



**CREATING AN
EDUCATIONAL
PROGRAM TO
PROMOTE
SUSTAINABLE
WATER USE IN
BAAN YANG**

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Creating an Educational Program to Promote Sustainable Water Use in Baan Yang

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Abstract

In the village of Baan Yang, a sudden shift away from opium cultivation left farmers practicing unsustainable techniques to grow food. Residents are aware of the ecological impacts, but tradition and socioeconomic barriers prevent them from transitioning to new, sustainable techniques. Our project focuses on creating an educational program for the Baan Yang School to introduce village students about their impact on the surrounding environment, along with educating them about water quality and conservation. The ultimate goal of our educational program is to promote sustainable farming techniques by instilling a passion for the environment in the younger generation.

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Authorship

The contribution to the project is summarized for each member as follows:

Sukulaya Bunuasunthorn: Wrote part of the report, mostly related to technical data and laboratory, qualitative testing. Helped edit report and final deliverable. Performed onsite and offsite testing. Translating educational program for Baan Yang and for the pilot test. Facilitated interviews and educational trial runs.

Carly Cidado: Contributed to the writing of every chapter of the report, specifically on topics related to the environmental effects of monocrop agriculture, technical data collection, educational program trial runs, interview questions, and final recommendations. Contributed to the editing of the whole report. Developed the learning activities included in the educational program.

Brooke Honzel: Contributed to the writing of every chapter of the report but focused on writing about topics related to effective educational techniques. Contributed to development of educational program, specifically the first and second themes for grades 1-3. Assumed the role of primary editor for the report.

Alongkorn Janjamratsaeng: Wrote part of the report, specifically about observations and findings. Helped edit report and final deliverable. Wrote content for the final deliverable for both age groups. Translated interview questions, educational program for Baan Yang and pilot tests. Facilitated interviews and trial runs.

Guy Katz: Contributed to the writing of every chapter of the report, specifically about our educational deliverable and conclusions, and thoroughly edited the whole report. Helped create interview questions and facilitate interviews. Developed the learning activities included in the educational program.

Sasivimon Noisri: Helped edit report and final deliverable. Translated interview questions, educational program for Baan Yang and pilot tests. Was in communication with outside stakeholders and sponsors. Official team photographer. Facilitated interviews and trial runs.

Rosa Reynoso: Contributed to the writing of every chapter of the report, specifically about technical and social data collection and analysis. Thoroughly edited the whole report and assumed position of primary editor for the final deliverables. Furthermore, helped with creating interview questions, and creating presentations.

Narueporn Wongwises: Helped edit report and final deliverable. Created graphics for presentations and report. Was in constant communication with our sponsor and outside stakeholders. Translated interview questions, educational program for Baan Yang and pilot tests. Facilitated interviews and trial runs.

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Executive Summary

Baan Yang is a small farming village in northern Thailand. Since King Bhumibol Adulyadej outlawed opium growth in northern Thailand and established a food processing factory, Baan Yang has evolved into producing fruit and vegetables for their own and others' consumption. This report examines the current state of water resources and agricultural practices of Baan Yang, Chiang Mai, and how these practices, often influenced by financial motives, have affected these resources. While the farmers and community leaders are aware of Baan Yang's water resources and their origins, there is a wide concern that the younger generation has little respect or knowledge for how they receive their water and how to properly utilize it now, and in the future.

Research Goals and Objectives

Continued exposure to environmentalism will inspire the children of Baan Yang to adopt more sustainable habits in their lives and thus improve the village's environmental prospects in the long term. Our research was directed at the following two objectives meant to ensure that we reach our goal of designing and implementing an educational program suitable for Baan Yang Elementary School that addresses some of the environmental problems present in Baan Yang.

***Objective 1:** Understand the extent and awareness of the environmental issues present in Baan Yang.*

***Objective 2:** Design and integrate an educational program for children of Baan Yang.*

To ensure our program aligns with the environmental situation in Baan Yang, we needed to understand the situation and the current public perceptions of it. In order for our educational program to help Baan Yang's environmental issues in the long term, the program needs to be effective and repeatable from year to year. Research into effective educational methods as well as the background of the Baan Yang School were vital to our design of a successful program.

Methods

In order to achieve our objectives, we utilized the following methods:

Technical testing and observation: To help us understand the problems facing Baan Yang, we performed both onsite and offsite water tests and observed the water sources and storage systems. The tests were simple initial indicators of the water's quality and included pH testing and water hardness measurements.

Social Data Collection: We utilized social data collected to achieve both research objectives. Interviews with farmers, village leaders, and shop owners provided us insight into the public perception of the environmental issues. Interviews with teachers and educational professionals gave us important understanding for the design of a successful, repeatable educational program.

Trial Runs: We performed two trial runs to test two iterations of our educational program. We took observations, surveyed both the students and teachers for their feedback, and incorporated the results into our final program.

Understanding Baan Yang Water Resources and Community Opinion

Our project focused heavily on community opinion in Baan Yang, as we wanted to ensure that we were taking the real problems of the community to heart. Through our observations and

interviews with community members we obtained the following findings about the community's water sources:

Finding #1: *The village's infrastructure and water storage systems allow for the excess water in the rainy season to be stored for use in the dry season so that the locals have enough water for household and agriculture use year-round.*

Finding #2: *Though the community safely utilizes their water sources for non-consumptive household and agricultural uses, they do not believe the water is safe to drink or even cook with, so the community faces the issue of a lack of healthy drinking water.*

Through our interviews with community members and our observations of Baan Yang's water storage systems, we came to understand that Baan Yang has sufficient water year-round for non-consumptive purposes but does not trust the water source for drinking and cooking. Due to the timeline of our project, we found that the best way to address the community's concerns would be to educate the village's youth about the importance of living sustainably within their community and to provide recommendations for future in-depth water testing.

Educational Program and Trial Runs

Through our discourse with the Baan Yang elementary school and other educational professionals, we obtained the following findings that helped us in the design of our educational program:

Finding #1: *Every expert who we interviewed agreed that hands-on or interactive educational methods were the most effective teaching methods and were, therefore, most appropriate for inclusion in our educational program.*

Finding #2: *Each interviewed teacher stressed how important they felt that teaching sustainability topics to the children is, yet the school lacks a concrete, yearly sustainability program or curriculum.*

Finding #3: *In order to implement a sustainable program in Baan Yang, we must design all activities with minimal low-cost resources.*

In order to create a good educational program, we began talking to educational experts including employees from WPI, the Bangkok Museum of Science, and Teach for Thailand. All of these experts came up with similar tips, specifically agreeing that hands-on or interactive educational methods were the most effective teaching methods and were, therefore, most appropriate for inclusion in our educational program. Through discussions with the teachers of Baan Yang, we identified two main guidelines for working with their school. First, all students, kindergarten through sixth grade, should participate in the program. Second, in order to implement a sustainable program in Baan Yang, we must design all activities with minimal resources, since the school does not have much money to purchase new materials.

Conclusions

Our final conclusions cover both long-term solutions, through the implementation of our educational program, and short-term solutions, through recommendations on how to eliminate outsourcing of drinking water.

Final Deliverable

The program we created includes three separate half-day programs, each with their own theme. The school can rotate these themes every year, so that the students can learn new things every year and never repeat the same activities. The first theme is water conservation, which aims to teach students about where their water resources come from and about the importance of conserving water for long-term benefits. The second theme is water quality and aims to teach students how to assess the quality of their water and how to possibly make the quality better in the future. The third theme is suitable waste management, which aims to teach the students about the importance of keeping the world's water clean and litter-free by promoting waste reduction.

The program schedule differs for grades one through three and four through six. For the older grades, the program includes two activities, which will run in parallel, followed by poster presentations. Students in grades four through six have more freedom in their experimentation than the younger group and can demonstrate their new knowledge in the form of poster presentations at the end of the day. For grades one through three, the program includes three shorter activities that teach the fundamentals of the program theme in a fun, hands-on way. These students demonstrate what they learned in the form of games like bingo or word searches.

Recommendations

Our project in Baan Yang worked towards a long-term solution to Baan Yang's environmental issues: enhancing students' understanding of where their water comes from, how they use it, and how they can improve it in the future. However, we found several avenues for future work that would help Baan Yang in the short term. The major concern of water quality requires more investigation and potential remedial action. Recommendations discussed in the body of the report include:

1. Outline appropriate water quality tests and testing parameters.
2. Compare the cost of water purification to the cost of outsourcing water.
3. Determine the feasibility of implementing water softening methods.
4. Expand the educational program to encompass sustainable farming.

