<b>Baseline:</b> Inexpensive	14	7%	21	11%
EOP: Inexpensive	3	3%	2	2%
<b>Baseline:</b> Multiple purposes (farming, brick making, etc.)	13	7%	18	9%
EOP: Multiple purposes	20	18%	15	14%
<b>Baseline:</b> No operational costs	17	9%	17	9%
EOP: No operational costs	6	5%	13	12%
<b>Baseline:</b> Reduction of workforce/workload	16	8%	14	7%
EOP: Reduction of workforce/workload	10	9%	7	6%
<b>Baseline:</b> More efficient water use	15	8%	3	2%
EOP: More efficient water use	0	0%	0	0%
<b>Baseline:</b> Nonresponses	13	7%	25	13%
EOP: Nonresponses	0	0%	44	40%
<b>Baseline:</b> Other responses	6	3%	4	2%
EOP: Other responses	0	0%	3	3%
<b>Baseline: Total</b>	<u>194</u>	<u>100%</u>	<u>194</u>	<u>100%</u>
<b>EOP: Total</b>	111	100%	111	100%

Compared to the Baseline responses, 27% less buyers provided a second reason for purchasing a pump. As in the Baseline, economics again predominated at EOP, accounting for 60% of primary reasons for purchase.

## Special Survey: Shortfall in Utilization of Layaway Finance Option

The answers reported in **Table 22** address the specific reasons why respondents, who had committed to purchasing a pump using the TKT treatment, subsequently did not buy, bought but could not complete payments, or were not able to buy either the treadle or hip pump. The respondents included in the End of Project TKT-Layaway Survey (EOPTKTS), had hoped to purchase and had verbally committed to purchase a KSI pump. This was the major focus of the study; KSI and USAID-DIV were particularly interested in the viability of the layaway savings financing scheme. Unfortunately, there were not nearly enough sales (8) to expect useful results from comparisons. At EOP the research team had no insight into the reasons why this had occurred and therefore designed and implemented the unplanned follow-up survey to learn, directly from the participants, why they had not completed the purchase process.

Forty-three of the original 61 who had not completed the layaway process were successfully contacted. The other 29% were unable to be contacted since this survey had to be done by cell phone or they preferred not to interview on this issue. Women made up 58.1 percent and men 41.9 percent of those who responded to the follow-up survey. Twenty-seven percent stated they did not understand the program. This was very likely due to the changing of KSI field representatives during the project period, inability to easily explain how and why MPesa would be used to carry out payments and, in at least three cases, because the potential buyer did not receive a follow-up visit by a KSI representative

**Table 22: Responses to layaway (EOPTKTS) follow-up survey**

EOPTKTS Responses	Yes (%)	No (%)	N
Received a “free” pump from another group	0	100	43
<i>If opting out, was first TKT payment made</i>	48.8	51.2	43
Treadle or Hip pump received after 2014	2.3	97.7	43
<b>Respondent was asked to agree or disagree with following statements:</b>	4.7	95.3	43
The TKT program was confusing	4.7	95.3	43
<i>Did not understand the MPesa system when we signed up</i>	14.0	86.0	43
<i>Time limit for laying away the purchase amount was too short</i>	23.3	76.7	43
<i>Did not make enough money to pay off the pump in the period allowed</i>	46.5	53.5	43
Heard about another finance option, R2O, and preferred that method	4.7	95.3	43
Felt misinformed by the KSI representative about the TKT program	0	100	43
The Money Maker people came to us in August 2015 and wanted to change the terms of our agreement; I decided to drop out of the program	0	100	43

The respondents were asked if there were other reasons for having stopped participating in the layaway program. Their responses are listed in **Table 23**. One issue that should be noted is that three individual reported that there had been no follow-up by KSI marketing personnel to arranged for participation in the program. This represents a minimum of 4.9% of the total potential TKT buyer sample that was not contacted again by KSI until the RT arrived to interview them at EOP.

