Securing Sustainable Livelihoods Through the Construction of a Flood-Resistant Irrigation System (FRIS) in Northern Thailand

An evaluation of nine projects implemented in 2019 and 2020

Report produced December 2021

The Karen Hilltribes Trust

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Executive Summary

The Karen Hilltribes Trust (KHT) is a British charity that supports indigenous Karen peoples in Northern Thailand. With roots dating back to 1989, for decades it has been supporting Karen communities through projects in clean water, livelihoods, and access to education.

The principal livelihoods project is the construction of a flood resistant irrigation system (FRIS) in rural villages, constituting an irrigation dam that pools irrigable river water and channels to village fields. These villages rely on subsistence farming, and often face poverty and food insecurity. Between 2007 and 2021 94 irrigation systems have been constructed in 47 villages.

The goal of the project is to secure agriculture as a sustainable livelihood for Karen farmers in villages. This is realised through five primary outcomes:

1. Direct beneficiaries having increased resilience to natural disasters;
2. Direct beneficiaries seeing increased crop yields;
3. Direct beneficiaries seeing increased annual income;
4. Direct beneficiaries seeing increased food security;
5. Direct beneficiaries placing less pressure on the local environment.

In 2019 a new monitoring and evaluation (M&E) framework was implemented to better track the impact of each irrigation project. A new logical framework was drawn up, and 20% of beneficiary households in all projects were interviewed during the project's implementation at baseline, and one to two years later at endline. This report summarises the findings from the first nine projects that have returned baseline and endline data.

Overleaf are the key findings from the report. Strong evidence has been found that KHT's irrigation projects do improve household resilience to natural disasters, boost crop yields, and in turn increase incomes and food security. Further work is needed to conclusively say that projects reduce pressure on the environment, but early signs are promising.

The implementation of KHT's new M&E framework continues beyond this report. Whilst as an organisation KHT is extremely encouraged by the findings, opportunities for further investigation have been identified. These include determining the direct beneficiary reach of projects, the effectiveness of a FRIS in reducing deforestation, and on measuring the project's effects on non-direct beneficiaries. A similar M&E process is currently underway for KHT's WASH programme and is due to be further rolled out to its access to education projects in 2022.

"Strong evidence has been found that KHT's irrigation projects do improve household resilience to natural disasters, boost crop yields, and in turn increase incomes and food security."

We hope you enjoy reading this report. Any comments or questions are welcome and can be sent to the contact details found in the report's cover page. Thank you for your interest in understanding how collectively we can help Karen communities attain a secure future.

Summary of Key Results of KHT's 2021 Irrigation Evaluation	
Outcome	Key Results
Increased resilience to natural disasters	• Farmland affected by natural disasters fell by 70%; • No households lost an irrigation dam in the past year at endline, whereas 76% of households had lost at least one dam at baseline; • 99.7% of paddy fields are now usable year-round, compared to 39% previously; • Reduction in farmland affected by natural disasters at endline was statistically significant to the 0.0001 (0.01%) level.
Increased crop yields	• 92% of households experienced crop increases; • Both rice and non-rice crops saw large increases, with non-rice increases larger; • The lower quartile of beneficiaries benefit the most, with crop yields increased 120% and KGs of crops grown in dry season increasing 17 times over; • The increase of household annual crop output at endline was statistically significant to the 0.0001 (0.01%) level.
Increased annual income	• 37% of households were lifted out of extreme poverty; • Average income increased between 15,000 THB (60%) and 27,000 (108%); • Increases in crop income account for increases in total household income; • The increase of household annual income at endline was statistically significant to the 0.0001 (0.01%) level.
Increased food security	• Households facing any food shortages a month fell from almost all to one third; • Days where households had insufficient food a month fell from 6.4 to 1.2 days; • Crop diversification increased, with households growing on average 11 different crops with over 50kg annual yield, up from 7 different crops; • Reduction of days households had insufficient food at endline was statistically significant to the 0.0001 (0.01%) level.
Decreased pressure on the environment	• Direct beneficiaries ceased felling trees to build wooden irrigation dams; • An initial estimate puts potentially 1,080 small trees saved from being felled for each year a FRIS operates, but more work is needed to verify this figure.
Other findings	• Observed increases in pesticide and fertiliser use are as-yet unexplained; • More data is needed to understand if income gains improve access to education; • Household income estimates during project proposals require improvement; • Projects return on their investments in a village within the first year and may have a net positive return of £329K to £568K in a project's lifetime.

Acronyms, Abbreviations, & Terminology

Baseline: A survey taken at the start of the project to gauge a base point for data;

Endline: A survey taken on the same households one year after the project, with the same questions as the baseline, with the purpose of seeing any changes in indicators;

FRIS: Flood-resistant irrigation system, the implemented project;

FX: Foreign exchange;

H_0: Null hypothesis;

H_a: Alternative hypothesis;

KHT: Karen Hilltribes Trust, a registered charity in England & Wales;

KHTF: Foundation for Karen Hilltribes in Thailand, a Thai Foundation that implements projects in Northern Thailand and partners with KHT via a Memorandum of Understanding;

LCU: The conversion factor provided by the World Bank to calculate purchasing power parity of a country's currency against the dollar;

LQ: Lower quartile;

M&E: Monitoring and evaluation;

NGO: Non-governmental organisation;

Rai: A land measurement used in Thailand. Equivalent to approximately 0.4 acres or 1,600 square metres;

RCT: Randomised control trial;

SD: Standard deviation;

SDGs: United Nations Sustainable Development Goals;

UQ: Upper quartile;

WASH: Water, sanitation, and hygiene.

Report Purpose

KHT's Past M&E Practices

KHT's mission is to partner with Karen communities to improve their health, livelihoods, and access to education. With a vision to provide a secure future for Karen communities in Northern Thailand, KHT's programmes should combine holistically to provide sustainable support through immediate (health), medium (livelihoods), and long (education) term impact.

KHT's key livelihoods programme has been to install flood-resistant irrigation systems (FRIS) in rural communities. Since February 2008 94 systems have been installed in 47 different villages. Initially, minimal data was taken to measure impact during or after the projects. Data on the beneficiaries and project locations were taken during an initial needs analysis up to one year prior to each project, and occasional case studies taken during project implementation.

In recent years, as KHT has developed its internal systems and frameworks there has been a drive to improve data collection and M&E practices during projects. For livelihoods, this started in earnest in 2016 with the design of an M&E framework, logical framework and theory of change. In 2017 a visit was made to Sao Hin, a remote region in Mae Hong Son province, to interview beneficiaries and non-beneficiaries of a FRIS project to understand how their lives differed. Whilst a positive start, it was deemed a more thorough process was needed to track changes in key indicators at a household and community level, to ensure project activities yielded counterfactual outcomes and impact.

New M&E Framework from 2019

Since 2019 a new process was implemented on all future irrigation projects. 20% of project beneficiaries were interviewed prior to the project's completion, as a baseline survey. The survey asked a range of questions that corresponded to key indicators in the project's log frame, covering topics including income, crop output, food security, farming and irrigation methods, and pressures on the local environment. One year on these same households were revisited and asked the same questions. Changes in the key indicators are then followed to see how households' lives had changed. Although this methodology does not guarantee overserved changes can 100% be attributed to the project, recipient villages were largely homogenous, there had been little observed activity from other NGOs or state projects, and baseline surveys continued in the districts at the same times that endlines from due projects were collected. It is hoped any observed significant changes can be credited to the project's activities with a degree of confidence, even if outside influence cannot be 100% ruled out.

An initial 10 irrigation projects were identified, with baselines corresponding endlines taken between March 2019 to December 2021. COVID-19 enforced delays and complications with collecting surveys, but overall 86 households across 9 village projects were followed through to endline. This report contains the findings from the data taken in this period, and constitutes the first substantial quantification and analysis of the impact of KHT's irrigation programme.

Project Summary & Logical Framework

Poverty in Northern Thailand

Thailand's recent development gains have mainly been focused in the urban South, with poverty and inequality continuing to pose significant challenges across the rural regions and for Thailand's ethnic minorities. For the Thai Karen communities KHT works with, average annual income is just 24,500 THB (769 USD) per household, below the international line for extreme poverty even after accounting for purchasing power. Most communities also have limited access to basic socioeconomic services such as healthcare and education - the enrolment of Karen children in primary education is 51% (compared to national average at 89%), whilst only 1 in 4 Karen children complete their secondary education.

Agriculture

High dependency on subsistence agriculture makes Karen communities extremely vulnerable to changes in weather and climate. Heavy rain sweeps away crops, whilst lack of rain makes crops wither. From KHT's research it is clear that in most villages at least 50% of villagers do not produce enough rice to last through the year, with most families suffering food shortages at least five times a month.

Traditionally, Karen communities build bamboo irrigation dams to ensure that their crops get enough water. However, for each dam, around 300 bamboo and other small trees are cut down, and they are not very stable; heavy rains and flash floods frequent in the rainy season often destroy traditional irrigation dams. Without a dam in place, crops cannot be irrigated. Most households are unable to farm in the dry season, and crop yields are low due to the regular loss of irrigated water.

The Intervention

Through the construction of a flood resistant irrigation system (FRIS), Karen communities are given a sustainable method to irrigate their crops. Built by local volunteers with KHT guidance and funding, concrete dams replace the previous temporary structures, and connect to the village's wider irrigation network. This improves livelihoods by boosting crop yields and allowing farmers to increase year-round crop production without damaging the surrounding natural resource base, boosting income and food security whilst negating the need to fell local trees. The flood-resistant nature of the systems allows farmers to become more resilient to extreme weather and natural hazards. The systems have an expected minimum lifecycle of 20 years, with maintenance primarily managed by the villagers.

The typical cost for a project is 645,000 THB/ £15,000 in 2021, with an expected direct beneficiary reach of 300 persons in one village community.

**The above figures come from KHT's prior internal research conducted during needs analyses for past projects, and do not stem from this report's dataset.*

A Storyboard of a KHT Irrigation Project

A traditional wooden dam in use pre-project. These are constructed from the surrounding forests and require 300+ bamboo and other small trees each to make. They typically break most years in the raining season.

A KHT team member training local volunteers how to construct and maintain the FRIS. The dams are made by the volunteers with guidance and materials provided by KHT. Once built the systems are maintained by the local community. Only 4% of systems constructed since 2007 have required additional KHT assistance.