Future technical projects can focus on testing local water sources to determine its acidity, salinity, and any traces of pesticide or metal contaminants that result in unsafe drinking water. Scheduled testing needs to take place over an extended period of time to ensure the water is safe to consume because local farmers spray pesticides at different times of year. Because the water sources in Baan Yang run through limestone mountains, they have a high hardness level. Further research to assess the economic feasibility of implementing water softening methods would be beneficial to the community. Since Baan Yang locals currently outsource their drinking and cooking water for their safety, determining the quality of the water could ease this financial burden from the community. Although removing the need to outsource water would mitigate the financial burden the community faces, future groups need to consider the effects of increased water usage in the community if outsourcing is eliminated.

We focused our educational program solely on water quality and conservation to meet the concerns of the community. However, we did not address the two unsustainable farming techniques the community relies upon heavily: swidden and monocrop agriculture. These farming techniques lead to further environmental degradation and the community is aware of this. Promoting alternative, sustainable agricultural methods to the current farmers would be difficult because of the economic incentives behind these agricultural techniques. For this reason, we

recommend that the Baan Yang teachers or other organizations further develop our educational program or integrate a curriculum to promote organic and self-sustaining farming techniques.

1: Introduction

The rise of the global population and its associated food and energy consumption rates continue to inflict unprecedented demands on agriculture and natural resources. Approximately one billion people are chronically malnourished due to extreme poverty and ever-rising food prices. To combat the world's food insecurity issue, farmers practice unsustainable agricultural techniques that degrade water, land, biodiversity, and the global climate, leaving an immense environmental footprint (Foley, J.A., 2011). Additionally, as demand for water grows globally, groundwater levels decrease, other water ecosystems become degraded and the cost of new water resource development rapidly increases. Although the achievements of irrigation have been impressive, poor irrigation management has markedly lowered groundwater tables, damaged soils, and reduced water quality in many regions (Rosegrant, 2002).

Misuse of land through monocrop agriculture has resulted in devastating environmental effects and a lower quality of life for farmers and locals in Northern Thailand. The goal of this project is to evaluate the current state of the water resources in Baan Yang, specifically the quality of water resources. Additionally, we will assess current initiatives taken by the community and government to address their depleting water supply and suggest suitable solutions such as water conservation initiatives and groundwater contamination evaluations.

The mission of our project sponsor, Paisarn Sukjarean, a local citizen in Baan Yang village, is to restore the area's forests and to augment the lives of the rural farming community. Spearheading a reforestation initiative in the region, Paisarn Sukjarean has begun the process of reforestation on his land holdings and has bought a significant amount of additional land in the Baan Yang village to further expand the reach of his initiative. Additionally, Khun Paisarn has identified a need to address the lack of understanding of the negative ecological impacts of monocrop agriculture and of the opportunities to restore and maintain water resources within this community. Our project will focus on teaching a new generation of Baan Yang students the importance of environmental sustainability.

In order to understand and address the environmental issues faced by our sponsor and the community in Baan Yang, we studied similar cases around the world and identified potential causes and solutions to the issues at hand. One group completed a waste management IQP that worked on educating local populations about the adverse environmental effects of certain agricultural techniques to alleviate issues (Steele, 2015). Upon their arrival in Thailand, the team quickly found that the local population did not see any environmental concerns for dumping fish blood into the water. Thus, the focus of their project changed to teach the younger generation about the environmental effects of contaminated local drinking water in hopes of a future cultural change. Our aim is to follow suit and instill a passion for living sustainably in the children of Baan Yang so that they may grow up to conserve the limited water resources in their community.

In this project, we assessed Baan Yang's agricultural methods and water usage in order to understand the issues facing the village. We also developed and designed an educational plan and interactive activities for children about sustainable water use in Baan Yang. We defined the appropriate method of information dissemination regarding these environmental initiatives. We collaborated with the teachers of Baan Yang School throughout the creation and implementation of our educational program to ensure that the program was appropriate for the school and that it would remain in the school's curriculum for years to come.

2: Background

The farming revolution, known as the Green Revolution, was a necessary response to the growing populations and economies of the world. The revolution focused on introducing new, tested technological advancements in farming to developing countries. These farming tactics focused on using seeds that were crossbred in the Western world in order to achieve higher food production. Not only did these plants bear more fruit, but their growth time was shorter, allowing for more growth cycles in a year (Foster, 1993). By using these specialized seeds, more food could be produced in the same amount of land area, allowing for self-sustaining food production and possible large-scale food markets in developing countries. Additionally, widespread pesticide and fertilizer use became popular due to the potential for mass production of these chemicals after the end of World War II (Pimentel, 1990). Soon, farmers practiced these harmful techniques across the world.

In response to the Green Revolution, the Thai King, Rama IX, founded the Doi Kham Royal Food Company, a food packager and producer that aims to work with local Thai communities to promote sustainable living both economically and environmentally, in order to introduce new farming methods to the poorer and more remote regions of Thailand. These new practices fostered an increase in food supply at a lower cost, making food more accessible for the residents in Baan Yang and Thailand in general. Although these new practices provided economic development within the region, they led to many environmental consequences. Deforestation for large-scale monocrop agriculture paired with the heavy use of pesticides may have played a large role in the degradation of Baan Yang's upstream water sources.

2.1: Effects of Monocrop Agriculture on Upstream Water

The globalization of industrial agriculture has led to an increase in the practice of monocrop farming methods. Industrial agriculture has served as a catalyst to increase the use of fossil fuels, biocides, fertilizer, high volumes of water, and farming machinery to maximize yield of large single variety crops at one time. Monocrop farming dominates the agriculture sector in Baan Yang. When farmers in Baan Yang and the surrounding area practice unsustainable techniques, such as spraying pesticides and utilizing fertilizers, the effects are felt throughout northern Thailand. Baan Yang is located high in the mountains, near the source of the Mae Ngon river. This river's watershed reaches throughout the region (Farmer communication, January 24, 2019). Therefore, when water degradation affects Baan Yang, the issues ripple down the mountains and into many more communities. The following sections describe unsustainable side-effects of monocropping that can have an effect on Baan Yang and the surrounding villages.

2.1.1: Monocropping in Baan Yang

The main crops grown in Baan Yang are lychee, orange, and corn. Farmers plant each crop annually, with lychee trees being the most popular crop in the area due to their low water requirements (Farmer in Baan Yang, communication, January 24, 2019). Lychee trees flower in February and March; at this time, most farmers spray pesticides to protect the flowers and increase their crop yields. Orange trees were at one time more popular than lychee trees; however, their concentration has declined because they require double the amounts of fertilizer, pesticides, and water to produce the same fruit yield as lychee trees. Farmers in the area have utilized commercial fertilizers and pesticides for the past fifty years; however, some farmers have slowly transitioned to more sustainable farming methods. One farmer transitioned to a fully self-sufficient organic

farming method after he passed out while spraying fertilizers in his field. He now uses entirely organic fertilizers and pesticides, has large crop diversity in his field, and teaches his fellow farmers about sustainable farming methods (Farmer in Baan Yang, communication, January 24, 2019).

2.1.2: Deforestation

Deforestation is a major ecological issue in developing countries that utilize conventional farming techniques like monocrop agriculture. Deforestation has a detrimental effect on surrounding water sources since forests play a significant role in the earth's water cycle. In large forest areas, like the Amazon rainforest, most precipitation is a result of local convection that stems from trees absorbing liquid groundwater and releasing it into the atmosphere as water vapor through transpiration (Malhi et al, 2008). In dense forests, this return of water vapor to the atmosphere is a key component to the water cycle. Model studies show that removal of 30-40% of a forest could alter the area's climate to be permanently drier (Malhi et al, 2008). Deforestation reduces the amount of rainfall in an area, increases sedimentation, and disturbs the regular water runoff. This worsens flooding during the rainy seasons and drought during dry seasons (Delang, 2002). Trees play another important role of providing the shade and coverage that keep soils moist and prevents soil erosion.

2.1.3: Soil erosion

Soil erosion occurs when rainfall or wind energy strips the soil of its nutrients and structure until it can no longer be cultivated. Soil erosion by wind and water reduces the soil's quality and productivity as it depletes the soil's nutrients, organic matter, soil depth, and capacity to hold water (Pimentel et al, 1995). It is a side effect of conventional farming techniques that results in decreased crop yields and an increase in the use of fertilizers and pesticides. Bare farmland is at high risk of soil erosion because there is no vegetation to provide protection from the weather elements. Similarly, hillside farmland, similar to that of Baan Yang, is at high risk of erosion because water runoff is greatly increased due to its slope. In fact, Baan Yang has recently faced landslides in its farms due to these farming styles (Farmer in Baan Yang, communication, January 24, 2019).

It is estimated that 10 million hectares of farmland are abandoned every year because the land is no longer productive due to soil erosion (Pimental, 2006). As the amount of arable, or farmable, land around the globe dwindles due to soil erosion, new land must be cleared to continue providing food for a growing population, thus leading to further deforestation. Furthermore, soil erosion leads to water pollution as water runoff carries the fertilizer- and pesticide-rich topsoil to local water sources.