**Table 23: Other reasons mentioned that impacted ability to continue the layaway program**

<i>1<sup>st</sup> Other Reason Reported</i>	<i>2<sup>nd</sup> Other Reason Reported</i>
1= Financial constraints	1=Financial constraints
2= Other priorities such as fees and food	2=Other priorities such as fees and food
3= Sickness	3=Sickness
4= Has other type of pump such as gas pump	4=Has other type of pump such as gas pump
5= Had other loans such as from KWFT	5=Had other loans such as from KWFT
6= Preferred R2O	6=Preferred R2O
7= Wanted to deepen the water source first	7=Wanted to deepen the water source first
8= Group disintegrated; it's hard to mobilize	8=Group disintegrated; it's hard to mobilize
9= Husband refused	9=Husband refused
10= Has group pump	10= Has group pump
11= No follow up by KSI people	11= No follow up by KSI people
12= Lost the number to pay cash through	12= Lost the number to pay cash through
13= Group member was conned hence feared to pay	13= Group member was conned hence feared to pay
14= I prefer cash to be picked at home since transactions costs are high	14= I prefer cash to be picked at home since transactions costs are high
15= Water source is so deep the pump cannot raise the water	15= Water source is so deep the pump cannot raise the water

## Implications of results

As of May 2016 at the EOP, only eight households had completed layaway payments and received their pump through the layaway scheme. Over 46% of respondents in the Layaway survey stated they “Did not make enough money to pay off the pump in the period allowed”. Forty-eight percent of the respondents reported they had made their initial layaway payment. Perhaps the other 52% were reluctant to layaway precious cash without an immediate return. However, there are many reasons provided in **Tables 22 and 23** that suggest there may have been other reasons that were not wealth related or MPesa related. It appears that the potential layaway participants were willing to test the finance treatment but did not have the time sufficient to purchase or did not have the cash necessary to continue in the program. This was in the second year of poor rainfall and poor production of their staple food.

A study in neighboring Tanzania proved a significant positive relationship between farming technology adoption and a household’s size, access to credit, a household’s productive assets and extension contact (Mohamed and Temu, 2008). Higher wealth favors adoption of new technology and that may have allowed Cash and R2O finance treatments to move forward more efficiently than use of the TKT treatment. However, there is little evidence found in the responses of the “expected” TKT buyers to suggest that the 48% who had made initial payments would not eventually completed the payment process to acquire their pump. The transactions costs for KSI to allow this prolonged purchase process would have been larger than planned. This appeared to be derailed by the inability of the respondents to make more money for payment and to do so within the time frame allowed for repayment. When combined these two categories account for 70% of those who dropped from the program which represents 30 of the 67 original respondents.

## Volunteered Comments from the End of Project Survey

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Insights are often provided by permitting farmers to speak for themselves. Enumerators recorded the following unsolicited comments by respondents during the EOP surveys.

### Non-Buyers’ comments

- She was given the pump by World Vision. She uses the pump, but the seedlings were given by World Vision so she incurred no cost of the irrigated crops
- Needs pump using rent to own
- Can we get a reservoir liner?

### Buyers’ responses

- Find a way to increase pressure to be able to till a larger area
- Farmer needs spare parts for an oil press
- Do you offer tanks
- Lost a pump
- Hasn't used the pump
- Farmer uses the pump to water his chickens

- Water dries up after three days, and

“I thank the money maker people for the initiative of making a manual pump available to the common man and for making it available”

## Summary, Conclusions and Recommendation

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The responses summarized in this report revealed that farmers in three counties of eastern Kenya (Machakos, Mkueni, and Kitui) were interested in KSI's small scale irrigation equipment. The program introduced, in the counties, presented individual participants the opportunity to either purchase equipment via cash or via Cash and one of the treatments, Rent to Own or Layaway. Treatments were separated topographically and spatially to reduce any spillover of information from one treatment to another. The design layout was successful and focused on individuals who had been identified from 256 groups, located across the three counties. Each respondent spent several hours with the enumerators in the interview sessions across two years.

Two of the three financing schemes (Cash and Rent to Own) provided *immediate* economic and food security reasons for being demanded by respondents since the equipment was provided at time of transaction. Layaway had been identified as a mechanism for introducing pumps to women and the base of the pyramid producers over time with the equipment available after full payment had been made. Layaway respondents may have found it more difficult to acquire the pumps otherwise. Layaway was tied directly to the use of MPesa to make payments. The vast majority of the participants had knowledge of and access to the mobile payment tool.

Unfortunately, all three of the treatments attracted lower levels of sales than required to meet the RT's identified minimum sample size numbers. Layaway, in particular was drastically under-represented, with fewer than ten individuals receiving pumps via this method at EOP, out of 68 who had committed to purchase, via layaway, at base.

Statistical interpretation of results was hindered due to the small number of layaway sales. Cash appeared to be the preferred method for purchase of MoneyMaker Max and MoneyMaker Hip irrigation pumps, with rent to own a close second.