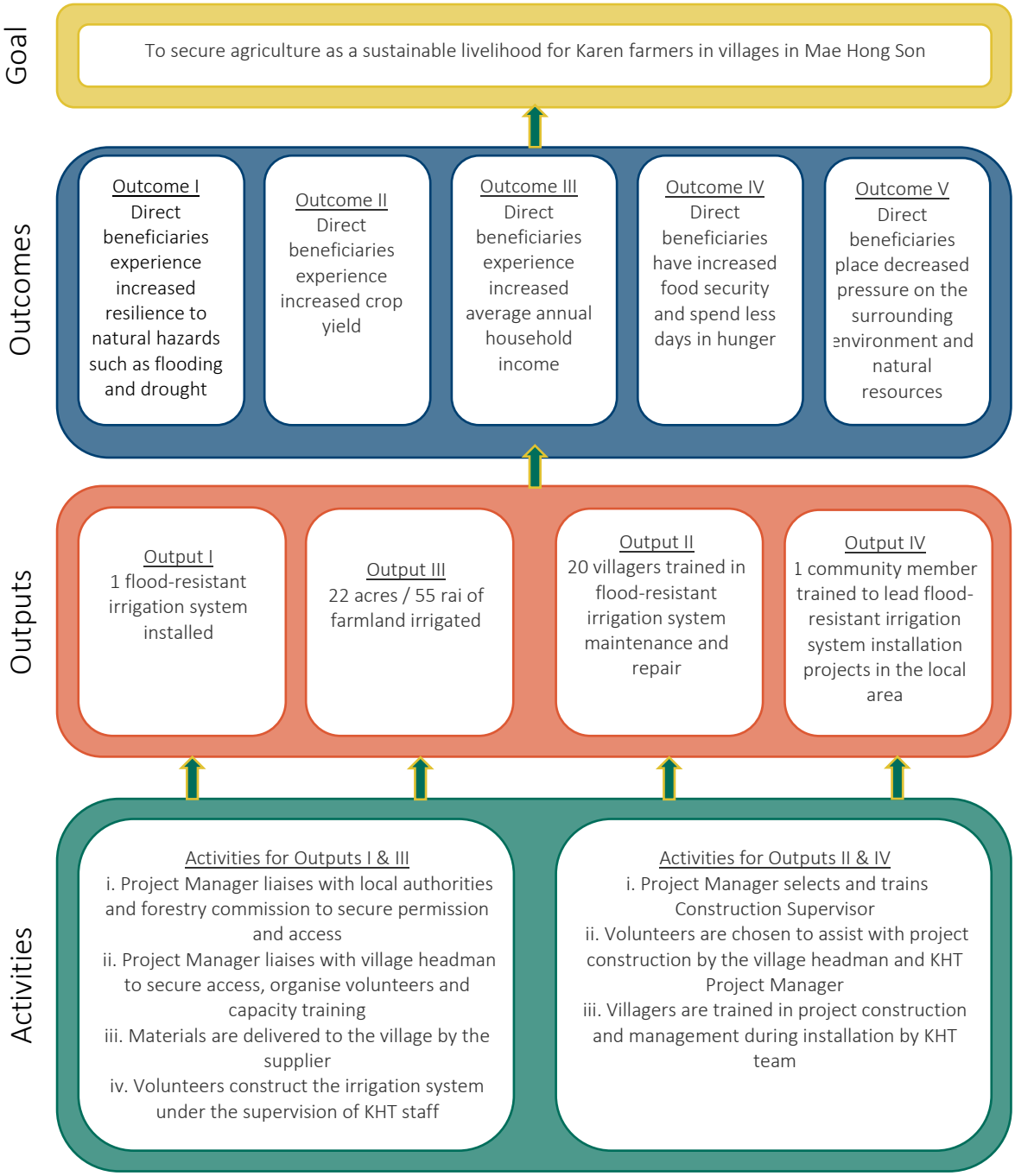
A dam under construction. They are made by pouring concrete into wooden moulds, with wire frames to add strength. Robust structures are needed to withstand the storms and extreme weather than frequently occurs during the wet season.

A completed flood-resistant irrigation system. The majority of the water flows over the dam, like a weir, with some stored behind the dam and siphoned off into irrigation channels. These channels connect with the village's existing irrigation network to provide water to crops year-round.

Logical Framework

Below is the logical framework (log frame) for the irrigation project, and relates to the expected activities, outputs, outcomes, and impact for each individual project.

The log frame was used as a reference point in the M&E framework, ensuring that collected data at a minimum answered questions on the success of the expected activities, outputs, and outcomes. The log frame has had minor tweaks over time, but is largely the same as when the survey questions and M&E framework were implemented in 2019.



Methodology

Survey Design

Prior to the commencement of each project, the project team were informed the number of households that they needed to interview for the M&E framework. The number was calculated as 20% of the number of beneficiary households estimated in the project proposal, a needs analysis document that would be created between 1 and 12 months prior to the project start. More on the project proposals is available below.

The surveys covered questions on demographics, household income, child education status, farming & subsistence farming, irrigation methods, occurrence of natural disasters, and local biodiversity. In total there are 116 data points in the finalised survey, many of which were collected through multiple choice questions.

In addition, a crop matrix was filled out for each household. This collected information on the principal 27 crops grown by farmers, with amount grown, type and amount of farmland and irrigation used, and the amount sold for each individual crop.

Surveys were collected using Kobo Toolbox, with crop matrices filled out on paper sheets digitised afterwards. The same format was used for baselines and endlines.

The surveys were developed over several years, with the first iteration created in 2017 for the first M&E framework. This period saw various data collection methods tested with the Thai project team. Guidance was taken from sources including the Food Insecurity Experience Scale, guidebooks by the W.K. Kellogg Foundation, BetterEvaluation, Charities Evaluation Services, USAID, and ACF International. The surveys were then refined in 2018, using feedback from the communities and Thai team. The surveys were further streamlined in line with the latest log frame and M&E framework, and to best align with indicators with the UN Sustainable Development Goals (SDGs) where appropriate.

Similar surveys are also taken for KHT's WASH projects, which install clean water tanks and latrines in villages. Some questions in the WASH surveys match those with livelihoods, including demographics, access to education, income, and biodiversity. This data was included in the dataset to verify project demographics were representative of KHT's typical beneficiaries.

The surveys saw minor tweaks during the data collection period of 2019-2021, as the team received feedback and were able to analyse the incoming data. Questions that were gathering unnecessary information were removed, and some additional questions were added. The only questions that related to key indicators that saw changes were related to 'Outcome V: Decreased pressure on the surrounding environment' (the amount of rai/acres of land farmed), and 'Outcome I: Increased resilience to natural hazards' (whether natural disasters destroyed wooden dams or irrigation channels). Overall, the vast majority of key indicators had a full dataset, those with a more limited baseline will be highlighted in the findings section.

Baseline and Endline Surveys

As noted, 20% of the number of households identified in the initial project proposal were interviewed with baseline and endline surveys. One household member was interviewed per household, with no preference made to gender or status. Interviewees were direct beneficiaries who were engaged with the project.

The project team would aim to revisit households one year after the end of construction of the FRIS and interview the same households that were interviewed previously. 82% (86 out of 105 households) of baseline interviews were reached for endlines. COVID-19 enforced delays on when villages could be reached, with local and national lockdowns in Thailand often preventing our staff from revisiting on time. This meant that the time taken to revisit for endlines was on average 2 years, with a range of 1.2 to 2.7 years.

Project Proposals

Pre-existing to the M&E framework was the project proposal process, which conducted a needs analysis and initial project plan for all projects prior to their commencement. Prior to 2019 this was the principal data point for irrigation projects; a secondary benefit of the new M&E framework is it allows KHT to check the accuracy of project proposals.

Each project proposal takes approximately two days, and is conducted by the Thai team's Director of Programmes. They will typically interview the village headman, the village leader, and the wider villagers. The proposals capture details on: village location and accessibility, demographics, access to education, health services, farming, other present aid actors (state and NGOs), as well as the project budget and infrastructure design. The project proposals are typically taken 1 to 12 months before the project start date; if older then key details such as the budget are re-verified prior to the project's start.

Whilst the baseline and endline surveys collect the majority of data used for the M&E framework, the project proposals provide key details on number of beneficiaries in each project, the total number of wooden dams in use, and whether results may be conflated with other aid actors' work.

Challenges with Data Collection

A variety of challenges were faced by the team when implementing the M&E framework. Some were external events (COVID-19), whereas others stemmed from the design of the framework. Whilst some of these challenges were unavoidable, various learnings have come from these that will be discussed here and in this report's Recommendations section.

COVID-19

Thailand was the first country outside China to report a COVID-19 case, on 13 January 2020. A national lockdown was implemented in March 2020, forcing KHT's international staff to leave the Thai HQ in Khun Yuam and for projects to be suspended until May 2020. Whilst project

construction work and corresponding baselines continued, endline collections were paused during 2020 to limit the number of contacts between staff and communities. The inability of international staff was also a factor, as training on conducting endlines that was scheduled for April 2020 had to be cancelled.

Thailand had some of the strictest COVID-19 restrictions globally; inter-provincial travel was limited, masks were mandatory in all public areas, and international travel did not open up until Q3 2021. With Mae Hong Son being one of the most remote and poorest Thai provinces, with poor access to healthcare facilities and misinformation rife, village leaders often prevented outsiders from entering villages.

Endline surveys restarted in March 2021, meaning many were overdue. Surveys were paused again with the reimposition of restrictions following a spike in cases between June and September 2021, meaning a large batch of surveys were conducted between October and December 2021. One village was unable to be reached as it was kept in a local lockdown due to positive COVID cases, reducing the total sample of villages from an initial ten to nine.

It is not anticipated that the delay in endlines would dramatically alter the results. The nature of the project means that expected crop yields should be realised by the next harvest cycle. The extra time may give farmers more time to adjust to the increased crop opportunities, but this would mean results would be closer to the long-term impact of the project. Going forwards the team will look to ensure endlines are taken on time after one year, unless external factors prevent this.

Surveying Direct Beneficiaries vs All Villagers

The surveys in their current format only interview direct beneficiaries of the project. As such the current data reflects the impact on direct beneficiaries. The data cannot determine the number of direct beneficiaries in the village, nor does it measure changes on indirect beneficiaries. The project proposals do record the total number of villagers in each village, and estimate the number of direct and indirect beneficiaries. Whilst we would expect the village population data to be correct as this is taken from the village leaders, we do not currently have data to verify the accuracy of the number of direct and indirect beneficiaries.

A change has been implemented for future surveys to help remedy this, with a new question added asking each household to estimate the number of wooden dams currently in use throughout the village. As each farming household typically builds one wooden dam per year, and the endline data shows direct beneficiaries stop building wooden dams entirely, a percentage drop in wooden dams in a village from baseline to endline can be an indicator for the total reach of the FRIS across the village.

Anecdotally the project team have estimated that 60%-70% of villagers are direct beneficiaries, and they have reported a proportional drop in the number of wooden dams in use. Other activities are likely also needed to understand the total reach of direct beneficiaries, as well as the impact on indirect beneficiaries.

Survey Length

Initially, the project team reported that surveys were overly long, and respondents were losing interest in answering later questions as a result. This was partly rectified early on, with a reduction in questions that did not provide additional information. The crop matrix in particular proved to be time consuming, both for the interviewees and for the KHT staff that had to digitise every response.

An update of the surveys has been scheduled to further correct this. Other redundant questions are being removed, and the crop matrix being rolled into the main survey in a shorter format. It is expected this should ensure the same data is gathered in a more efficient format.

Recipients' Numeracy Skills

When looking at survey answers on an individual level, small discrepancies appear in some questions that require numerical skills. For instance, a recipient may state their total income at 20,000 THB, but the total of earnt income from selling crops collated in the crop matrix may total 22,000 THB. No glaring errors were made, likely due to assistance from the project team when taking surveys, but it does increase the margin of error for individual responses.

This is deemed an underlying flaw of the survey method. Small changes will be incorporated in the future to address this, such as asking for percentage thresholds of some figures (such as farming income) instead of full numbers. It is not expected that this threatens the validity of findings where large changes have been seen, but it does mean a large margin of error should be applied for certain questions relating to income or farmland owned.