2.1.4: Pesticide usage

The regular use of pesticides is commonplace in modern farming techniques with the primary focus of increasing productivity. Chemicals are sprayed directly onto crops to kill and disrupt pests, particularly weeds and insects (Aktar, 2009). Without weeds, crops have less competition for water and nutrients and are thus more productive. However, pesticide residue left on food can have adverse effects on consumers and the environment. For humans, being in contact with pesticides in large doses can lead to infertility and other health issues (Aktar, 2009). Baan Yang residents are already dealing with health deficits from their heavy use of pesticides, with some farmers reporting passing out or other harmful effects directly due to pesticides (Farmer in

Baan Yang, communication, January 24, 2019). Our sponsor has conducted blood tests that indicate that Baan Yang residents have higher than average amounts of organophosphates and carbamates in their blood; high levels of both compounds lead to inhibition of an important enzyme that stops neurotransmitter signalling. This means that sufferers can have permanently contracted muscles or neurons that never stop firing (Silberman & Taylor, 2018).

Since the 1960's, twelve pesticides have been banned worldwide due to their health hazards to humans and restrictions to future pesticides have been created. However, despite their harmful side effects, the world continues to use an immense amount of pesticides, using about 5.2 billion pounds of pesticides a year (Mahmood, 2016). The world agricultural community therefore agrees that the boost in productivity that results from using pesticides far outweighs the health risks that pesticides pose to the environment.

2.1.5: Water degradation

Water degradation is an ecological issue around the world and refers to both the depletion and contamination of water sources. Water depletion strongly correlates to the ever-increasing global population. A study of the human population's water footprint around the globe indicates that agriculture accounts for 92% of the world's water use (Hoekstra, 2012). When the expansion of industrial agriculture pairs with growing populations in developing countries, the demand for water increases exponentially and access to water becomes increasingly limited.

In addition to impacting the atmospheric water cycle, deforestation alters stream and river flows through its impact on groundwater. A study in Madagascar investigated the relationship between agricultural deforestation and the hydrological functioning of soils (Zwartendijk et al, 2017). The study showed that deforestation increases the soil's capacity to resist water infiltration and thus leads to over-saturation in the topsoil and increased water runoff. These increased rates of water runoff lead to higher rates of soil erosion as the water carries the topsoil and all its nutrients (and harmful chemicals) with it. Additionally, decreased soil infiltration and higher water runoff leads to decreased groundwater recharge; this causes a decrease in accessible water for both natural vegetation and human-centered activities. However, the study also showed that this effect can be reversed over time through reforestation or natural regrowth and that original infiltration rates can be achieved again (Zwartendijk et al, 2017).

As the demand for water increases and the availability of surface water, like streams and reservoirs, remains limited, farmers and governments have to turn to the extraction of groundwater. However, irrigating groundwater impedes its natural flow into the surface water basin. At high rates of irrigation, the surface water source actually begins to seep into the surrounding land and results in surface water depletion (Sophocleous, 2002). Groundwater and surface water are not two separate entities, they intermingle as a result of the hydraulic cycle. This means, however, that pollution to one source greatly affects the other as well (Sophocleous, 2002). Increased pesticide use on exhausted farmland combined with increased soil erosion and water runoff causes the pesticides to seep into the groundwater and thus contaminate local surface water basins.

2.2: Rehabilitation of Water Sources

In this study, we focused on identifying recommendations to improve the degradation of water sources in Baan Yang. Our sponsors have identified that agricultural activities in the area have polluted and degraded upstream water sources in this community. Researchers have identified methods to maintain and develop upstream water sources around the world which we will discuss in this section.

2.2.1: Reforestation

A case study from the Department of National Parks, Wildlife and Plant Conservation by Mr. Prapan Polpanpow (นายประพันธ์ พลพันธ์พั้ว), a senior professional officer in the Department of Forestry, discusses the idea of rehabilitation of upstream ecosystems. Polpanpow argues that to manage water degradation, rehabilitation efforts should focus on increasing the land's natural recovery potential. It would take an extended amount of time to repair the watershed, the area of land that catches rainfall and other precipitation, of a region that has been completely degraded by deforestation (Polpanpow, 2010). Although reforestation helps in reducing the degradation of soil and increasing soil quality, it is a time-consuming and labor-intensive solution.

Reforestation facilitates the restoration of upstream water by preventing water runoff. In well-forested areas, trees can slow down the flow of water by absorbing the water in the soil. The accumulated water seeps out from the soil and into streams and creeks in both the rainy and dry seasons, promoting a healthy water cycle in local streams and creeks throughout the year. There are many guidelines to follow to ensure sustainable reforestation within a region. Determining the appropriate types of plants or trees is vital to preserve local soil and water resources as they can prevent soil erosion in the upstream areas. Reforestation efforts have been implemented by our sponsor over the past years to rehabilitate the local upstream sources. These efforts led by community members have provided additional shade and coverage in the region, keeping soils moist and temperatures consistent for all life in the forests (Suwanchatri, 2009).

2.2.2: Mitigation of water depletion

Methods to increase irrigation efficiency are imperative in order to help mitigate both global and local water scarcity problems. Irrigation systems rely on groundwater sources to provide water for crop growth, thus leading to intensified groundwater depletion. One broadscale method to reduce the groundwater depletion rates is to increase the supply of surface water. Implementing more, higher-quality water storage sources can achieve this (Scanlon et al., 2012). Storage systems, in turn, help resolve the geographical disconnect between water supply and water demand. In fact, Baan Yang has recently implemented such above ground water storage units, which they claim has provided sufficient water for the village in the dry season and reduces flooding in the rainy season (Farmer in Baan Yang, communication, January 24, 2019).

There are other options geared toward reducing unnecessary water loss in everyday life. In the agriculture sector, farmers could reduce accidental loss of water by converting from flood to sprinkle- and drip-watering or subsurface watering tactics (Levidow et al., 2014). These tactics specifically focus the water towards the roots, eliminate evaporation, and reduce the amount of water used on the household level. Practicing daily conservation habits, such as reducing personal hygiene and dishwasher water usage is also effective. Some habits include reducing water use for personal hygiene, fixing any leaky taps or pipes, and reducing washing machine and dishwasher use.

2.2.3: Soil erosion alleviation

Soil erosion due to farming is inevitable, especially in areas that use swidden agriculture like Baan Yang, but can be minimized with proper care. A study of swidden agriculture in Madagascar illustrates the benefit of long fallow periods on the restoration of soil fertility. In the case of monocrop agriculture, it is notable that longer periods of rest paired with the natural growth of vegetation will go a long way to conserve the soil between cropping seasons. There are further basic conservation steps that can be taken to reduce soil erosion like applying mulch, laying mats

or tarps down on the soil, applying terrace or contour farming on sloped land, and planting wind-breaking vegetation around the areas. These methods could impose a financial burden on impoverished farmers that would result in their hesitation to incorporate them into their farming but would return long-lasting environmental benefits.

2.3: Water Testing Methods

Chiang Mai University projects have collected data about the quantity of water at Baan Yang multiple times over the years. However, the quality of the water sources has never been assessed. In order to fully map out the level of degradation in Baan Yang and come to defensible conclusions, we will need to assess the water quality.

2.3.1: Bioindicators and observation

The ecosystem surrounding any water system is dependent on both the quality and quantity of the water. Therefore, the state of the ecosystem and any changes it undergoes is a good indication of the quality of a water resource; these indicators are known as bioindicators. Identifying bioindicators as a measure of water quality is a time-conserving and cost-effective method of water quality testing and requires only the observation of the biodiversity surrounding a water source. The introduction of chemicals or other dangerous materials to a water source can adversely affect the ecosystem's food web. Usually, the presence of healthy fish in water is a strong indication of good water quality; however, due to the nature of food webs, their presence cannot fully indicate clean water. Instead, species richness and diversity are ideal indicators of clean water.

Bioindicators can also be used to determine poor water quality, as certain species thrive in lower quality water than that which sustains most life. Algae blooms thrive in acidic water, multiplying quickly and blocking resources from other parts of the ecosystem; algae blooms indicate low pH. Prior to using bioindicators as a determination of water quality, the baseline biodiversity of the region in question should be known in order to properly analyze the results (Queensland Government, 2018).

2.3.2: Technical testing

The primary cause of poor water quality is chemical contamination due to agriculture, mining, or waste. When chemicals are present in high concentrations, bioindicators will provide evidence of the poor water quality. However, the designation of water quality as "poor" is not enough; the causes of the poor quality should be elucidated through testing. There are two possible ways to test for water quality: lab testing and field testing. Lab testing is more time-consuming and requires the collection of water samples for analysis; field testing allows for the use of portable kits. These test kits contain paper strips that change color depending on the concentration of their target chemical in the water; the strips are meant to be dipped into a sample, dried, and compared to a color chart to determine the approximate concentration of the chemical (Lawson, 2017). While these field tests are less accurate than lab tests, performing multiple tests in the same water sample will help determine an accurate range of results. One such field test is the pH test, which is the simplest test of water quality. The EPA recommends a pH range of 6.5 and 8.5 for drinking water (Wellcare, n.d.). If a water sample is more acidic or alkaline than this, there is a strong possibility that the water is contaminated. Any water pH outside of a normal range can affect human health, agricultural techniques, and more. As such, it is a good initial indicator of poor water quality and is the first in a series of field tests that can effectively show possible water contamination.