The pumps were viewed as a means of increasing farm income and intensifying or expanding irrigated cropland. The farmers also reported that the pumps offered a more convenient and less demanding form of irrigation.

A diverse set of media sources and organizations were used by farm households to access information and this marked an important opportunity for KSI's marketing in the future. Cell phones had become prevalent in the most remote locations. A transition toward smart phones will transform access to information and improved access to mobile banking. New information communication technologies should be utilized to link vendors with participants who have purchased via R2O or TKT. Attitudes toward accessing information this way are changing rapidly empowering participants.

Women are becoming empowered to make many of the important household and production

decisions. Strong pluralities of decisions were made jointly or “Both Equally” in 12 of the 14 decisions reported. However, women were reported to be making over 30% of the decisions in response to 7 of the 14 questions and out of the total number of questions asked, men were identified as the main decision maker only once. In the “Leadership” category, 40% or more of the decisions are made by women. These findings should inform KSI when attempting to target women producers with the opportunity to purchase treadle or hip pumps.

Transactions costs for KSI need to be minimized but over 40% of potential layaway buyers defaulted after their first payments and withdrew from actively trying to secure their pump. Lack of money and too short a repayment period were identified as the two main constraints for successful participation in the layaway program. KSI should try to determine how best to keep the base of the pyramid and women clients engaged and active in their layaway programs during periods of climatic stress.

In the End of Project (EOP) results farmers reported a preference for increasing area of irrigated cropland to increasing profit. Expanding irrigated cropland area may reflect a greater concern for food security than for profit from *marketed* crops. The lesser importance of profits might relate to the lower popularity of the layaway financing method because it imposes a delay in boosting food production.

Statistical t- tests also evaluated changes in selected household wellbeing measures for non-irrigators versus irrigators who used *each* of the three finance methods at EOP. With rare exceptions, irrigators using all three finance options versus non-irrigators showed significant increases in acres of total cropland, net revenue per acre and per farm from irrigated food crops, household wealth and reductions in household hunger. Wealth for cash purchasers at KSh 675,378 easily achieved highest superiority over non-irrigators and is significant at the 0.01 level. Rent-to-own and layaway irrigators lacked statistically significant superiority in wealth over non-irrigators. Off-farm earnings is statistically superior at the 0.01 level for cash compared to non-irrigators, but rent-to-own and layaway lacked statistical significance. A plausible explanation may be that higher off-farm earnings, at a mean of KSh 204,267, permitted cash households to pay cash for their irrigation pump. On the other hand, poorer rent-to-own and layaway pump purchasers showed statistically weaker off-farm earnings compared to non-irrigators. This would support the findings that layaway participants who dropped out either had to little money or could not make all payments in the time period allotted.

Taken collectively, these results showed that cash purchasers had the highest household wellbeing advantages over non-irrigators. Rent-to-own purchasers were in second place and layaway a distant third. These results are disappointing relative to the project aspirations that the innovative rent-to-own and layaway finance options would sharply improve financial and physical wellbeing for poor households.

To better control for confounding variables aside from irrigation that could have boosted household wellbeing between Base and EOP, two multiple regression approaches were attempted: Differences in differences (DID) analysis and regression with panel data. Both methods showed that only Household Savings Exceeding KSH 15,000 and Higher Education Level consistently improved several household wellbeing measures. Both these variables tend

to be positively correlated with wealth. The results corroborate the t-test results that irrigation tended to improve wellbeing primarily in wealthier households.

The results in this report offered insight into selected reasons for the major shortfall in take up of pumps by layaway. More investigation is needed on this issue beyond the scope of this project which terminates in mid-2016. KSI's marketing team is strongly advised to explore all possible remedies when addressing reasons given, by respondents, for dropping from the layaway treatment; a response which led to a partial collapse of the layaway financing option in eastern Kenya during 2015-2016.

KickStart International's equipment is demanded and utilized by farmers in the three counties where the project was implemented. Demand for the technology exists far beyond this limited area of eastern Kenya, as was described in the report. Cash and R20 options are comparatively easier to introduce than the layaway option. However, continuing to utilize all three options and applying ICTs to disseminate and receive information will help drive down transaction costs for both purchase and maintenance functions. These evolving technology drivers will continue to improve the value added from the transfer of KSI treadle and hip pump technology. With that next step taken, many more can aspire to exit from the poverty trap in which so many individuals and families currently exist.