Question Changes

Ideally the set of questions that were included at the start of 2019 would be the same as those that currently constitute the survey. Whilst it is natural that lessons learned as the surveys were conducted would need to be incorporated into the framework, it has meant that a minority of questions have a more limited dataset available.

A single update will be made in early 2022 to incorporate identified necessary changes, with the goal of the vast majority of the dataset continuing to be built upon and the survey to then go unchanged for the next several years.

Findings

Findings of the study are outlined in the following pages. Findings are predominantly split by the five key outcomes from the project log frame, with additional findings listed thereafter. A full breakdown of results, as well as case studies, can be found in the report's annexes.

Data marked with an asterisk has a reduced dataset, likely due to the question being added later. Details on reduced datasets are included where relevant. All statistical tests have been made to the 0.05 (5%) level.

Overall, KHT has been able to find strong evidence towards all five of the log frame's key outcomes. Data gaps remain, in particular on total beneficiary reach and on the environmental benefits of the programme, and there are some unexplained results relating to the increased use of pesticides and fertiliser.

KHT is confident that the surveyed respondents represent a typical demographic for the rural Karen communities that KHT works with. In the same period, 114 household surveys were taken at KHT WASH projects at distinct villages. Key demographic indicators such as average age, years living in the village, household size, average income, income sources were all very similar between the WASH baselines, endlines, and irrigation baseline. Further, average household income data collected at baseline closely matched figures KHT had found previously from external sources. This provides reassurance that results found in the following section can be extrapolated to the wider Karen communities where KHT's irrigation projects operate.

Outcome 1: Direct Beneficiaries Experience Increased Resilience to Natural Hazards, Specifically Flooding and Drought, Compared to Baseline Level

The first outcome is whether direct beneficiaries of each project, i.e., those that farm and irrigate their fields with the KHT-constructed FRIS, show increased resilience to natural hazards and extreme weather.

Typically, households would be vulnerable to various forms of extreme weather. During the wet season (June to October) increased rain and river flow causes most traditional wooden dams to break. The burst dams release stored water, flooding fields and reducing the pool of irrigable water available for the dry season. Droughts and lack of rain fall in the other months mean unirrigated fields are unproductive or unusable. Wooden dams and irrigation channels are also frequently destroyed by landslides or falling trees during storms.

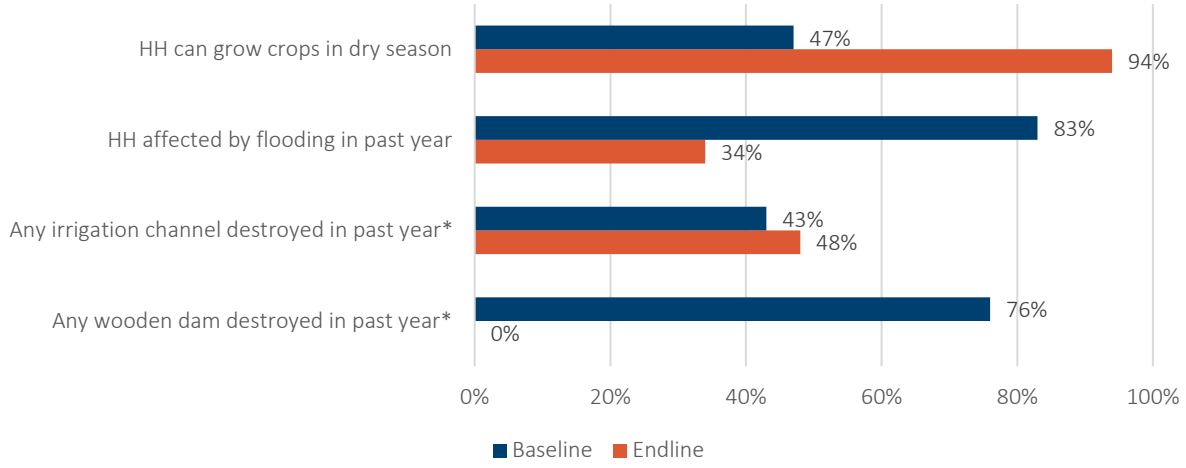
"... the installation of an FRIS dramatically improves weather resilience. Prior to the projects 83% of surveyed households were affected by flooding in the past year, but this dropped to 34% at endline."

Figure 1 below shows that the installation of an FRIS dramatically improves weather resilience. Prior to the projects 83% of surveyed households were affected by flooding in the past year, but this dropped to 34% at endline. 76% of households had at least one wooden dam destroyed in the past year at baseline, but none had one destroyed at endline. As we know that all the installed FRIS were fully functioning when visited at endline, no surveyed direct beneficiaries had suffered a failure of their irrigation dam at endline compared to 76% at baseline. This is a significant time saving for households, as on average each wooden dam would take 2.2 weeks of work to build.

The number of households able to farm during the dry season increases from 47% to 94%, indicating that the new irrigation systems are able to withstand the storms and increased rainfall from the wet season and retain stored water for irrigation in the dry season.

The data does show that there was no meaningful change to the amount of irrigation channels destroyed by weather, with 43% of households having at least one irrigation channel destroyed at baseline versus 48% at endline. This is not surprising; irrigation channels can run for several kilometres and so remain vulnerable to weather events such as landslides or flooding away from the irrigation dams. This is not seen as a major issue as irrigation channels are much quicker and cheaper to repair than irrigation dams. Repair work typically only requires re-digging ditches, and does not require additional materials.

Figure 1: Changes in resilience to natural disasters



** Questions marked with * for Outcome 1 had 51 HH respondents for baseline. All others had 86 respondents.*

The reduced impact of natural disasters and extreme weather can be evidenced in Figure 2, where rai of farmland affected by natural disasters fell by 70%, from 1.7 rai a year to 0.5 rai. This is particularly significant as the amount of unusable rai in the dry season fell by 5.3 rai (Figure 6), meaning the amount of households farmland farmed year-round increased whilst impact from natural disasters decreased.

Figure 2: Rai of farmland affected by natural disasters in past year

	Mean	SD	LQ	Median	UQ
Baseline	1.69	1.5	1	1	2
Endline	0.51	1	0	0	1
Comparison %	-70%	-33%	-100%	-100%	-50%

Figures 3 and 4 show the standard deviation of data in Figure 2. Both baseline and endline are influenced by upward outliers, with the median for baseline at 1 rai and for endline at 0 rai.

Figure 3: Standard deviation: Rai affected by disasters baseline

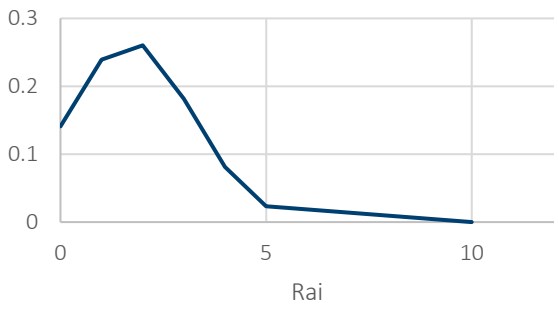
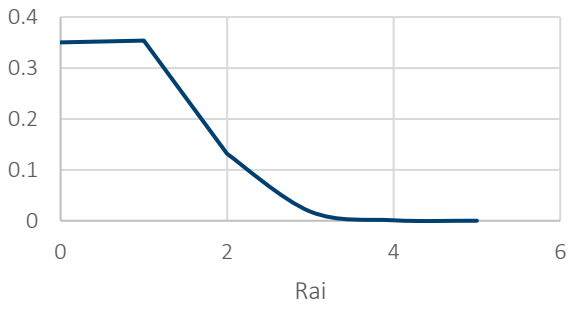


Figure 4: Standard deviation: Rai affected by disasters endline



To determine the statistical significance of the reduction in rai affected by natural disasters, a t-Test on the data was conducted, with the results in Figure 5. This approach is used for one key output across all five output categories in the log frame. A conventional significance level of 0.05 (5%) was used across all t-Tests in this report.

Figure 5 shows that the reduction in rai affected by natural disasters following construction of a FRIS is statistically significant, with a p-value below 0.0001 (0.01%).

"The typical household can now use 99.7% of their paddy fields year-round, when they could only use 39% before the project."

Figure 5: Rai affected by natural disasters

H_0 Amount of rai affected by natural disasters per HH does not reduce after construction of FRIS

H_a Amount of rai affected by natural disasters per HH reduces after construction of FRIS

t-Test: Two-Sample Assuming Unequal Variances

	Baseline	*Endline*	
Mean	1.69	0.51	
Variance	2.34	0.84	
Observations	86	86	
Hypothesized Mean Difference	0		
df	139		
t Stat	6.11		
P(T<=t) two-tail	9.4186E-09	****	
t Critical two-tail	1.98		

**** *Statistically significant to 0.01% level*

Paddy fields and other flat farmland are expected to the principal type of farmland that benefits from a FRIS, as hillside farmland is generally unsuitable for river-fed irrigation channels. Prior to projects, on average 5.5 rai of paddy fields were unusable during the past dry season. This amounted to 61% of farmed paddy fields for the average respondent being unusable each dry season. At endline only an average of 0.2 rai of paddy fields was unusable in the dry season, with the upper quartile being at 0 rai. Amount of available paddy fields (i.e. available to farming whether used or not) had stayed largely the same at endline. The typical household can now use 99.7% of their paddy fields year-round, when they could only use 39% before the project.

Figure 6: Rai of paddy fields unusable in last dry season*

	Mean	SD	LQ	Median	UQ
Baseline	5.5	3.8	3	4	9
Endline	0.2	1	0	0	0
Comparison %	-96%	-74%	-100%	-100%	-100%

Key results: Improved resilience to extreme weather and natural disasters

- Farmland affected by natural disasters fell by 70%;
- No households lost an irrigation dam in the past year at endline, whereas 76% of households had lost at least one dam at baseline;
- 99.7% of paddy fields are now usable year-round, compared to 39% previously;
- Reduction in farmland affected by natural disasters at endline was statistically significant to the 0.0001 (0.01%) level.

Outcome 2: Direct Beneficiaries Experience Increased Crop Yields Compared to Baseline Level

The second key outcome is whether beneficiaries see their crop yields rise after using the FRIS. This is hoped to occur due to numerous factors, principally:

1. Households are able to increase the amount of farmland that is used year-round;
2. Fields are more productive due to improved, consistent irrigation;
3. Fewer crops are lost due to natural disasters.

For those households that did not farm in the dry season, year-round irrigation means crops can be grown in previously underutilised fields. For those that did farm in the dry season, it is likely they are able to increase the proportion of their fields that are utilised throughout the year. Yields are expected to also increase in the wet season, with constant irrigation better irrigating fields compared to just intermittent rainfall. This is especially important for crops such as rice that require a reliable water supply to attain maximum yields. As mentioned in Outcome 1 the FRIS are expected to reduce the amount of rai, and consequently crops, that are impacted by natural disasters and extreme weather, meaning fewer crops would be lost during events such as storms.