2.4: Effective Educational Methods

Sustainability is a growing topic of conversation throughout schools across the world as parents and teachers aim to create a generation of students who will be stewards of the environment. On a global scale, The looming threat of several environmental disasters, like climate change, rising oceans, depletion of natural resources, and more, has accelerated this trend (Stone, 2009). Many schools utilize a wholly integrated approach to teaching sustainability, endeavoring to teach students sustainable methods both inside and outside of the classroom. These schools can teach sustainability through four main avenues: food, the campus, community, and teaching and learning (Stone, 2009). In the case of Baan Yang, we focused on teaching and learning about sustainability through hands-on methods.

Hands-on activities are popular among teachers, especially those who teach in science, technology, engineering, and mathematics (STEM) disciplines. These activities usually allow students to work in groups or otherwise interact with their peers to “manipulate various objects, ask questions that focus observations, collect data, and attempt to explain natural phenomena,” (Satterthwait, 2010). These steps are a simplified version of the scientific method and lead to achievement in areas such as language development and creativity, not just science proficiency. There are three factors that especially contribute to effective learning through hands-on activities: peer interaction through cooperative learning, object-mediated learning, and embodiment (Satterthwait, 2010). These three factors alone significantly contribute to students’ learning; however, the use of these three factors in combination leads to stronger neural connections and deeper understanding of the topic at hand.

The first factor in effective hands-on learning activities, peer interaction through cooperative learning, has roots in social constructivism theory: students learn through cooperation with their peers. Under this theory, students who are able to share their knowledge, observations, and beliefs with each other learn more, as group discussions enhance the formation of new meaning and promote shifts away from previously-held ideas. In the context of hands-on learning, group discussions are best conducted in conjunction with object-mediated learning. This tactic adds to students’ learning outcomes by leading them to question the effects of the learning tools in different contexts. This allows students to also incorporate elements of play into their learning, as they often alternate from learning about the traditional uses of an object to playing with the object, often testing the object’s design or construction. The hands-on learning style also leads to deeper understanding and memory of the activity, as students remember actions that elicit a positive emotional response better than those actions that do not (Satterthwait, 2010). Finally, students learn best from embodied experiences, which are those which require a person to be present through interacting with others and using equipment. Activities that allow the use of both allow for deeper neural networks as they engage both the cerebral cortex (associated with thinking processes) and the cerebellum (responsible for motor control). Satterthwaite summarizes the concept of embodiment well: “How humans move is how humans learn is how humans experience,” (2010). Effective hands-on learning activities utilize all three of these factors to maximize the opportunity for student learning.

3: Methodology

Through this project, our group aimed to promote a cultural shift towards sustainable agriculture and water usage through the education of schoolchildren in Baan Yang. Our hope was to create long-lasting change in the sustainability habits of Baan Yang by ensuring that the children practice good habits as they grow up and become the leaders of the village. In addition, we planned to provide several options for future research in order to create a short-term solution to the water degradation issues faced by the village. The previous section outlines several of the village's current unsustainable habits as well as methods to mitigate the environmental issues caused by these habits. To reach our goal of creating an effective educational program for Baan Yang School, the team worked to achieve the following two objectives:

***Objective 1:** Understand the extent and awareness of the environmental issues present in Baan Yang.*

***Objective 2:** Design and integrate an educational program for children of Baan Yang.*

Our team collected technical and social data about the current state of water resource degradation in Baan Yang; this data provided the foundation for our recommendations. We collected data through visual analysis of water sources and through interviews with farmers, teachers, and community members and leaders. We used our findings to synthesize two final deliverables: an educational program for Baan Yang School and recommendations for future water quality measures.

3.1: Understand the Extent and Awareness of Environmental Issues Present in Baan Yang

In order to make suitable recommendations to the community, we must first understand the state of the land and water sources in their region. Our background chapter provided information about the various types and causes of land and water degradation around the world; the following section provides information as to how we focused our efforts on researching the specific environmental issues facing Baan Yang.

3.1.1: Onsite technical data collection

Baan Yang has suffered the consequences of water degradation for years. The team determined the type, extent, and causes of this environmental issue through observation and water testing. These methods allowed us to collect a range of both qualitative and quantitative data regarding the quality of Baan Yang's water supply.

Site walks and water source observations allowed us to obtain information regarding the state of the land in Baan Yang, the common agricultural techniques practiced in the region, and the extent of water degradation in the area. We took a tour of the region to assess the village's agricultural practices such as crop type, pesticide use, and irrigation techniques. We assessed several categories of the water sources according to a water source observation chart (listed in Appendix A). We also performed simple pH tests using universal indicators to gain a preliminary understanding of the water's pH.

3.1.2: Offsite technical data collection

In order to obtain an exact measure of Baan Yang's water quality, we collected water samples from several of the village's water sources and performed two tests at Chulalongkorn University. These tests, while basic, allowed us to corroborate some of the information given to us

in interviews and give us a basis for our technical recommendation. We performed pH testing using a pH meter to determine exact values for each sample. In addition, we determined that water hardness affects the day-to-day lives of Baan Yang citizens. We performed complexometric titration to elucidate the exact hardness levels of the water samples in parts per million (ppm) of calcium.

3.1.3: Social data collection

In addition to collecting technical data regarding water supply and water quality, the team collected data regarding the village's social structures, educational systems, and perceptions on sustainability and water conservation through interviews. Interviewees included community leaders, farmers, and community members. Through these interviews, we determined the economic, social, environmental, and technical aspects of our project. This information allowed us to obtain an in-depth understanding of the community's perceptions of their agricultural practices, the quality of their water sources, and their thoughts on potential solutions to the water quality issues. Appendices B through E contain the structured and semi-structured interviews used for the social data collection aspect of our project.

We utilized the technical data collected onsite in conjunction with the community's perceptions of potential solutions to formulate recommendations for the community that will help to mitigate the environmental issues they are facing. These recommendations provide various avenues for future work in the community that will address the water quality issues of the region in the short and long-term.

Our data collection methods have ensured that our recommendations will reflect the attitudes of Baan Yang residents regarding the future of their water supply. We based our educational program and our technical recommendations for future work on the information gained from our interviews with Baan Yang residents. The addition of our educational program into the schools' yearly curriculum will ensure that the youth of Baan Yang are invested in the preservation of their water resources for years to come. The implementation of our recommendations will also lay the foundation for future research into solutions for the community.

3.2: Design and Integrate an Educational Program for Children of Baan Yang

The primary goal of this project was to design and test-run an engaging, educational activity geared toward elementary level students in order to instill a passion for their local environment, resources, and farming. To determine an activity best suited for the community in Baan Yang, we performed research on effective educational techniques, conducted interviews with successful elementary educators, and observed successful hands-on educational activities. The specifics of our research are detailed in the sections below.

3.2.1: Interviews

In order to create a viable educational program, we interviewed child education professionals both in Thailand and abroad. We interviewed STEM education professionals at Worcester Polytechnic Institute, the Bangkok Museum of Science, and the not-for-profit organization Teach for Thailand. All the interviews were semi-structured and focused on how to create interactive educational programs for children that will keep the children active and engaged, along with ensuring that a clear educational point is understood. Furthermore, our conversations also centered around how to properly assess our educational program. Appendix F contains our interview questions.

During our first site visit, we conducted semi-structured interviews with local teachers in Baan Yang to gather data regarding the implementation of our educational program. They provided insight into the age and socioeconomic composition of the student body, the current educational measures in place regarding sustainability, and the potential barriers to implementing a successful program in Baan Yang. The conversation also centered around the teachers' expectations for us and for the educational program. Appendix G contains the interview questions for the Baan Yang teachers.

3.2.2: Trial runs

Following the creation of our educational program, our group tested the program by running sample activities at the Wansawangchit School, located in Bangkok, with a sample of 52 students. Conducting trial runs allowed us to both prepare to conduct the program onsite and allow us to gather feedback about our program. We chose Wansawangchit School due to the student body's similar makeup and size to the Baan Yang elementary school. The trial run began with an introduction of our team and the goal of our project to the entire group of students. Afterwards, we played a "yes or no" game with students to gauge their knowledge about the topics of water conservation and sustainable habits. We then broke the students into two groups of 26 and rotated them between two activities related to water conservation and water management. After the activities, we had the children make posters about what they learned and present them to us and their fellow classmates to serve as the debrief section of the program. In small groups, students gave short presentations about a topic they had learned about throughout the course of the program. These presentations were used in conjunction with teacher feedback to determine the amount of knowledge gained by the students and, therefore, the efficacy of the program. In addition, we asked the teachers to fill out a survey rating the program in the categories listed in section 2.3. As a team, we adjusted the educational program according to the results of this trial run.