## References

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- Angrist, J. D.; Pischke, J. S. (2008). *Mostly harmless econometrics: An empiricist's companion*. Princeton University Press.
- Amudavi, D.M. et al. 2009. "Assessment of technical efficiency of farmer teachers in the uptake and dissemination of push-pull technology in Western Kenya." *Crop Protection*, 28(11): 987-996.
- Bertrand, M.; Duflo, E.; Mullainathan, S. (2004). "How Much Should We Trust Differences-in-Differences Estimates?" *Quarterly Journal of Economics* 119 (1): 249-275..
- Card, David; Krueger, Alan B. (1994). "Minimum Wages and Employment: A Case Study of the Fast-Food Industry in New Jersey and Pennsylvania". *American Economic Review* 84 (4): 772-793.
- Gitau, Teresiah, Boris Houenou, Douglas Young and Thomas Byers. July 23, 2015. Can the results of the KSI-WSU research in eastern Kenya during 2014-2015 be generalized to other regions in Kenya and to other African countries? KSI/WSU Project Research Paper 2015-1.
- Goshu, Degye, Belay Kassa and Mengistu Ketema. 2012. "Is food security enhanced by agricultural technologies in rural Ethiopia?" *African Journal of Agricultural and Resource Economics*, 8(1): 58 - 68.
- Kabunga, Nassul Ssentamu, Thomas Dubois and Matin Qaim, 2011."Heterogeneous information exposure and technology adoption: the case of tissue culture bananas in Kenya". *Agricultural Economics* 43(2012):473-485.
- Kenya Food Security Steering Group. *The 2013 Long Rain Seasons Assessment Report*. Web. Retrieved on 10 July 2015.  
<<http://www.humanitarianresponse.info/en/system/files/documents/files/LRA%202013%20National%20Report%20Final.pdf>>
- KickStart International. *Empowering women with technology*. February 2015.  
<http://www.kickstart.org/about-us/Women's%20Empowerment%20Report%20-%20KickStart%20International%20-%20February%202015.pdf>
- Kirui, Oliver., Okello, Julius., Nyikal, Rose & Njrani, Georgina. Impact of mobile phone-based money transfer services in agriculture: evidence from Kenya. *Quarterly Journal of International Agriculture*, 52, 2013, (2): 141-162.
- Liverpool, Lenis Saweda O., and Alex Winter-Nelson. 2010. "Poverty status and the impact of formal credit on technology use and wellbeing among Ethiopian smallholders." *World Development*, 38(4): 541-554.

- Mohamed, Khalid S. and Andrew Temu. 2008. "Access to credit and its effect on the adoption of agricultural technologies: the case of Zanzibar". *African Review of Money and Banking*-2008:45-89.
- Moser, Christine M., Christopher B. Barrett .2006. "The complex dynamics of smallholder technology adoption: the case of SRI in Madagascar". *Agricultural Economics* 35(2006): 373-388.
- OpenDataKenya. Retrieved from <https://kenya.socrata.com/Poverty-Rate-byDistrict/i5bp-z9aq/>  
Retrieved 10 July 2015.
- Omonona, B.T., J.O. Lawal; A.O. Oyinlana.2010. "Determinants of credit constraint conditions and production efficiency among farming households in southwestern Nigeria." *The Social Sciences*, (20100401) (v5 n4): 326-331.
- Owuor George.2009. "Is micro-finance achieving its goal among smallholder farmers in Africa? empirical evidence from Kenya using propensity score matching." *Paper submitted for visual presentation at the XXV11 International Conference of Agricultural Economists* (August 2009).
- Savid, Osman., Abdelghani, Echchabi. & Abdi, Aziz. Investigating mobile money acceptance in Somalia: an empirical study. *Pak. J. Commer. Soc. Sci.*, 6, 2012, (2): 269-281.
- WSU and KSI Staff. (March 2015a). Final condensed version of Buyers Baseline Questionnaire.
- WSU and KSI Staff. (March 2015b). Final condensed version of Non-Buyers Baseline Questionnaire.
- KSI, USAID and WSU. KickStart – Washington State University (WSU) Research Study Milestone 2: Implementation Plan: Mobile Layaway and Rent to Own: Bringing an Innovative Savings Solution to the Rural Poor for Small-Scale Irrigation Pump Purchases, KickStart – Washington State University (WSU) Research Study
- Wu, Di and Doug Young (July 30, 2014). "Estimation of minimum sample sizes for Kenya baseline and end-of-project surveys based on data from the May-June 2014 Rapid Appraisal- Demographic Survey" Unpublished research paper.
- Young, Douglas and Thomas Byers. Research proposal by WSU to KSI, 12/08/2013 and application by WSU to NCOSTI to do research in Kenya, 3/25/2014.
- Young, Douglas and Di Wu (July 30, 2014). "Estimation of minimum sample sizes for Kenya baseline and end-of-project surveys based on data from the May-June 2014 Rapid Appraisal- Demographic Survey" Unpublished research paper-Dropbox