Figure 7: Changes in crop output at endline

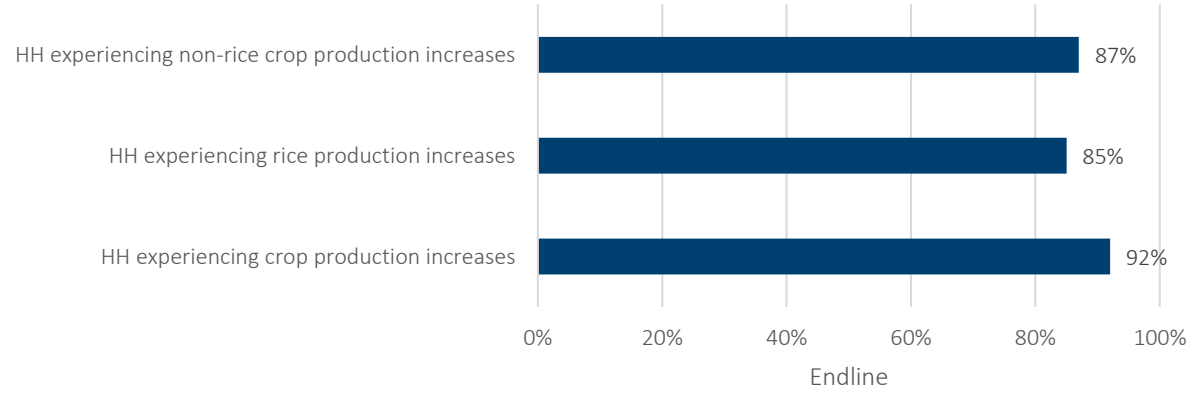


Figure 7 shows that at endline the majority (92%) of households experienced crop production increases. This increase was spread across rice (85%) and non-rice (87%) crops. Anecdotally KHT has been told that different households respond differently to the different crop opportunities that come from the increased ability to grow crops year-round. Some may focus on cash crops and reduce their rice (typically a subsistence crop) output, others may prioritise increasing subsistence farming to guarantee food supply, and some may look to balance both. Overall, it is encouraging to see that over 90% of survey respondents saw improved crop yields.

Average total crop output significantly increased, with the mean increasing by 101% and the median by 80% (Figure 8). As can be seen in Figure 9, the lower quartile of respondents at endline (7.1 tonnes) had higher annual output than the upper quartile of respondents at baseline (6.4 tonnes).

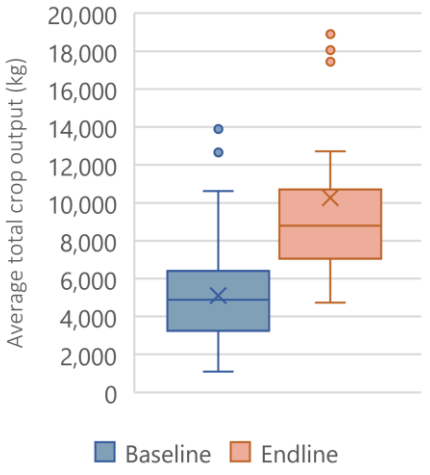
"… at endline the majority (92%) of households experienced crop production increases"

Figure 8: Average total crop output (kg)

	Mean	SD	LQ	Median	UQ
Baseline	5,108	2,373	3,239	4,890	6,414
Endline	10,282	5,658	7,060	8,800	10,740
Comparison %	+101%	+138%	+118%	+80%	+67%

The mean total crop output is higher than the median due to the presence of large positive outliers at endline, with six households growing more than 20 tonnes of crops annually at endline whereas no household grew more than 14 tonnes at baseline. The largest beneficiary group however is the lower quartile, which increases nearly 120% from 3.2 tonnes to 7.1 tonnes. This suggests that whilst some households see outsized crop increases by overall quantity, the benefits of the project are well distributed, with households in the lower quartile seeing the largest percentage gains in crop output.

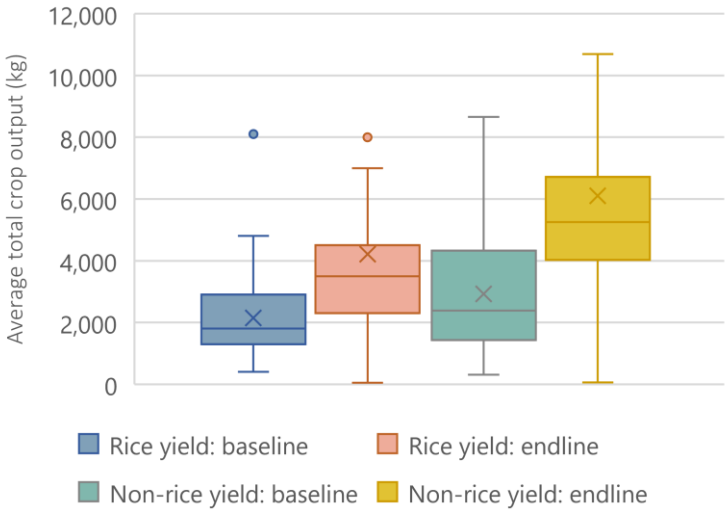
Figure 9: Average total crop output (kg)



"… benefits of the project are well distributed, with households in the lower quartile seeing the largest percentage gains in crop output"

Rice and non-rice crops both see increased crop output, but increases for non-rice crops are larger, with increases of 89% and 111% respectively. There are two theories for why this is the case. As rice is primarily a subsistence crop, there may be an upper limit on the amount of rice a family is wishing to grow for their own purposes, as they cannot eat an unlimited quantity of rice. Non-rice crops are more likely to be cash crops which are less likely to have an upper threshold as more yield means more to sell. Secondly, rice is solely grown in the wet season, meaning that improved ability to grow crops in the dry season would not result in improved rice yields.

Figure 10: Crop output of rice and non-rice crops



As with total rice output, the means are higher than the medians due to the presence of positive outliers. Looking at the median, typical rice output increases from 1.9 to 3.5 tonnes,

and non-rice output from 2.4 to 5.3 tonnes. For both rice and non-rice crops the endline median is higher than the baseline upper quartile, and the endline lower quartile higher than the baseline median.

The standard deviation for the total crop output follows a standard normal distribution at both baseline and endline, as shown in Figures 11 and 12.

Figure 11: Standard deviation: Crop output baseline

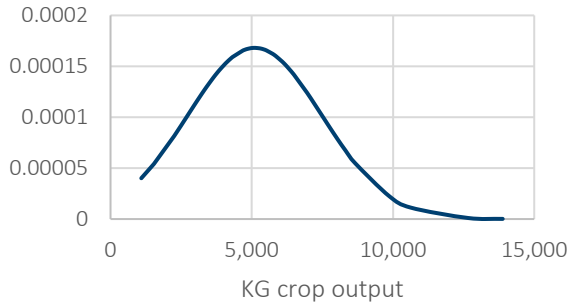
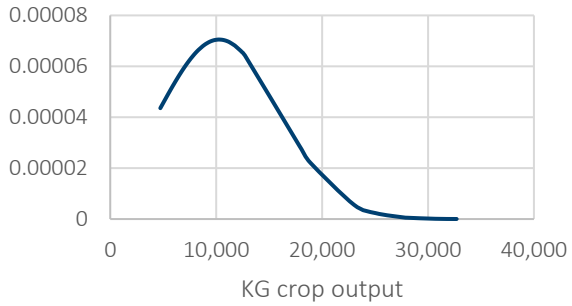


Figure 12: Standard deviation: Crop output endline



A t-Test was run on the baseline and endline results for total crop output, with the results in Figure 13. The increase in total crop output from baseline to endline is statistically significant to the 0.0001 (0.01%) level.

Of the four to five tonnes increase in total crop output (median and mean respectively), approximately half this increase comes from crops grown at least partially in the dry season. Both the mean and median see similar increases of around 250%, with an increase of crops grown fully or partially in the dry season from one tonne to 3.5 to 3.7 tonnes.

The largest increases can again be seen in the lower quartile, which increases 1,639% from 161kg to 2.8 tonnes. This is also evidenced from the contraction of the endline 'box' in Figure 15. This suggests that whereas at baseline significant farming during the dry season was only an option for a minority of households, it is now available to the majority of farmers in communities with a FRIS.

Figure 13: Total crop output (kg)

H_0 Total HH crop output does not increase after construction of FRIS

H_a Total HH crop outputs increases after construction of FRIS

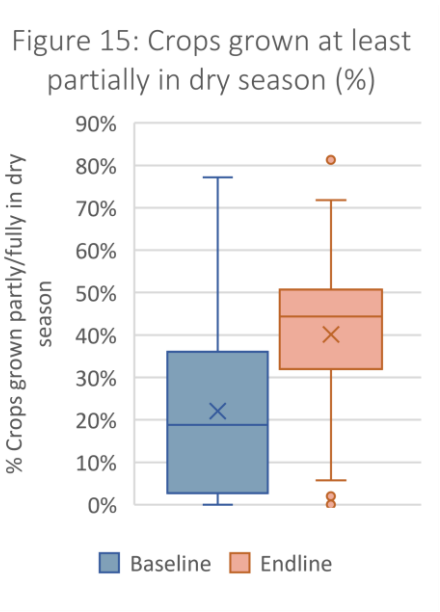
t-Test: Two-Sample Assuming Unequal Variances

	Baseline	*Endline*	
Mean	5,108	10,282	
Variance	5632477	32016546	
Observations	82	83	
Hypothesized Mean Difference	0		
df	110		
t Stat	-7.68		
P(T<=t) two-tail	7.17244E-12	****	
t Critical two-tail	1.98		

***** Statistically significant to 0.01% level*

Figure 14: Crops grown at least partially in dry season (kg)

	Mean	SD	LQ	Median	UQ
Baseline	1,067	1,051	161	995	1,654
Endline	3,658	1,882	2,800	3,495	4,670
Comparison %	+243%	+79%	+1,639%	+251%	+182%



Key results: Increased crop output at endline

- 92% of households experienced crop increases;
- Both rice and non-rice crops saw large increases, with non-rice increases larger;
- The lower quartile of beneficiaries benefit the most, with crop yields increased 120% and KGs of crops grown in dry season increasing 17 times over;
- Increase of household annual crop output at endline was statistically significant to the 0.0001 (0.01%) level.

Outcome 3: Direct Beneficiaries Experience Increased Average Annual Household Income Compared to Baseline Level.

Outcome 3 relates to the expected corresponding increase in annual incomes that would come from increases in crop yields. The majority of Karen rural communities are subsistence farmers, so a portion of their crops would go towards domestic food supply. Once sufficient food is available for domestic use then the remainder can be sold, alongside allocated yields from cash crops.

Karen communities farm a variety of crops, but common cash crops include corn, garlic, soya bean, onions, chili, and mangos. As many of these are grown partly or fully in the dry season, whereas rice is exclusively grown in the wet season, improvements in the ability to grow crops during the dry season would particularly benefit cash and non-rice crops. The factors identified at the start of Outcome 2 as key reasons a FRIS should increase crop yields also relate to why the project should increase income from selling crops, and in turn total income.

Average total incomes increase from 25,000 THB at baseline (approximately £581 at 2021 FX) to between 40,000 THB (median) and 52,000 THB (mean), an increase of between 60% (median) to 108% (mean). This is reflected in Figure 16. The greater increase in mean is due to large positive outliers in income, which is also reflected by the large standard deviation in the endline results.