Our second trial run, completed in the Baan Yang School, was a bit more extensive, with a bit over 120 students ranging from kindergarten to 6th grade. Due to the wide range in ages we decided to split the group into two. Fourth through sixth graders completed a program similar to our first trial run, while kindergarten through third graders completed another program, which was more focused towards a younger audience.

The program for the older students was similar to that of our initial trial run, with a few tweaks. First, the program was built to be three hours long, rather than two. With the extra time, we added initial ice breakers to the beginning of the program to help introduce us to the students. Also, we added a "sanuk break" in between the two programs, allowing for students to take a break from learning and have some fun. Another edit to our program was including more thoroughly detailed instructions for each program, specifically running through an entire experiment with the group and allowing students to ask questions before they ran the experiment themselves. Better explanation, along with a detailed worksheet for the more technical part of our program, ensured that students remained engaged throughout the program and were able to represent what they learned well.

For the younger students, we designed a program to teach them about the fundamental science topics they need to know before they progress to sustainability topics. We designed the program to be fun and hands-on in order to capture the attention of the students. The program structure for grades kindergarten through third was similar to that of the older grades, with a little more time dedicated to fun games.

4: Findings and Analysis

Our background research prepared us to address a variety of environmental issues in the community that have resulted from unsustainable agricultural practices. The following section details the environmental problems that are specific to Baan Yang. These environmental issues provide a rationale for our educational program about sustainability. Additionally, this section outlines the team's progress in creating an effective educational program that will ultimately introduce themes of sustainable living to the children of Baan Yang.

4.1: Understand the Extent of the Environmental Issues Present in Baan Yang

Baan Yang is a small farming village in the Chiang Mai province of Northern Thailand with a total population of 1200 people living in 250 households. We set out on our first site visit to determine the availability and quality of the main water sources used to meet the population's farming and household needs in order to understand what issues, if any, the community faces with respect to water sources. This section details the following findings:

Finding #1: *The village's infrastructure and water storage systems allow for the excess water in the rainy season to be stored for use in the dry season so that the locals have enough water for household and agriculture use year-round.*

Finding #2: *Though the community safely utilizes their water sources for non-consumptive household and agricultural uses, they do not believe the water is safe to drink or even cook with so the community faces the issue of a lack of healthy drinking water.*

4.1.1: Technical observation

The Mae Ngon River, shown in Figure 1, runs through the Fang district, providing a source of flowing surface water to the community. In addition, multiple mountain springs are present in the area; the community of Baan Yang currently utilizes two spring sources from the mountainside. A gravity fed distribution system distributes water from these springs to individual households, providing community members tap water year-round. Water from both springs is piped to the village's first large storage tank. The water flows through two smaller tanks located near the village's Chinese Buddhist temple before being distributed among Baan Yang's households.



Figure 1: Mae Ngon River

We found that the river has clear running water that is surrounded by vegetation and has plenty of shade coverage. There is a high level of biodiversity in and around the river. We observed several species of insects, amphibians, and algae. The river flows past several homes, so floating debris is common.



Figure 2: Spring Source 1

The first groundwater spring is directly adjacent to the Mae Ngon River and is shown in Figure 2. Community members have built a catchment around the spring to store the water and direct it to the village's storage tanks. The catchment provides consistent shade coverage to the spring but does not prevent the introduction of life; we observed several small amphibians, fish, and insects present in the clear water. Banana and lychee crops surround the catchment.



Figure 3: Spring Source 2

The second spring, seen in Figure 3, is located in a well-forested valley surrounded by farms; taro trees surround the spring and provide constant shade coverage. The taro trees are indicators of the quality and amount of the water: the healthy growth of taro trees only occurs in the presence of an abundance of water. The farms surrounding the valley grow mainly lychee trees. We observed the water to be clear with a strong current.



Figure 4: Storage Tank 1

Baan Yang's water storage infrastructure includes three storage tanks (Figures 4-6) and a piping system that distributes water to every household in the village. Water from both springs is piped directly to the first storage tank, located on a hill directly outside the village. This tank has an estimated volume of 250,000 liters; the tank is typically full and no filters are currently utilized here.



Figure 5: Storage Tank 2



Figure 6: Storage Tank 3

The second storage tank has an 80,000-liter capacity and is located inside a small building; the roof provides adequate coverage to prevent evaporation. Water flows here from the first storage tank; from this tank, water travels to the third storage tank. The third storage tank is located downhill from the second tank in the complex of the town's Buddhist temple. This final tank is an

outdoor tank constructed similarly to the first storage tank and has a capacity of 10,000 liters ((Farmer in Baan Yang, communication, January 24, 2019). The addition of this third storage tank served to reduce flooding in the rainy season and provide additional water in the dry season so that the community has sufficient water year-round.

4.1.2: Water quality results

During our tour of Baan Yang, we took multiple samples of the surrounding water basin, including the two springs that provide the tap water of the village. Our tour guides expressed much concern over the quality of the spring water and asked us to test the water. We collected five samples: river water, water from springs one and two, water from the third water tank, and tap water. Initial pH measurements indicated that most samples collected were slightly basic. Upon further, more accurate testing, we corroborated our initial results; the average pH values for each sample can be found in Table 1.

Our Baan Yang guides also voiced concern about the hardness of the Baan Yang water. For years, residents drank the water without utilizing purification methods; when they introduced boiling as a method of water purification, they noticed the presence of precipitates in their water. The presence of these calcium and magnesium precipitates indicates water hardness; this is likely due to the fact that the tap water originates in the limestone mountains. Drinking hard water over a short period of time has some health benefits; however, consistent consumption over years can increase the risk of kidney stones and gallstones.

We used the complexometric titration method to find total hardness and permanent hardness of the water. Table 1 contains the hardness results. The water samples that we tested all fall in the standard that is regulated by the law in terms of pH and hardness. However, without testing for lead, cyanide, or mercury, we cannot conclude that the water is safe for consumption. Even though the water falls under the normal range for hardness, Baan Yang residents do not consume the water due to the presence of precipitates after boiling.

Table 1: pH and Water Hardness Results

	River	Spring #1	Spring #2	Resting Tank	Tap Water	Drinking Water Standards
pH	8.15	7.93	7.48	7.83	7.54	6.5 - 9.2
Total Hardness (ppm)	165.48	264.36	245.52	265.031	265.031	≤ 300
Permanent Hardness (ppm)	51.66	55.83	51.80	57.18	59.19	≤ 200

Due to the concern of prominent community members, we came to understand that Baan Yang residents do not trust its water source for drinking and cooking. The time frame and scope of our project limits us from performing the necessary tests to confirm that the community's current water sources are safe to drink. The tests would need to take place the span of at least a year, aligning with the surrounding farmers' use of pesticides. For this reason, we decided that the best way to help the community is to provide recommendations for water and soil testing in the

region and to focus our attention on educating younger generations about the importance of sustainable agriculture and sustainable lifestyle habits, which we hope to achieve through the design and implementation of an educational program for children of Baan Yang.

4.2: Educational Program for Baan Yang

We designed our program to suit Baan Yang elementary school, which is the local public school that teaches kindergarten through sixth grade with a total student population around 120 students. The school has classrooms for each grade, a computer room, a communal garden, and a courtyard with a soccer field and playground. The following section details the following findings:

Finding #1: *Every expert who we interviewed agreed that hands-on or interactive educational methods were the most effective teaching methods and were, therefore, most appropriate for inclusion in our educational program.*

Finding #2: *Each interviewed teacher stressed how important they felt that teaching sustainability topics to the children is, yet the school lacks a concrete, yearly sustainability program or curriculum.*

Finding #3: *In order to implement a sustainable program in Baan Yang, all activities must be completed with minimal low-cost resources.*

4.2.1: Educational program

The goal of our program is to educate children about sustainable water use and respect of their surrounding environment so that they choose to live or farm sustainably in the future. We tailored the program to address the issues we found facing Baan Yang and to suit the needs of Baan Yang's elementary school. Our determination of the environmental issues in Baan Yang led us to design our program with three major educational topics:

1. *Water Conservation*
2. *Water Contamination*
3. *Suitable Waste Management*

Our first theme explores how Baan Yang gathers and uses their water and encompasses most of the requests made by the community into one theme. Students will discuss and learn how Baan Yang collects its water, which will also encompass learning about the water cycle, as requested by the teachers of the Baan Yang School. Students receive an introduction to the concept of water input and output, allowing them to incorporate data gathering techniques and allowing students gain problem solving skills. Students will participate in a discussion and activities about water conservation and how much water different activities, such as bathing, cooking and drinking, may require. Given a problem statement relating to a community's lack of water, students receive the opportunity to creatively come up with solutions and discuss how they can reduce individual water consumption in their day to day lives.