Young, Douglas, Boris Houenou, Wu Di, T.E. Byers, Patrick Kirui, Andrew Wanyonyi, Teresiah Gitau, and Jennifer Mueni (July 2014). "Summary of results of rapid appraisal - demographic survey for KSI/WSU eastern Kenya project". RA-DS Results Report.

Young, Douglas, B. Houenou, T. Byers, T. Gitau, P. Kirui, J. Mueni and A. Wanyonyi. August 2015. Milestone Two: Baseline Survey of Pump Buyers by Three Finance Options and of Non-Buyers: Process and Results Highlights and Appendices.

## Appendix 1: Sub-Counties (previously Districts) in which the study was undertaken

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1=Athi River	21=Machakos
2=Ikombe	22=Makueni
3=Kaiti	23=Masinga
4=Kalama	24=Matungulu
5=Kalawa	25=Mbooni East
6=Kangundo	26=Mbooni West
7=Kanyangi	27=Migwani
8=Katangi	28=Mtito Andei
9=Kathiani	29=Mukaa
10=Kathonzweni	30=Mutitu
11=Kibwezi	31=Mutomo
12=Kilome	32=Mwala
13=Kithimani	33=Mwingi Central
14=Kitui	34=Mwingi West
15=Kitui Central	35=Ndalani
16=Kitui East	36=Nguluni
17=Kitumbi	37=Nzau
18=kwa Vonza	38=Wambiti
19=Kyangwithia East	39=Yatta
20=Lower Yatta	

## Appendix 2: Groups contacted to participate in the longitudinal study

Group Name		
1=Athi River	29=Kyekonge Women group	57=Nzilani
2=Ikombe	30=Kyeni Kya Kyaani	58=Nzukini
3=Kaiti	31=Kyeni Kya Mukameni	59=Pawa Group
4=Farm Field Schools	32=Kyeni Kya Nzueni	60=Persons with Disability Group
5=FSA	33=Mango good member	61=Rise and Shine
6=Hand in hand	34=Maroda farmers	62=Sakai Seed Bulklers
7=Ika Wiyike	35=Matendo SHG	63=St.Francis Mwanyani
8=Iuni Pepper Growers	36=Mbee Nthei	64=Tei wa Kyamboa
9=Jikaze Women Group	37=Mbikila Witei	65=Twikumbe SHG
10=Kaka	38=Mbingoni water harvesting SHG	66=Umiisyo wa Kitaita
11=Kakuyuni Farmers	39=Mikuyuni	67=Umoja SHG
12=Kamen	40=Mitaboni Kunena na kuwika	68=Waekandeka
13=Kanguma Green Growers	41=Mitalani	69=Wendano wa Kyambingu
14=Katutuini Farmers	42=Mithanga horticultural Group	70=Wendano wa Maiuni
15=Kavutini Women Group	43=Mituki Iveti Women Group	71=Wendano wa Manyatta
16=Kiembeni Utiini Sita	44=Mkombozi	72=Wendano Waaka Kiusini
17=Kikesa Horticulture	45=Movers and shakers	73=Wendo wa Mbuini
18=Kipawa SHG	46=Mwanzo Mpya	74=Wendo wa Musyai
19=Kisiuni	47=Mwooni SHG	75=Wendo wa Omwe
20=Kithia SHG	48=NCKK	76=Wikwatyo
21=Kithiasani	49=Ndulule Wendo	77=Wingu Makanda SHG
22=Kithoni Farmers	50=Ngetha Tu Tethie	78=Wiyisi
23=Kola Horticulture	51=Ngomeni kwa Mwania	79=Woni Wa Mbee
24=Kuleta SHG	52=Ngumbuki Shg/Mangumu shg	80=Young Mbilini
25=Kwa Munini	53=Nguno	81=Yumbuni Disabled
26=Kyambebe	54=Nguumo Women Group	82=Umiisyo waaka iiani
27=Kyatuni Traders Business Ladies	55=Nkolo	
28=Kyawema	56=Nzeve Nzau SHG	