Figure 16: HH annual income (THB)

	Mean	SD	LQ	Median	UQ
Baseline	25,133	11,161	19,500	25,000	30,000
Endline	52,285	36,980	30,000	40,000	60,000
Comparison %	+108%	+231%	+54%	+60%	+100%

At 2021 FX rates, the global threshold for extreme poverty ($1.90) is approximately 64 THB per person per day, converted to 24 THB at purchasing power parity using the World Bank's 2020 LCU rate. With an average of 4.7 persons per household for respondents, this would mean the average income per person at baseline is 15 THB, 9 THB below the threshold for extreme poverty. At endline, this increases to between 23 (median) and 30 THB (mean), putting the lower estimate of the average household still in extreme poverty threshold but the higher estimate lifting them out of extreme poverty.

At baseline only 7% of households had sufficient income to not be classed as being in extreme poverty, but by endline this rose to 44%. Whilst improvement in incomes is still needed to provide all households sufficient income to escape extreme poverty, on the assumption that the FRIS project is entirely causal for seen income increases, then over a third (37%) of surveyed Karen households have been lifted out of extreme poverty by the project within the first one to two years.

Figure 17: Standard deviation: HH income baseline

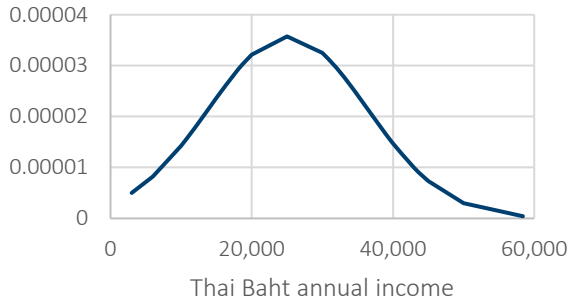
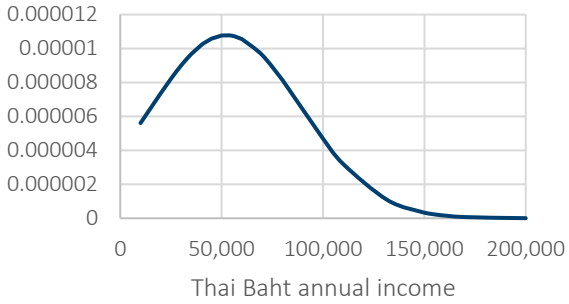


Figure 18: Standard deviation: HH income endline



Standard deviation of income largely follows standard normal distribution at both baseline and endline, albeit with a curtailed left tail at endline.

The increase in household incomes from baseline to endline is statistically significant, with a p-value below the 0.0001 (0.01%) threshold, as calculated in the t-Test in Figure 19.

> "… on the assumption that the FRIS project is entirely causal for seen income increases, then over a third (37%) of surveyed Karen households have been lifted out of extreme poverty by the project within the first one to two years."

Figure 19: HH annual income (THB)

H_0 Total HH income does not increase after construction of FRIS

H_a Total HH income increases after construction of FRIS

t-Test: Two-Sample Assuming Unequal Variances

	Baseline	*Endline*	
Mean	25,133	52,285	
Variance	124565280	1367520828	
Observations	86	86	
Hypothesized Mean Difference	0		
df	100		
t Stat	-6.52		
P(T<=t) two-tail	2.913E-09	****	
t Critical two-tail	1.98		

***** Statistically significant to 0.01% level*

Whilst all surveyed households engaged in some farming, the lower quartile of households see their incomes increase from 19,500 THB to 30,000 THB, which brings the endline lower quartile above the baseline's median. The 54% increase is however lower than the 118% increase in crop income.

This is largely explained by the fact that farming is not the only economic activity for most households. Whilst all households have income from farming crops (at endline), 70% are also labourers, 85% animal breeders, and a minority also receive family remittances or pensions. Generally, the level of non-farming income is relatively similar across households, meaning poorer households will see smaller outright income gains from increased farming.

Figure 20 shows that income specifically from selling crops increases in a more balanced manner across groups, with the lower quartile income increasing by 188% and median income increasing by 203%.

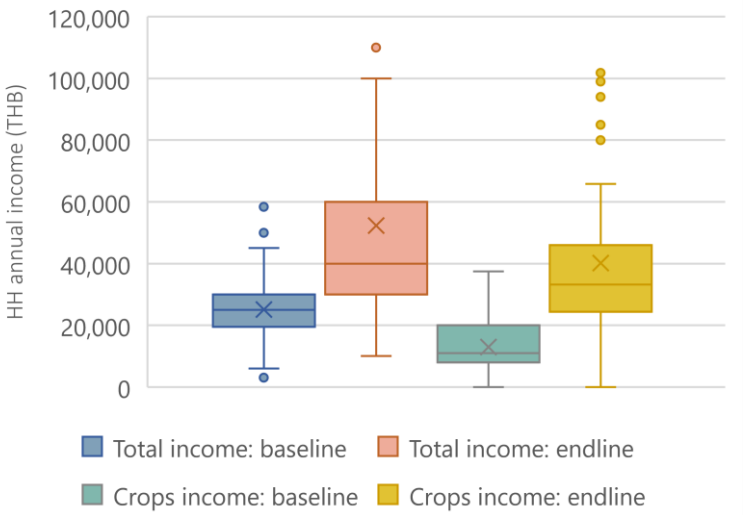
Figure 20: HH income from selling crops (THB)

	Mean	SD	LQ	Median	UQ
Baseline	12,970	11,161	8,466	10,960	20,000
Endline	40,125	25,574	24,400	33,200	46,000
Comparison %	+209%	+129%	+188%	+203%	+130%

The majority of observed increases in income can be accounted for by increases in crop income, with the mean of both total income and crop income increasing by 27,000 THB.

As seen in Figure 21, the increase in crop income is substantial, with the lower quartile at endline higher than the upper quartile at baseline.

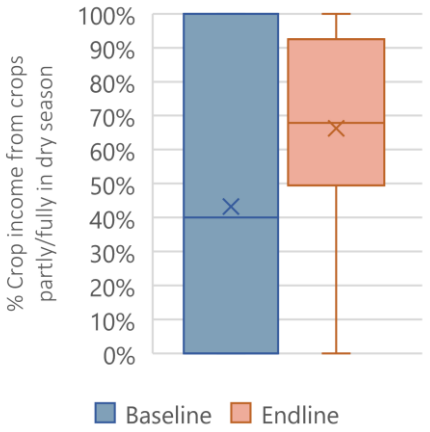
Figure 21: Total and crops income



Crop income predominantly comes from non-rice cash crops. 90% of mean crop sales are for non-rice crops, with the median income from rice sold nil. Rice is a stable crop that provides towards food security but is not actively an income source for Karen communities.

With cash crops often grown during the dry season, improved capacity to grow crops in the dry season sees an increase in proportional income from crops grown in this time. As highlighted in Figure 22, crops grown in the dry season contributed to 43% of crop income (mean) at baseline, and 66% at endline. The lower quartile sees the largest increase, going from 0% to 49%. This implies that many households are now able to make an income from crops grown in the dry season when before they were unable to.

Figure 22: Crop income from crops grown partly/fully in dry season



Key results: Increased income at endline

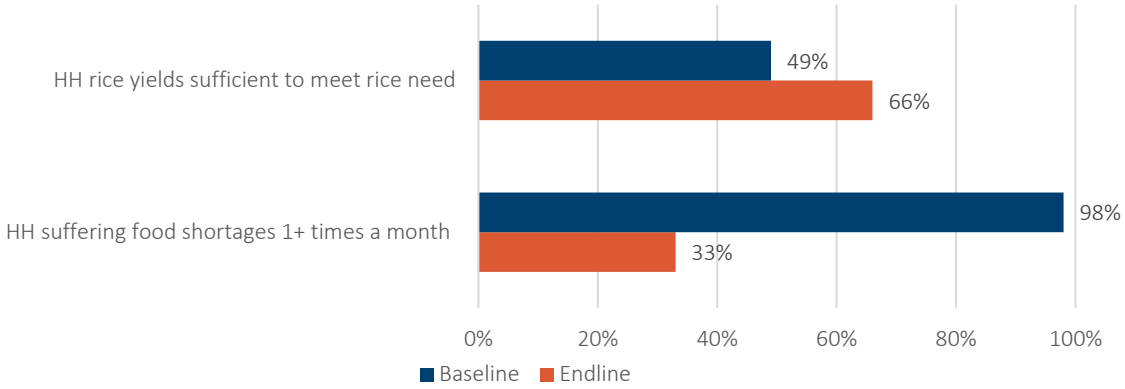
- 37% of households lifted out of extreme poverty;
- Average income increased 15,000 THB (60%) to 27,000 (108%);
- Increases in crop income account for increases in total household income;
- Increase of household annual income at endline was statistically significant to the 0.0001 (0.01%) level.

Outcome 4: Direct Beneficiaries Have Increased Food Security and Spend Less Days in Hunger

With rural Karen communities predominantly subsistence farmers, and food insecurity a known challenge, increases in crop outputs are hoped to also reduce hunger and food insecurity alongside improving incomes. Many of the communities KHT work in are located on unpaved roads that become impassable in the wet season, or several kilometres away from market towns where outside produce can be bought. As such improved local food production is seen as a key way to improve available of food throughout communities.

Figure 23 shows that 66% of households at endline could grow sufficient rice to meet their domestic need, compared to 49% at baseline. Only one third of households suffered any food shortages a month, compared to almost the entirely of baseline respondents.

Figure 23: Food security



Overall, the mean number of days where households had insufficient food a month fell from 6.4 to 1.2 days, a reduction of 81%, with two thirds of respondents having sufficient food for throughout the month. This is shown in Figure 24 below.

Figure 24: Days a month HH have insufficient food

	Mean	SD	LQ	Median	UQ
Baseline	6.4	2.9	5	6	8
Endline	1.2	1	0	0	2
Comparison %	-81%	-66%	-100%	-100%	-75%

Standard deviation of the results again largely follows standard normal distribution, but with a shortened left tail due to the mean being close to 0.

"... the mean number of days where households had insufficient food a month fell from 6.4 to 1.2 days, a reduction of 81%, with two thirds of respondents having sufficient food for throughout the month."

Figure 25: Standard deviation: HH food shortages a month baseline

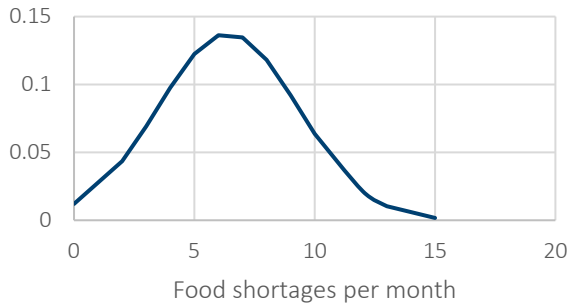
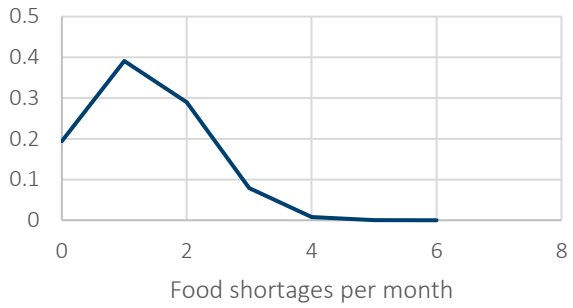


Figure 26: Standard deviation: HH food shortages a month endline



The reduction in days a month where households have insufficient food from baseline to endline is calculated to be statistically significant in the adjacent t-Test, with a p-value below the 0.0001 (0.01%) threshold.