The second theme explores the contamination of water resources. The students will discuss how water can become polluted and the effects of pollution within water sources. Demonstrations of groundwater will show the children how pollution can spread throughout spring sources. These demonstrations will show the long-lasting nature of pollution. Independent research and discussion will allow students to learn about different methods to protect the environment from pollution. This topic is especially important, since many local farmers use pesticides, a chemical contaminant in water, while farming. The conversation will hopefully pay long-term dividends, with students

understanding that their actions directly affect their surrounding water sources. The following sections describe the process of creating our educational program.

The third theme relates solid waste pollution and littering to the world's water resources. The students learn about the repercussions of littering and of using too much plastic waste in the sense that our excess waste ends up in the world's water sources, endangering marine life. In this program, the students explore both creative and simple ways to reduce, reuse, and recycle waste, such as creating games out of every day waste items rather than throwing them out. Furthermore, students will create compost, a beneficial alternative to local swidden practices, and discuss the harmful effects of burning both organic and non-organic waste. The discussions about how to reuse everyday objects into beneficial tools will hopefully find its way into the community and reduce the overall waste production of Baan Yang.

4.2.2: Characteristics of an effective educational program

In order to build on our background knowledge of effective educational programs, we interviewed three individuals: a STEM education professional from WPI, an academic studies officer at Bangkok's Museum of Science, and an educator from Teach for Thailand. The three interviews yielded a wealth of information regarding the structure and content of our educational program as well as methods of quality assessment for our program. One interviewee stressed the importance of hands-on activities, especially for younger children: if children do not have some control over the activity at hand, they will become disinterested and put their energy into causing distractions for other students. This corresponds with our findings from our background research, which also indicated that incorporating hands-on activities into our educational program was crucial.

Two of the interviewed experts suggested that we utilize a common method for activity structure: Background, Activity, Debrief. This structure allows for a brief introduction to the topic at hand, which will be especially useful in the context of introducing the children of Baan Yang to topics in sustainability. The background portion should also allow the students to make a connection to their lives: by making a connection early on, the students are more likely to find the course material relevant for the rest of the program. The activity should take up a majority of the time, as this will be the time where the students are most engaged and learning the most about the topic. Finally, the debrief is a period of time that will allow students to clear up any confusion about the program and to ask any questions that they may have. We have adapted this model to our educational program.

Finally, all of our interviewees suggested that our educational program would benefit from an assessment method. The assessment should assess not only the students' knowledge of the topic at hand before and after the program, it should also gauge the program's ability to engage and excite students. One interviewee mentioned doing both aspects of the assessment together by asking both the teachers and students about their thoughts on the effectiveness of the project as well as asking the students questions to gauge their increase in knowledge. We believe that the students' input is invaluable and will be asking them for their opinions regarding the ability of the program to engage and excite them.

4.2.3: Baan Yang School's ideal educational program

To determine the best program for students at Baan Yang School, we visited the school and discussed our ideas with the principal and three grade school teachers. Through our discussion we determined that the best program for their school is a three-hour-long, annual sustainability

half-day. This half-day program would allow students from each grade to participate in various sustainability-related activities throughout the duration of the program. Including all age groups is incredibly important: due to the school's small population, excluding a particular age group would prompt feelings of jealousy or being left out. The teachers also mentioned that the educational program should have a variety of activities that could be rotated from year to year to prevent students from becoming bored with the material over time.

The Baan Yang School lacks a concrete, yearly sustainability program or curriculum. The school has, however, implemented some STEM activities for the children, including a STEM day where the children learn about various STEM topics such as the creation of stars or the science behind airplanes through hands-on activities. They also incorporate a weekly gardening session where the children in grades 4-6 can plant seeds or take care of plants in the communal garden. Occasionally, outside organizations will visit the school and perform activities with the children. Unfortunately, these activities often require materials that the school does not have access to, which prevents the teachers from being able to duplicate the programs. Additionally, these organizations do not visit frequently. The teachers were excited to work with us so that their school can have a solid, yearly program to teach their students about important sustainability topics.

In order to implement a repeatable, yearly program at this school, we needed to include activities with minimal required resources. Currently, the school utilizes videos and marker-and-paper drawing activities for all of their "hands-on" activities about science. There is no existing budget to pay for materials for our sustainability program, so we incorporated inexpensive materials that the students' parents can provide or create a program utilizing recyclable materials such as plastic bottles.

4.3: Trial Run Results

From our observations and the feedback from the teachers and students, we found many areas for improvement of our program. To ensure a smooth, organized and well-prepared program, the presenters need to make certain all the topics of the day are set forth in a schedule. This allows students to know exactly what to expect and ensures that the teachers can stick to the schedule. Furthermore, each activity and its importance should be clearly explained to the students prior to its completion, even to the extent of running through an example with the class before letting students do their own experiments. This ensures that students can apply that knowledge to the task at hand and gain a deeper understanding of the activity. Second, we determined that we need to adjust our activities to have the same duration, especially if two activities are running in parallel. In the event that the activities cannot have the same duration, shorter activities should have additional games to keep the students engaged if the main activity fails to pique their interest. On the same note, we need to provide ways to increase or decrease the difficulty of the activity based on the group's abilities so that they remain constantly challenged but capable of succeeding. Younger students, specifically kindergarteners and first graders, may need much more basic activities that include more running, singing, and other energy-consuming activities. On the other hand, the older students enjoyed the freedom to think critically and to represent their own findings. The observations and feedback from our trial runs were incorporated into the final deliverable before we delivered it to Baan Yang.

5: Conclusion

Through our interactions with the citizens of Baan Yang, they clearly have an interest in living and farming sustainably. The main issue in the village is their water supply: while the quantity is consistent year after year and throughout the year, the quality is lacking. While we initially set out to determine the effect of Baan Yang's agricultural practices on their water supply, we quickly realized that this was a large undertaking and was impractical given our project timeline and funding. Through our background research and onsite interviews, we determined that the best way to help Baan Yang become a sustainable farming community is to create an educational program for the community's youth that will instill a passion for sustainable living in the children. In this section, we will discuss the sustainability and effectiveness of our educational program and outline our recommendations for future work in Baan Yang.

5.1: Sustainability and Feasibility of the Educational Program

Our primary goal for the educational program is its sustainability over time. We hope that the program will have a place in Baan Yang long after our departure. The following section outlines the steps that we have taken to ensure its future success in Baan Yang School.

5.1.1: Duplicability

Because we have given the educational program to Baan Yang School in the form of both physical and digital booklets, it is possible for the teachers to implement our program every year. The lesson plans are comprehensive and provides a high level of detail while also allowing teachers to have a wide degree of freedom in executing the lessons. Therefore, teachers can disseminate the information to the students, parents, and school faculty in several ways. We designed the lessons to be easy for a teacher to follow and execute even with little to no prior knowledge of the program. Due to the school's limited access to funding, we created the program to require very few materials; teachers can easily obtain all required materials in Baan Yang.

5.1.2: Possible limitations and lessons learned

As outsiders in Thailand, it is important to understand how our presence during trial runs could have altered the program's success and future. Having foreigners in the classroom was notably exciting for the students, therefore, it is important to note that students may have lesser enthusiasm or interest in the activities when repeated in future years by their teachers. Although the impact of this factor on the program's future success is unclear, a possible way to mitigate this issue is to have outside volunteers from local organizations assist teachers with the program every year. Perhaps Doi Kham, which has shown interest in and given funding to the Baan Yang primary school, could fill the outside organization role.

5.2: Recommendations for Future Work

We designed our educational program to help the community in the long-term by promoting sustainable behavior in children so that they will grow up with a passion for sustainability. Throughout our research, we determined that there are several avenues to help the community in the short-term. This section details a list of our recommendations for future work to be done in Baan Yang to further help the community address their water quality issues.

5.2.1: Outline and conduct appropriate water quality tests

We recommend that a future project outline and complete the appropriate water quality tests and testing schedule required to ensure the results are representative of the quality of the water year-round. This project would require determining the water tests needed to evaluate its suitability for use, including drinking. Testing should include testing for the specific pesticide and fertilizer used in Baan Yang. Next, the project would need to test the water over the course of a full year in order to accurately test during times of heavier or lesser pesticide use in the fields. The team would also need to determine the best locations for the testing, likely at all extraction points that we collected samples, to ensure that the data is significant.

5.2.2: Determine the economic feasibility of implementing water softening and purification methods

We recommend that a future project assess the potential options for the community to soften and purify their water. As their water sources run through limestone mountains, they have a high hardness level that has led to possible health complications in people that consume the water over a long span of time. Even if water quality results show that the water is safe to drink with respect to chemical contamination, the community would likely still not drink the water due to the calcium-carbonate precipitate that occurs when boiling the water. The future project would need to assess the economic feasibility of implementing both large- and small-scale water softening and purification methods in the community.