## **Appendix 3: On-Line Appendices (Located in Dropbox Online – request share from Byers or Young)**

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Byers, Thomas. 2015. Clustering of Potential Buyers Across Topographical and Spatial Areas, File Name: FINAL Clustering Results.xlsx

Byers, Thomas. (June 2016). Buyers Baseline Survey Data Set, File Name: FINAL BBaseS Data Set.xlsx

Byers, Thomas. (June 2016). Non-Buyers Baseline Survey Data Set, File Name: FINAL NBaseS Data Set.xlsx

Byers, Thomas. (June 2016). Buyers End of Project Survey Data Set, File Name: FINAL BEOPS DATA SET.xlsx

Byers, Thomas. (June 2016). Non-Buyers End of Project Survey Data Set, File Name: FINAL NBEOPS Data Set.xlsx

Byers, Thomas. (June 2016). Layaway EOPTKT Survey Data Set, File Name: FINAL EOPSTKT Data Set.xlsx

Byers, Thomas. (June 2016). Base – EOP Data Set, File Name: FINAL BaseS and EOPS Data Set.xlsx

Byers, Thomas. (June 2016). Buyers and Non-Buyers Output, File Name: FINAL BBaseNBase Output Data.xlsx

Byers, Thomas. (June 2016). Buyers End of Project and Non-Buyers End of Project Output, FINAL BEOPSNBEOPS Output Data.xlsx

Gitau, Teresiah, Boris Houenou, Douglas Young and Thomas Byers. July 23, 2015.

Can the results of the KSI-WSU research in eastern Kenya during 2014-2015 be generalized to other regions in Kenya and to other African countries? KSI/WSU project research paper-Dropbox.

WSU Staff (July 2015a). Table 1. Descriptive statistics by three finance options of buyers, and for all buyers and all non-buyers, for 71 selected variables, baseline surveys of three eastern Kenya counties, March-June 2015. [Table 3 of Milestone Two Appendices 08-10-15]

WSU Staff (July 2015b). Table 2. Statistical tests of equality of sample means of all buyers versus all non-buyers for 42 selected continuous variables, baseline surveys of three eastern Kenya counties, March-June 2015. [Table 1 of Milestone Two Appendices 08-10-15]

WSU Staff (July 2015c). Table 3. Selected sample proportions by finance option and statistical tests of equality of proportions for all buyers versus all non-buyers, baseline surveys in three eastern Kenya counties, March-June 2015. [Table 2 of Milestone Two Appendices 08-10-15]

WSU and KSI Staff. (March 2015). Final version of Buyers Baseline Survey Questionnaire, File Name: FINAL BBaseS Q'aire.docx

WSU and KSI Staff. (March 2015). Final version of Non-Buyers Baseline Survey Questionnaire, File Name:FINAL NBBaseS Q'aire.docx

WSU and KSI Staff. (March 2016). Final version of Buyers End of Project Survey Questionnaire, File name: FINAL BEOPs Q'aire.doc

WSU and KSI Staff. (March 2016). Final version of Non-Buyers End of Project Survey Questionnaire, File Name: FINAL NBEOPS Q'aire.docx

WSU and KSI Staff. (March 2016). Final version of End of Project TKT Survey Questionnaire, File Name: FINAL TKT - Layaway Q'aire.docx

Young, D. Hypothesized coefficient signs (directions of influence) from theory for the explanatory variables in DID dependent variable equations, WSU/KSI research project on adoption of human-powered irrigation pumps in eastern Kenya, 2014-2016. WSU staff paper. May 2016. File Name: Hypothesized Coeff Signs.docx

Young, Douglas and Boris Houenou. June, 2016. Descriptive statistics for EOP survey explanatory variables in DID regression. File Name: Descr Stats Regression Models' Explanatory Vars.docx

Young, Douglas and Boris Houenou. June, 2016. Complete DID Regression Results File Name: Results for Panel Data Regression.docx

Young, Douglas and Boris Houenou. June, 2016. Complete DID Regression Results File Name: DID Regression.docx

Young, Douglas. June 2016. End of Project Retained DID Variables Data Set. File Name: FINAL EOP Ret DID Vars.xlsx