Figure 27: Days a month HH have insufficient food

H_0 Food shortages a month per HH does not decrease after implementation of FRIS

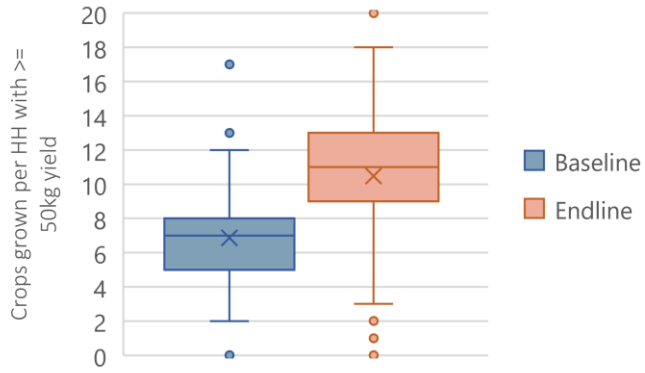
H_a Food shortages a month per HH does decreases after implementation of FRIS

t-Test: Two-Sample Assuming Unequal Variances

	Baseline	*Endline*	
Mean	6.43	1.17	
Variance	8.46	2.22	
Observations	86	86	
Hypothesized Mean Difference	0		
df	127		
t Stat	14.92		
P(T<=t) two-tail	1.06283E-29	****	
t Critical two-tail	1.98		

**** *Statistically significant to 0.01% level*

Figure 28: # Crops grown per HH with >= 50 kg yield



Alongside increased yields, another potential tool to boost food security is through crop diversification. This ensures that if one crop fails, there are sufficient alternatives available to feed households. Both the mean and median number of crops grown per household with a yield of 50kg or over increases from 7 to 11, a 57% increase. Similarly, the number of crops with a yield of 100kg or more increases from 4 to 6. Whilst this may not improve daily food security, increased crop diversification may add resilience in event of a disaster such as a drought or occurrence of blight.

Figure 29: Number of crops grown per HH with >= 50kg yield

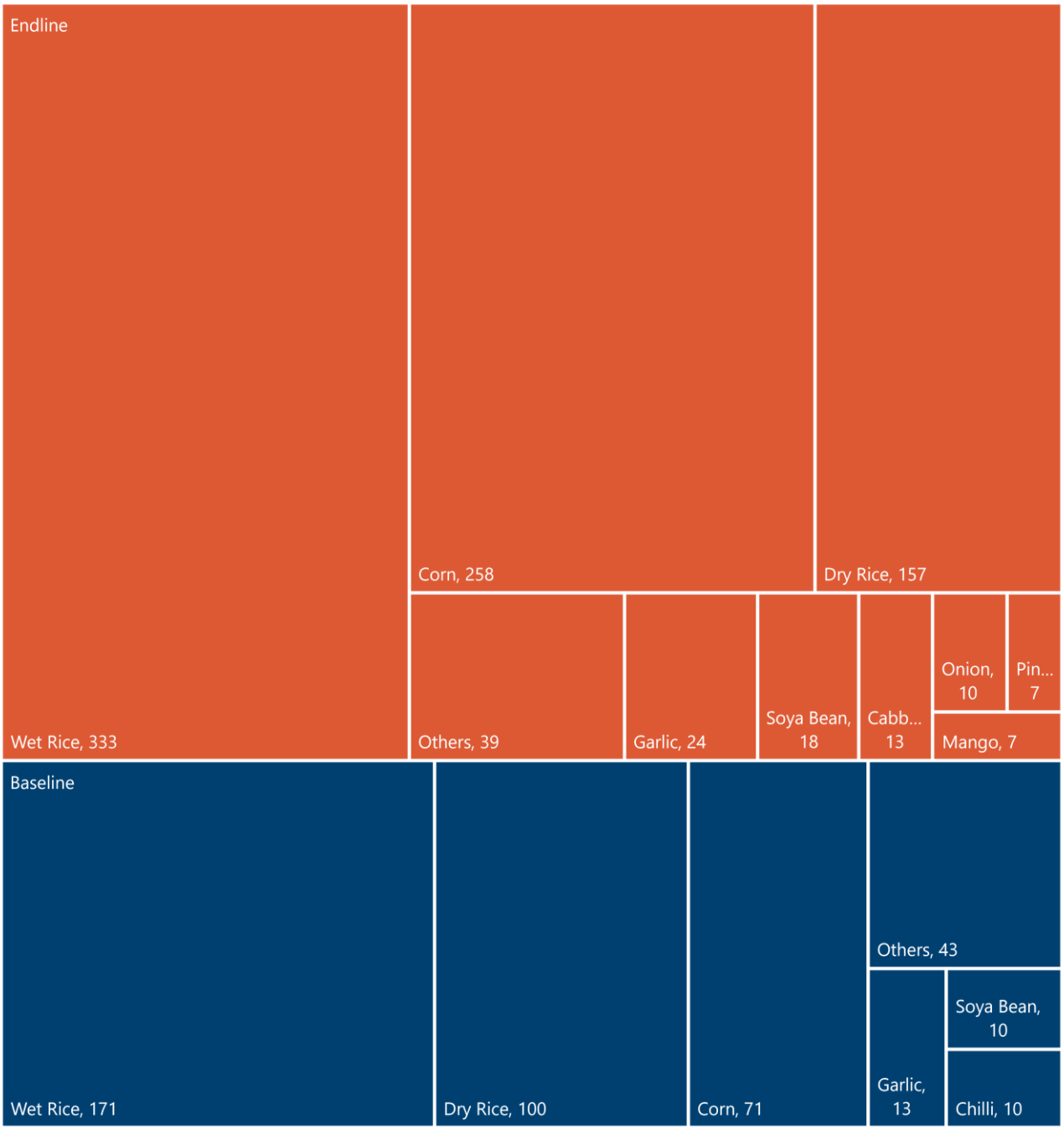
	Mean	SD	LQ	Median	UQ
Baseline	6.9	3.0	5	7	8
Endline	10.5	3.8	9	11	13
Comparison %	+52%	+27%	+80%	+57%	+63%

Key results: Increased income at endline

- Households facing any food shortages a month fell from almost all to one third;
- Days where households had insufficient food a month fell from 6.4 to 1.2 days;
- Crop diversification increased, with households growing 11 different crops with over 50kg yield, up from 7 different crops;
- Reduction of days households had insufficient food at endline was statistically significant to the 0.0001 (0.01%) level.

Below is a treemap showing the proportional output of different crops, summed from the total output of all survey respondents.

Figure 30: Combined total crop output of surveyed households (tonnes)



Outcome 5: Direct Beneficiaries Place Decreased Pressure on the Surrounding Environment and Natural Resources Compared with Baseline Level

An additional benefit of the project is that it is hoped the reduced usage of wooden dams will benefit the local environment. Each wooden dam uses approximately 300 bamboo and other small trees that are sourced locally, meaning a village with multiple dams could go through thousands of small trees each year to maintain a traditional irrigation system. If a FRIS removes the need to build new wooden dams for direct beneficiaries, then it is hoped this will reduce pressure on local forests.

KHT seeks to run its projects in a sustainable manner both in project ownership and in impact on the local environment. With deforestation gaining growing recognition as a major driver of both species loss and climate change, projects that can boost incomes and food security whilst protecting flora and fauna are to be encouraged.

At baseline, on average each household built 1.1 wooden dams per year. No surveyed households had built a wooden dam in the past year at endline, suggesting the projects had been successful in negating the need to create new wooden dams. Surveys confirmed earlier KHT research on the tree usage of each wooden dam, with baseline respondents using an average 349 trees per dam, and a median of 300.

The surveys have not been able to currently confirm the total reduction of wooden dams in each village, as it is likely that non-direct beneficiaries and non-beneficiaries would continue to use wooden irrigation dams. As noted previously, changes have been made in the survey to attempt to capture this figure in the future.

A rough approximation of the number of trees saved each year from being felled can be made by using data from project proposals on observed number of dams in the village. The mean is inflated by some large outliers, but the median number of wooden dams present pre-project per village is six. Using the median figures, an estimated 1,800 trees are felled a year in each typical village before a FRIS is installed.

Another missing data gap is the total beneficiary reach in the village, with KHT's current estimate that on average 60% to 70% of villagers are direct beneficiaries of each FRIS. Using the lower 60% figure, and having observed that all direct beneficiaries have ceased constructing wooden dams when using a functioning FRIS, a figure is reached of 1,080 bamboo and small trees are saved a year that a FRIS is operational. If a system runs for its 20-year lifespan then over 21,000 small trees may avoid felling from each project.

It is important to emphasise that at this stage this is only a first guess, and further work is needed to gather more data and make a more accurate estimate. Anecdotally, comments from case studies do indicate that local woodland benefit from the reduced need to be felled for building irrigation systems.

Another factor in the irrigation projects' environmental impact is whether beneficiaries increase the amount of land farmed due to the improved irrigation systems. This does not refer to under-utilised farmland that was not in use, or not in full use, due to poor irrigation. It refers to whether households clear new land for farming and thereby increasing deforestation.

Data on household farmland at baseline and endline is nearly identical, with minimal changes in amount of rai farmed or in types of rai farmed. Households continue to farm hillside and other farmland alongside paddy fields and irrigated land, and there is no indication that any type of farmland is being increased.

Figure 31: Standard deviation: Rai farmed per HH baseline

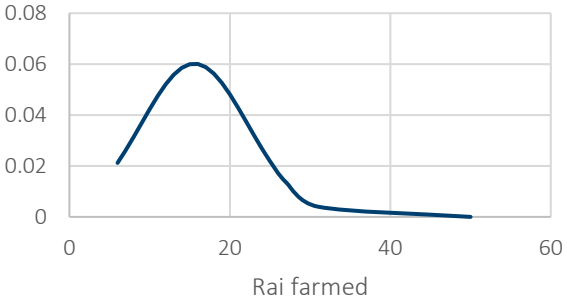
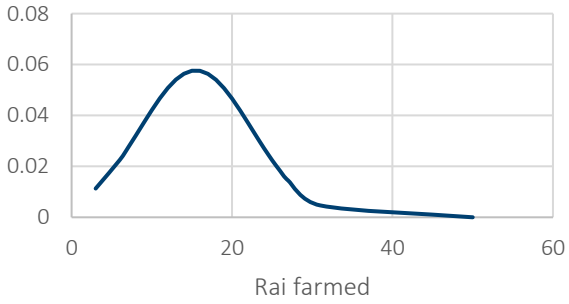


Figure 32: Standard deviation: Rai farmed per HH endline



The t-Test in Figure 33 shows there was no statistical significance between the rai of farmland per household at baseline against endline. The respective means are within 0.1 rai of each other, and Figures 31 and 32 show that the standard deviation of rai farmed per household does not change between surveys.

Questions on biodiversity highlighted the importance of protecting the local environment. Between baseline and endline there had been 13 sightings of leopards (critically endangered), 3 sightings of tigers (endangered), 76 sightings of langurs (near threatened), 108 sightings of Lar gibbons (endangered), and 81 sightings of binturong (vulnerable). The vulnerability statuses in parenthesis are taken from the IUCN red list of threatened species. It is hoped that reduced deforestation can help protect the habitats of the above and other animals.