5.2.3: Determine the economic feasibility of eliminating drinking water outsourcing

This future work, done after the water testing, would determine possible solutions to any quality issues that are found and determine whether it is economically worthwhile for the community to cease outsourcing their drinking water and to perform the water quality and purification solutions that will ensure their water sources are safe to consume. In addition to this cost analysis, the project would also need to consider what would happen to the water quantity in the community if they stop outsourcing their drinking water; they currently do not face water shortage issues, but this could change if the community begins to extract a significantly higher volume of water for drinking and cooking.

5.2.4: Expand educational program

We focused our educational program on water quality and conservation because these were the primary concerns of the villagers and our sponsors. On our site visits and through our background research, however, we found that the village's reliance on swidden and monocrop agriculture could begin to lead to further environmental degradation, if it has not done so already. The community is aware of the repercussions of such agriculture but will not alter their methods either due to budgetary reasons or lack of knowledge of alternative systems. We recommend that the Baan Yang teachers or other organizations either expand our program or instill a curriculum to teach students about alternative, sustainable agricultural methods.

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Appendices

Appendix A: Technical Questionnaire

Water Source Observation

Modified from Assessment-Pre-Trip Plan Engineers without Borders WPI (Orton, 2017).

Source	Date and Name of Observer	Water Level	Color	Turbidity	Shade Level	Moisture of Soil	Livestock nearby	Agriculture uphill	Notes (odor, slime, etc.)
		Empty	Abnormal If so, describe:	Very Turbid	Total Shade	Muddy	Yes, actively drinking from source	Yes	
		Low		Somewhat Turbid	Partial Shade	Damp	Yes, potentially drinking from source	No	
		Average	Normal	Clear	Full Sun	Dry or Dusty	No	Farm owner, if known:	

Appendix B: Interview with Community Members

Interview with Community Members

Modified from Assessment-Pre-Trip Plan Engineers without Borders WPI (Orton, 2017).

Goal: Begin to establish a relationship with community members. The team wants to begin a conversation with community members in order to learn more about the community and the general opinion towards topics including water, public health, environmental health, agricultural techniques, access to technology and education.

Deliverable: Two people will take notes in notebooks. One person (native speaker) will lead the interview, while the two people take notes. The interviewer will also have an additional notebook to keep track of thoughts during the interview noting any particular body language that is important to note. At the end of each day notes from the notebook along with any additional analysis or thoughts will be recorded on a Google doc to ensure that notes are not misplaced. Brief summaries of each interview will also be written.

Logistics to Consider during Interview: Make a connection with community member during the interview like mentioning something about their home. Remember to introduce individuals within the team in a respectful and culturally appropriate manner. These questions are just guides. Ensure interviews are conducted when community members are available. Some questions may seem repetitive because it's important to ask questions multiple times in different ways to ensure you are getting clear and consistent information. Remind community members participation is optional and they are not required to answer any questions they do not feel comfortable answering. Remember to thank the community member for taking the time to participate in this interview.

Introduction:

Hello and thank you for taking the time to meet with us. We are a group of students from Chulalongkorn University, located in Bangkok, and Worcester Polytechnic Institute, located in the United States of America. We are here to Understand the extent and awareness of the environmental issues present in Baan Yang, Determine suitable recommendations through collaboration with the community and ultimately design and integrate an educational program for children of Baan Yang. We hope to work you to ensure the success of this project.

GPS Coordinates of House _____
 House Number _____
 Residents _____

Theme: Demographics

Family Makeup

How many people living here fall in the following age category?

0-10 _____

11-20 _____

21-40 _____

40+ _____

How long have you lived in the community? Have you lived somewhere else?

Name	Skill/Occupation	Experience Level (Years)	Education background

Water

1. What is your main source of water and how do you get it?
2. Do you have enough water for your daily needs in the rainy season? How about the dry season?
3. What do you do for water during the dry season? Is water stored in the rainy season for use in the dry season?
4. Are there certain times of day/year or circumstances under which you get more or less water?
5. What is the current distribution/rainwater harvesting/water collection system? Do you think it is efficient? Or can it be improved?
6. What's that current management like, who manages the water and monitors its quality?
7. Is water access equitable? I.e. Do some people get more water than others?
8. What do you use water for around your household? Do you use any water for crop growing purposes?
9. How would you rank the following in order of what you use the most water for? 1 (used the most) - 5 (used the least)

___ drinking

___ bathing

- ___ cooking
- ___ washing clothes
- ___ food preparation
- ___ agriculture
- ___ household chores

1. Do you believe the water you use is polluted? With chemicals, trash, etc?
2. Is the water dirty looking/brown?
3. Does the water have a funny taste?
4. Do you reuse water?
5. Do you boil your water before drinking it? How do you ensure its safe to drink?
6. What do you do daily to conserve water? Or are you not concerned about the quantity of water you have access to?
7. Does your drinking water and agricultural use water come from the same place?

Theme: Land Use/Agriculture

1. Do you know anything about reforestation?
2. Do you grow any crops, if so what and where?
3. What agricultural techniques do you use for farming?
4. Are you familiar with the technique of monocropping? If so, do you know of its effects on the land? Long term and short term?
5. How do you water your plants?
6. Do you sell your crops/auto consumption? (grow crop for yourself?)
7. Do you use pesticides?

**Theme: Access to Technology
Communication**

Do you have internet access?

YES NO

Do you have a cell phone? A smart phone?

What is the primary platform you use to communicate with friends and family?

Observations made by us

Is there a water tap inside?

Is there a toilet inside? A latrine outside?

What is the floor made of? What is the house made of? Walls and roof?

Do they have electricity/appliances such as TV refrigerator, radio, computer, iron etc.
Do they have their own rainwater harvesting? If so, what is it made of?
Socioeconomic level?

Appendix C: Interview with Farmers

Interview with Farmers

Modified from Assessment-Pre-Trip Plan Engineers without Borders WPI (Orton, 2017).

Goal: Begin to establish a relationship with community members. The team wants to begin a conversation with community members in order to learn more about the community and the general opinion towards topics including water, public health, environmental health, agricultural techniques, access to technology and education.

Deliverable: Two people will take notes in notebooks. One person (native speaker) will lead the interview, while the two people take notes. The interviewer will also have an additional notebook to keep track of thoughts during the interview noting any particular body language that is important to note. At the end of each day notes from the notebook along with any additional analysis or thoughts will be recorded on a Google doc to ensure that notes are not misplaced. Brief summaries of each interview will also be written.

Logistics to Consider during Interview: Make a connection with community member during the interview like mentioning something about their home. Remember to introduce individuals within the team in a respectful and culturally appropriate manner. These questions are just guides. Ensure interviews are conducted when community members are available. Some questions may seem repetitive because it's important to ask questions multiple times in different ways to ensure you are getting clear and consistent information. Remind community members participation is optional and they are not required to answer any questions they do not feel comfortable answering. Remember to thank the community member for taking the time to participate in this interview.

Introduction:

Hello and thank you for taking the time to meet with us. We are a group of students from Chulalongkorn University, located in Bangkok, and Worcester Polytechnic Institute, located in the United States of America. We are here to Understand the extent and awareness of the environmental issues present in Baan Yang, determine suitable recommendations through collaboration with the community and ultimately design and integrate an educational program for children of Baan Yang. We hope to work you to ensure the success of this project.

GPS Coordinates of House _____
 House Number _____
 Residents _____

Theme: Demographics

Family Makeup

How many people living here fall in the following age category?

0-10 _____

11-20 _____

21-40 _____

40+ _____

How long have you lived in the community? Have you lived somewhere else?

Name	Skill/Occupation	Experience Level (Years)	Education background

1. What type of crops do you grow?
 - a. Do you grow one crop or multiple?
 - b. What is the cropping schedule like? i.e. years of cultivation, crop rotation, any resting periods?
 - c. What portion of your crop yields are for selling versus auto-consumption?
2. Is there enough water in the dry season for your farming needs? Household needs? How about the rainy season?
 - a. How much water do you need on a daily basis to grow these crops?
 - b. What technique do you use to water your crops? (flood, sprinkle drip, etc.)
 - c. How do you get your water and from what source?
3. Are there times of the day/ year where you don't have enough water or struggle to get enough water for your crops or household use?
4. Do you believe the water you're using is clean? Or polluted?
 - a. Does the water have a strange taste?
 - b. What color is your water throughout the year? (rainy season vs dry season)
5. Do you use pesticides and fertilizers?
 - a. If so, what time of year do you apply them?
 - b. What is the brand/ kind of pesticide and fertilizer you use and why?
 - c. Do you use the same amount of fertilizer every year or does the necessary amount increase or decrease with time?