Figure 33: Rai farmed per HH

H_0 Rai farmed per HH does not change after construction of FRIS

H_a Rai farmed per HH changes after construction of FRIS

t-Test: Two-Sample Assuming Equal Variances

	Baseline	*Endline*	
Mean	15.6	15.5	
Variance	43.9	47.8	
Observations	86	86	
Pooled Variance	45.9		
Hypothesized Mean Difference	0		
df	170		
t Stat	0.079		
P(T<=t) two-tail	0.937	*ns*	
t Critical two-tail	1.974		

ns Not statistically significant to 5% level

Key results: Increased income at endline

- Direct beneficiaries ceased felling trees to build wooden irrigation dams;
- An initial estimate puts potentially 1,080 small trees saved from being felled for each year a FRIS operates, but more work is needed to verify this figure.

Other Findings

Pesticide and Fertiliser Usage Appears to Increase

At endline it was observed that the number of households using pesticides and fertilisers had increased, going from 81% to 91% and 64% to 85% respectively. The cause for this is not yet clear, and will be investigated in future M&E visits. One hypothesis is that increased incomes has allowed households to invest in other farming resources, including pesticides and fertilisers, and that there may be the potential for income gains to have a multiplier effect. Alternatively, if for some reason fertiliser and pesticide use had increased for reasons separate from KHT's projects, that may conflate findings if said usage also improved crop yields.

KHT is not aware of any other actors operating in the beneficiary villages, and no mention of any relevant programmes have been mentioned either by local staff or in case studies. Additionally, baselines conducted in 2019, 2020, and 2021 show no difference in use of pesticides and fertilisers, suggesting there is not a wider trend to turn to these resources. Further research will be made to ascertain why pesticide and fertiliser use may be increasing.

No Observed Improvement in Child Education, but Survey Questions Need Improving

There was an attempt with survey questions to understand whether irrigation projects influenced the number of children in school. From KHT's education projects there is an understanding that various cost barriers prevent some children from regularly attending school, including costs in paying for school food, dormitory places, and school transport. The hypothesis was that an increase in income may reduce the number of children in each community not regularly attending school.

No evidence was seen that the project had improved access to education in the villages, but analysis of the survey questions and answers indicate some issues with the methodology. At endline 80% of households whose children did not go to school said the reason was they were too young. The surveys also only captured outright lack of schooling where a child never attended school, and recorded no data on whether children missed some days of school but remained enrolled.

Changes in survey questions and training for KHT project staff will be implemented to improve the data collection on education and to further understand if there is any relationship between improving Karen household incomes and access to education.

Case Studies Corroborate Findings

Alongside surveys, one case study was taken at each village to gather qualitative data to support the findings. The case studies support the overall findings of this report, with interviewees noting improved crop yields, income, and food security from using the FRIS. A collection of case studies is included as an annex for reference.

Accuracy of Project Proposals

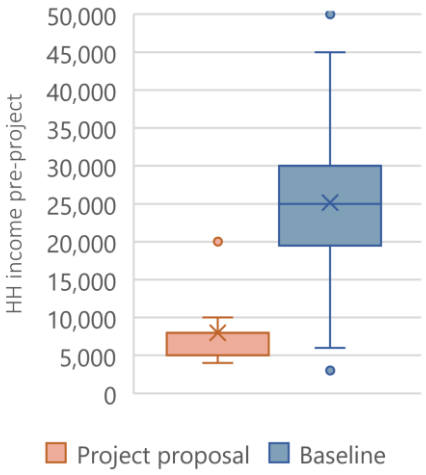
Prior to the implementation of the current M&E framework the principal method for collecting data on KHT's livelihoods projects were via the project proposals. A part of each project proposal is a needs analysis that evaluates the prospective village's need against a variety of factors including income, vulnerability to natural disasters, and food insecurity. By comparing these collected figures against the more robust data collected at baseline it has been possible to determine the general data accuracy of project proposals.

As shown in Figure 34, the income estimates made in the project proposals significantly underestimated household income against the baseline level. Project proposals averaged an estimation of 8,000 THB per household, against over 25,000 THB at baseline.

This likely stems from a data collection error by the KHT staff that undertake the project proposals, and work will be undertaken to improve accuracy in the figures.

Food security appraisals appear to be more accurate. 51% of households in project proposals had insufficient rice to meet their domestic need, against 67% at baseline.

Figure 34: Forecast vs actual household income



Household vulnerability to natural disasters also proves more accurate, with project proposals averaging 70% of households being affected by natural disasters in past two years, with 7 of the 9 villages at 70% or 80%. 83% of baseline respondents had been impacted by natural disasters in the past year.

Financial Analysis of Projects and Projects' Return on Investment

Figure 35 below estimates the financial return of each KHT irrigation project. KHT estimates from the current project data that a FRIS can provide £329K to £568K of economic value to a village over a 20-year period, not taking into account the assumptions and caveats detailed below. There can be more certainty in the one-year gross return (xii.) of £17K to £29K, as this would relate to the period actively tracked between baseline and endline. This figure means that a typical project returns on its investment in a village within its first year.

"… a typical project returns on its investment in a village within its first year."

Figure 35: Average irrigation project's return on investment

		Mean	Median
i.	Village population	318	335
ii.	Village population (HH)	77	81
iii.	Direct beneficiaries, 60% reach	191	201
iv.	Direct HH beneficiaries, 60% reach	46	49
v.	Increase in HH annual income (THB)	27,152	15,000
vi.	Project cost (GBP)	£14,299	£14,538
vii.	Project cost (THB)	556,280	552,592
viii.	Cost per beneficiary (GBP)	£75	£72
ix.	Cot per beneficiary (THB)	2,913	2,749
x.	Project spend vs budget	100%	102%
xi.	Gross return (annual, THB) iv. * v.	1,248,992	735,000
xii.	Gross return (annual, GBP)	£29,046	£17,093
xiii.	Gross return (20-year lifespan, THB) iv. * v. * 20	24,979,840	17,700,000
xiv..	Net return (20-year lifespan, THB) iv. * v. * 20 – vii.	24,423,560	14,147,408
xv.	Net return (20-year lifespan, GBP)	**£567,990**	**£329,009**

Various assumptions and caveats exist in the above calculations. Systems are given a 20 year lifespan. Whilst only 4% of KHT projects installed between 2007 and 2021 have required repair work, none have yet reached their full lifespan and so the true lifespan is difficult to concretely predict, as is the failure rate of projects as they age. The calculation does not take into account economic factors such as inflation or FX rate changes over time, with figures set to a 2021 level.

Conversely, the direct beneficiary reach of 60% of households per village is the conservative end of KHT's current estimate and may prove to be higher. The figure only tracks direct beneficiaries; others in a community who do not grow crops with the FRIS may also benefit, for instance through improved local food supply or by labouring on irrigated fields. It is also unknown if the current income gains are the maximum limit for the project's impact, or whether households will continue to see income growth for future years. If KHT is able to return to the surveyed communities over a longer time frame that may help ascertain the accuracy of the above figures.

Key results: Other findings

- Observed increases in pesticide and fertiliser use are as-yet unexplained;
- More data is needed to understand if income gains improve access to education;
- Household income estimates during project proposals require improvement;
- Projects return on their investments in a village within the first year, and may have a net positive return of £329K to £568K in a project's lifetime.

Recommendations & Next Steps

Below is a summary of recommendations and areas of further investigation that have been highlighted in this report.

Improve Survey Content and Collection Methods

During the data collection process various parts of surveys were identified as room for improvement. Survey length will be shortened to ensure unnecessary data is not collected and to help maintain respondents' attention throughout. Most of this will be achieved by consolidating the crop matrix into the main survey.

Some questions are to be reworded to be more accessible to less numerically skilled respondents. Where a proportion of a number is required, for instance the amount of total income that is derived from selling crops, this can be captured through a percentage rather than a separate figure.

Questions on the level of access to education proved insufficient to gauge whether there was any relationship between increasing incomes and more children accessing schools, or whether there were any access to education challenges in the communities. New questions and training are being rolled out to fill this data gap.

Whilst the challenges in accessing communities for endline surveys posed by COVID-19 were unforeseen, and it would be hoped would not be faced again, some changes could be made to gather data remotely where necessary. As many households have mobile phones, taking phone numbers at baseline may allow KHT's project staff to reach households who were not available for the endline surveys, or whose village may be currently unreachable.

Improve Project Proposal Estimates

As highlighted previously, a large discrepancy exists between average household income estimates made during project proposals and the captured income data at baseline. This likely stems from a training issue with the staff that conduct the project proposals.

Whilst other data points such as food insecurity and natural disaster vulnerability proved to be more accurate, other key figures recorded during project proposals should also be verified to ascertain if they are reliable. This includes the number of wooden dams present per village, the population and number of households per village, and the potential beneficiary reach of each project.

Research Typical Beneficiary Reach in Village

The findings in this report relate to direct beneficiaries of the village, but the current M&E framework does not determine the total beneficiary reach of each project. Beneficiary estimates are made at project proposals, but this data point has not yet been verified. Currently KHT's estimate is that a typical project reaches between 60% and 70% of village households, which is based on anecdotal reports from project staff who have conducted endline surveys.

Changes in the survey will measure the total number of dams in the village at baseline and endline, which can act as a proxy for beneficiary reach. Other data points, either recorded through the household survey or through other means, are likely required to determine with greater clarity both how many persons reside in a village, and how many of those are direct beneficiaries of a project.

Understand Increases in Pesticides and Fertilisers

An unexplained increase in usage of pesticides and fertilisers was seen at endline. Whilst this may be caused by increased incomes allowing farmers to reinvest in farming resources, if the cause for these increases is unrelated to the KHT project then they may conflate the data on increased crop yields and subsequent impact on incomes and food security.

Whilst it is deemed unlikely that this increase is unrelated to KHT, further research should be conducted to confirm potentially conflating factors are not influencing results.

Measuring Impact on Indirect Beneficiaries

As the survey results focus on direct beneficiaries there is currently a lack of data on any impact on indirect beneficiaries, or on the wider communities. This is important both as there may be unmeasured impact from the project, and because KHT has not yet confirmed with certainty there are no negative spill-overs to non-recipients (albeit none have yet been reported).

It is important to ensure the current surveys continue to interview the same demographic (i.e. direct beneficiaries) so that the dataset can be grown and further examined. A parallel or additional M&E process is therefore required to understand if there are any effects on non-direct beneficiaries and wider communities from the presence of the FRIS.

Calculate Reduction in Wooden Dams per Village and Corresponding CO_2 Equivalent Benefit

The changes in survey questions will allow KHT to better quantify the reduction in wooden dams per village following the implementation of a project. Once this figure is available it will be possible for KHT to calculate the benefit of the project in combatting climate change through reducing deforestation. By estimating the total number of trees that are not felled a year due to the reduced use of wooden irrigation dams, and the typical age and type of tree felled, a calculation can be made to estimate the CO_2 equivalent amount of greenhouse gasses that are counterfactually removed from the atmosphere for each year of a project's operation, accounting for factors such as the building materials used in constructing each FRIS.

Testing Changes in Impact if Integrated with Other KHT WASH or Education Programmes

Alongside livelihoods, KHT supports Karen communities in Northern Thailand through providing access to clean water and supporting access to education. The project findings focus solely on projects which have had recent livelihoods projects installed, but overall KHT is looking to better coordinate programme implementation so multiple projects can support communities simultaneously in a holistic manner.

This report represents the first major study of KHT's programming, but as of December 2021 WASH data is also being collected in a similar manner, with an education M&E framework due

to be rolled out in 2022. As the overall M&E dataset grows, and more projects are implemented with a multitude of WASH, livelihoods, and/or education at the same time, it will be possible to test whether coordinating KHT projects improves respective programmes' impact.

Expanding the M&E Framework to Allow for 'RCT-Light' Village Comparisons

Randomised control trials (RCTs) are judged to be the gold standard of impact evaluations in the development sector. Borrowed from medical trials, RCTs randomise recipients and non-recipients of a project and then follow both from baseline to endline to see if changes can be attributed to a project or are due to unrelated factors. They are however expensive to run, as they require large datasets following both project beneficiaries and similar non-beneficiaries.

KHT could in theory expand its M&E framework to include elements from an RCT to add robustness to findings. A bank of project proposals are being drawn up of prospective recipient villages; if KHT were to randomly select from this list which villages are to receive support and which will not, and were to follow a sufficient number of non-recipient communities to endline, it would add significant weight to impact findings.

The principal limitation is cost, as it would require an increase in staff and management capacity to properly coordinate such a process and double the number of surveyed villages. A secondary drawback is that by randomising which villages receive assistance, albeit from a vetted list of suitable recipient communities, KHT's ability to target the most in need communities may be hampered. It may be the case that of a shortlist of 20 communities there are one or two that evidently have the greatest need, but under a randomised selection KHT would not be able to explicitly target those sites for projects. This is a topic that can be explored further if funding and capacity becomes available.

Conclusion

The findings from this report constitute the first major multi-year study of a KHT programme to determine its effectiveness. Results are highly promising; strong evidence has been found to suggest that the installation of a flood resistant irrigation system can significantly boost crop output, household incomes, food security, and resilience to natural disasters. There are also indications that the projects reduce pressures on the local environment, but further data is needed to confirm this.

KHT's M&E framework that obtained this data will continue and is being expanded to also cover KHT's WASH and access to education programmes. Further investigations will build upon this report's work, including determining the direct beneficiary reach of projects, the effectiveness of a FRIS in reducing deforestation, and on measuring the effects on non-direct beneficiaries.

If you have any comments or questions on this report, or would like to know more about how you can support KHT's work in empowering Karen communities in Northern Thailand, please do reach out at the contact details below. Donations of any size can help continue the progress made in supporting Karen livelihoods that this report has studied.

Thank you for reading about the work of The Karen Hilltribes Trust, and in your interest in assisting the Karen people to achieve a secure future.

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Annex 1: Full Data Summary

Annex 1 is attached as an additional excel sheet. This contains the full list of quantitative data retrieved from the surveys, as well as a summary of the key indicators used in the log frame. Survey respondents personal details have been removed for their data protection.

Annex 2: Case Studies

On the following pages are a collation of case studies from some of the recipient projects. These were translated from Thai or Karen to English by the KHTF team in Northern Thailand; language has not been altered from the original translation to retain authenticity.

Overall, the case studies support the findings of the report. Interviewees report increased rice output providing more reliable food supply, additional crops being grown to boost incomes, and an improvement in the local environment as pressure is reduced on the local forest.

Case Study 1: Ban Huay Pong

Brief outline of background/personal history (Family, Livelihoods, Age, place of birth)

My life when was young it difficult and hard for me. No road in the village. We don't have the doctor and no medication in our village. Each year we have less food and we do not have enough rice. In the village we do not have school and we have to school in another village. It far from our village. I am went to school Ban Po Saw until I finished primary 4 and after that I continue for adult education until I finished primary 6. In my village my village we do not have the water system and we do not have a rice bank in the village.

Our life in the past when we want to travelling to Mae Sariang district and we have to walk and stay in the forest for one night. We walk and follow the stream to Ban Mae Lap to Mae La Noi and go to Ban Mae Sariang district.

The beneficiary's needs, problems, or issues.

My life before the project is hard. We do not have enough rice, because in our field not enough water it make we get less rice, because our dam is destroyed by the water flooding. Some year is our dam is not got flooding we can get more rice and enough for one year. In the paddy field if the rice flower bud and the dam got flooding is damage rice. We do not get much rice and that year we have to buy the rice. We have to cut down the trees and bamboo for build the dam and take long time to build the dam nearly a month to build the dam.

How did project impact the situation?

Our life after the project. We have a better life. We do not cutdown the trees for build the dam like our life before. Our field we have enough water for our field 100 percent. We can control the water in our field how much we can let the water in -out the field we can do. We get double more rice in our field when we have a irrigation project. Before we have the dam we get rice 1000 kg and after we have the new dam we can get more rice 4000 kg.- nearly 5000 kg. We can grow more plant in our field in dry season, soya bean, garlic. We have more income from crops, when we have enough rice and we do not worry anything.

Short term and long-term change?

So much changing. We have more trees and more green. The trees protect the windy and it help in the hot season and make it cooler. In our village we do not the air we use natural air from the forest.

Plans and hope for the future?

Sure for the future we will have a better life. In the dry season we can plant the garlic, soya bean we will have more income. We can spend for our family buy the new cloth and food. We will have more food.

Any other notes?

I have one child and he go to study in the university. I would to have the scholarship for my child, because we do not have much money to support our children.

Case Study 2: Ban Mae Ler

Brief outline of background/personal history (Family, Livelihoods, Age, place of birth)

In my when I was young I have difficult life. We do not any car or bike in the village. We are only walk for travelling everywhere. I do not have shoes and when we collect the water. After that we have shoes make from the bark of the tree and when I put shoes on it heart my feet. After that I met my wife and after that got married I stay with my mother -in law house. I have one child that time we do not have enough rice. We have to eat banana and collect sweet potato in the forest.

The beneficiary's needs, problems, or issues.

My life before the project is hard and each year we have to build the dam nearly hold year, cutdown a lot of the tree and when the dam got flooding we have to go to the field for build the dam and cut down the tree again and again. For the plant of rice in the field when the dam get flooding our rice is drop for growing it make our rice get a bad quality and after that we get less rice . We hope we can get more rice for each year but we do not have enough rice for each year.

How did project impact the situation?

After we have the project from KHT. Our life in the village much getting better everything. We do not have to cut down the tree for build the dam like our life before. The concrete dam is very strong. The field is have a lot of water it make our rice have a good quality. In the past we got a rice for each year 1000kg, but after the KHT build the dam we get the rice 4000-5000kg. When the villagers coming to help we can share the rice to the villagers and we can sale it some for buy another food for our family. Our life is very happy.

Short term and long-term change?

We have more trees to grow up. If we do not have the concrete dam from KHT we have to cut down the trees many year and have to cut down a lot of tree. For us we have no choice. When we have the KHT dam and we can see very clear the tree is get back to the forest. We have more tree to get back.

Plans and hope for the future?

Have a great life when after the project. When the rainy season we can grow the rice in our field. We can grow many crops in the field. We can grow soya bean, garlic for more income in our family and spend it in our family.

Any other notes?

Thank you to the sponsor and the KHT team. The big project like this if you are not helping we cannot do it for our villagers without you. God bless you all and growing in the future.

Case Study 3: Ban Mae Phae

Brief outline of background/personal history (Family, Livelihoods, Age, place of birth)

When I was young and when I grow up I use to work in the field. All my sibling is finished for adult education. I got married when I 35 years old I got one child.

The beneficiary's needs, problems, or issues.

My life before the project it hard. My job is working in the field. For the dam we have to build it every year and have to cut down the trees and bamboo quite a lot for each year. And we got the dam flooding many times in a year and we have to repair to many times too. The area for cutdown more tree and bamboo we cutdown many for each year. We got less wood and bamboo, because we cut down it every year before the project. The quality for rice when we have less water from the field and then we can get less rice. Most we do not have enough rice for each year. For the dry season we cannot grow anything in the field.

How did project impact the situation?

My life after KHT installed the project our life is getting better. We do not have to cutdown the tree and we do not have to build the dam like in the past. We have a very good quality for the rice and we can get more rice . Our relative have enough rice too. We are very happy.

Short term and long-term change?

In the village now we do not have any problem with the forestry, because we are not cutdown the tree for build the dam anymore like in the past. Now we have more tree in the forest.

Plans and hope for the future?

We have the irrigation it make our life is getting better. In the future when we have the concrete dam it make it more easy to grow more crops soya bean, garlic in the dry season etc.

Any other notes?

Thank you very much to the sponsor and KHT team for helping installed the concrete dam to our village.

Case Study 4: Ban Mae Po

Brief outline of background/personal history (Family, Livelihoods, Age, place of birth)

Our life in the past it hard. We do not have enough rice. I just only do slash-and-burn. We did slash and burn it hard for us and a lot insect destroy our rice in the field. We have difficult life and we do not enough clothes and blanket in cold season we have to stay close to the fire in the night, because not enough clothes. For rice when do not have enough rice in the family each meal we have to boiled the rice with sweet potato and taro for feed all the people in the family.

The beneficiary's needs, problems, or issues.

My life before we have the project in the village I have a difficult life. I do not have enough rice. I have to grow more rice, pumpkin, sweet, potato, taro and more Karen vegetable. Sometimes I have to more food for my neighbour for the next day keep for my energy.

How did project impact the situation?

After it changing a lot, because I can grow more crops and can more thing for the rainy season we can grow rice and dry season we can grow garlic, vegetable, onion very good for us to have more crops to grow.

Short term and long-term change?

After KHT installed the project. It changing a lot, because I working with environmental protection and forestry I can see the villagers they cut down less tree. Now we have more tree to grow up. We have a good air. The villagers have more time to work, because they do not have to cut down the tree for build the dam anymore.

Plans and hope for the future?

For myself my life is getting much better, especially in the dry season I can plan to grow for another crops in my field. In my field I am ready for everything especially water. Now I have water for agriculture for the future too.

Any other notes?

I would like to thank you for all of the team for helping our village. May god to bless you all.

Case Study 5: Ban Mae Song

Brief outline of background/personal history (Family, Livelihoods, Age, place of birth)

When I was young. I have a difficult life. I do not have enough rice in our family. We are only do slash- and -burn. I did not go to school. I have to help for my parent for working in the field. In the rainy season is very hard for me for the travel, but now much getting better and especially for a food and rice.

The beneficiary's needs, problems, or issues.

My life is a difficult life. I work in field. My life is a difficult life. I work in field every year we have to repair the dam for twice a year. It make me too tired. Some year if no flooding it mean we are lucky. Some year we do not have enough rice. Our field normal in the past we can get rice each year we can get 3000 kg, but now we get it 1000kg for each year.

How did project impact the situation?

Now we are getting better, because our field we can grow the crop in dry season too. For the rice we can get it more like we expect the number we want to get it 3000kg.

Short term and long-term change?

Now I can see the weather is getting better, because they have more trees. The villagers they not cut down the tree they dam build by concrete. It make the tree get it back to the forest.

Plans and hope for the future?

I have a better life. I am planning to grow more crops in dry season, garlic, soya bean, vegetable. I planning to support my children to study in the future.

Any other notes?

I do not nothing to say, but I have one word to say Thank you very much. Wish you happiness.