6. Do you have to follow any regulations pertaining to water use or pesticide/fertilizer use?
 - a. Why do you think those regulations are in place?
 - b. Are there any repercussions to not following these rules? Who enforces them?
7. Do you believe your farming practices are sustainable (can be practiced for years without harming the environment)?
 - a. Do you actively try to farm sustainably?
8. If you found out your farming practices were harmful to the land and local water sources, would you consider changing your farming style in order to benefit the land for future generations?
 - a. Why or why not?

Appendix D: Community Member Interview Regarding Water Usage

Door to Door Interviews

Goal: Gather data on the water usage of members of the village. Data on the number of jugs each community member buys for drinking and cooking and the amount of tap water they use is especially important. This data will be used to assess that if the water is clean to drink, will the current spring water sources be enough for the village.

Deliverable: Two people will take notes in notebooks. One person (native speaker) will lead the interview, while the two people take notes. The interviewer will also have an additional notebook to keep track of thoughts during the interview noting any particular body language that is important to note. At the end of each day notes from the notebook along with any additional analysis or thoughts will be recorded on a Google doc to ensure that notes are not misplaced. Brief summaries of each interview will also be written.

Logistics to Consider during Interview: Some people may not want to answer and that is ok.

Questions:

1. How many people live in your household?
2. How many jugs of water (20L) do you use in a week?
 - a. What do you use the bottled water for? (i.e. cooking, drinking, washing clothes, etc.)
3. What do you use tap water for? (i.e. cooking, drinking, washing clothes, etc.)
4. Do you have any concerns about the tap water?

Appendix E: Interview with Community President

Interview with Community President

Goal: The team wants to begin a conversation with community leaders in order to learn more about the community and the history of the region. Additionally, the team would like to define and clarify expectations of our project.

Deliverable: Two people will take notes in a single notebook. One person (native speaker) will lead the interview, while the two people take notes. The interviewer will also have an additional notebook to keep track of thoughts during the interview noting any particular body language that is important to note. At the end of each day notes from the notebook along with any additional analysis or thoughts will be recorded on a Google doc to ensure that notes are not misplaced. Brief summaries of each interview will also be written.

Logistics to Consider during Interview: Remember to introduce individuals within the team in a respectful and culturally appropriate manner. These questions are just guides, and the goal is to promote a conversation, not all questions have to be asked. Thank all participants for taking the time to participate in this interview.

Introduction:

Hello and thank you for taking the time to meet with us. We are a group of students from Chulalongkorn University, located in Bangkok, and Worcester Polytechnic Institute, located in the United States of America. We are here to Understand the extent and awareness of the environmental issues present in Baan Yang, Determine suitable recommendations through collaboration with the community and ultimately. Design and integrate an educational program for children of Baan Yang. We hope to work you to ensure the success of this project.

Date:

Team Members Present:

Local Municipality or Community Leadership Representatives:

1. Can you give us permission to collect social data and technical data for our research here in Baan Yang?
2. What is the best time to interview farmers?
3. Is there anyone that can show us around for the next couple of days?
4. What are other ways that you have worked with communities like this in order to resolve this issue of water degradation and if so, what was your role in that?
5. What other organizations are in the area working on similar projects?
6. Do you have information about other projects which have occurred in the immediate area?
 - a. Do you have access to technical data or technical studies done in the area?
 - b. Do you have access to previous water quality or soil quality data?
 - c. Do you have topographical maps of the immediate area?
 - d. Has a hydrogeological study been done in the past?
 - i. If so, can we have access to this technical data?
7. What are common things Doi Kham does in the community?
 - a. Are there any educational programs that you have supported?
 - i. If so, how where these carried out?
 - ii. How did you promote or advertise this program?
 - b. Are there any initiatives you have supported?

- i. If so, how where these carried out?
 - ii. How did you promote or advertise this program?
8. What do you expect be accomplished at the conclusion of the trip, along with the expected next steps for the project?

Appendix F: Interview with Educational Professionals

Interview with Educational Professionals

Goal: The team wants to begin a conversation with a STEM center director of to understand how to disseminate and teach our educational program in the most efficient, sustainable and effective way.

Deliverable: Two people will take notes in a notebook or laptop. One person (native speaker) will lead the interview, while the two people take notes. The interviewer will also have an additional notebook to keep track of thoughts during the interview noting any particular body language that is important to note. At the end of each day notes from the notebook along with any additional analysis or thoughts will be recorded on a Google doc to ensure that notes are not misplaced. Brief summaries of each interview will also be written.

Logistics to Consider during Interview: Remember to introduce individuals within the team in a respectful and culturally appropriate manner. These questions are just guides, and the goal is to promote a conversation, not all questions have to be asked. Thank all participants for taking the time to participate in this interview.

Introduction:

Hello and thank you for taking the time to meet with us. We are a group of students from Chulalongkorn University, located in Bangkok, and Worcester Polytechnic Institute, located in the United States of America. We are here to understand the extent and awareness of the environmental issues present in Baan Yang, Determine suitable recommendations through collaboration with the community and ultimately design and integrate an educational program for children of Baan Yang. We hope to work you to ensure the success of this project.

Date:

Team Members Present:

Individual(s) Name:

1. What kind of activities are most enjoyable by 5th grade children?
 - a. What role do interactive activities usually play in a 5th grade curriculum?
2. Do you have any kinds of activity that related to conservation of environment?
3. What is an optimal length for 1 activity?
 - a. What is a good meeting structure? (ie. background, activity, debrief)
4. The activities for large group/small group?
 - a. if small group, how many students per group?
 - b. how many adults per group to take care of children?
5. What are key aspects of simple experiments (related to water/environment) for children around 10-11?
 - a. Types, how to perform?
 - b. Any risk that could happen?
6. Are there examples of surveys used to test programs?
 - a. Types of questions to ask children? (yes/no, short answer, etc.) (use pictures, use words, etc.)
 - b. Types of questions to ask teachers?
 - c. How many question should we include in the surveys?
 - d. How do you use feedback to measure the success of the program?

- e. We were thinking of having the students fill out a survey before and after to see if they learned from the program, does this make sense to do?
- 7. If children are not concentrated on activities, what will be the techniques that can make the children be more concentrated?
- 8. How would you go about creating a basic curriculum/set of lesson plans?
 - a. In total, how many days does a curriculum last?
 - b. How can you explain to teachers the importance and get them on board?
 - c. How many hours per day should it include?
 - d. What method is used to deliver knowledge?
- 9. How do you get teachers on board to teach a curriculum?
 - a. What are teachers looking for when they search for good programs?
 - b. How do you interact with teachers during trial runs of the programs most effectively?

Appendix G: Interview with Local Teacher

Interview with Local Teacher

Goal: The team wants to begin a conversation with local teachers in order to learn more about the community's educational curriculum and identify suitable environmental activities for students in Baan Yang. We will identify local schools and teachers in the areas that would be able to incorporate this program in their curriculum.

Deliverable: Two people will take notes in a single notebook. One person (native speaker) will lead the interview, while the two people take notes. The interviewer will also have an additional notebook to keep track of thoughts during the interview noting any particular body language that is important to note. At the end of each day notes from the notebook along with any additional analysis or thoughts will be recorded on a Google doc to ensure that notes are not misplaced. Brief summaries of each interview will also be written.

Logistics to Consider during Interview: Remember to introduce individuals within the team in a respectful and culturally appropriate manner. These questions are just guides, and the goal is to promote a conversation, not all questions have to be asked. Thank all participants for taking the time to participate in this interview.

Introduction:

Hello and thank you for taking the time to meet with us. We are a group of students from Chulalongkorn University, located in Bangkok, and Worcester Polytechnic Institute, located in the United States of America. We are here to Understand the extent and awareness of the environmental issues present in Baan Yang, Determine suitable recommendations through collaboration with the community and ultimately. Design and integrate an educational program for children of Baan Yang. We hope to work you to ensure the success of this project.

Date:

Team Members Present:

Teacher(s) Name:

1. We want to create an educational program for kids about environmental sustainability, what grade would be the best audience for the program at your school?
 - a. What topics regarding sustainability are already taught to this age group?
 - i. Which are the ones relating to environmental or agricultural sustainability?
 - ii. When are these taught?
 - iii. Are students typically interested in these topics?
 - b. Do you think that sustainability is an important topic to cover in your school?
2. What is the structure of your lesson plans? Do you incorporate hands-on activities or is it more lecture based?
 - a. If you incorporate hands-on activities, what resources or craft materials are available to you?
 - b. What resources would be available to us?

- c. What are some examples of the most effective learning activities you've done throughout your career? What made them successful?
 - d. How do the students respond to group discussion? How can we ensure that they are engaged?
3. What is a typical day like in your classroom?
4. Do you have any advice or preferences on the type of program we should design for your students? (i.e. Stem day, activities for current curriculum, a new lesson plan, etc.)