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Increasing Self-Sufficiency in Agriculture with Hydroponics

Improving the productivity of a Hydroponics Demonstration Center

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Abstract

In Thailand, the absence of economic self-sufficiency among small-scale farmers has led to a reduced standard of living. Increasing self-sufficiency through the implementation of sustainable farming practices can help alleviate this issue. The Hydroponics Demonstration Center (HDC) in Prachinburi, Thailand intends to help farmers achieve self-sufficiency by setting an example for the efficient and productive use of hydroponics. Our goal is to aid our sponsor, the Chaipattana Foundation, in their mission to increase the productivity of the HDC by providing recommendations pertaining to its operations. This report will include relevant background information and methods utilized to develop solutions to present our sponsor.

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1 Introduction

Of the developing world's three billion rural people, over two-thirds reside on small farms of less than two hectares; there are nearly 500 million small farms. These people include half of the world's undernourished people and the majority of people living in absolute poverty (Nagayets, 2005). As the number of rural households that use farming as a platform for their livelihood strategies continues to grow, it is essential to ensure the self-sufficiency and sustainability of small scale farmers (Hazell, 2010). Self-sufficiency is the ability to provide for one's self without outside aid (Self-Sufficient, n.d.). This means the ability of a small scale farmer to provide for the needs of themselves and their household based solely off produce and income generated from their farm. Additionally, sustainability is the concept of development and practices that meets the needs of the present without compromising the ability of future generations to meet their own needs (Lele, 1991). Currently the problems of water scarcity, soil depletion, and overuse of pesticides place the future of agriculture in jeopardy (Hazell, 2010). It is imperative to find a sustainable solution for small scale agriculture in order to support the self-sufficiency and future of small scale farmers.

Thailand relies heavily on the success of agriculture. As of 2011, 38.2 percent of labor force of over 39 million people in Thailand was employed by the agricultural sector (Thailand Economy, 2014). The agriculture sector in Thailand is split into two sections: small scale and large scale farmers (Charuk, 2014.). Small scale farmers have not been able to reach the same market success as large scale commercial farmers (Van Der Meer, 2006). The economic contribution of small scale farmers is significantly less than that of large scale farmers despite a greater number of small scale farmers (Jitsanguan, 2001). An increase in productivity could help small scale farmers increase their contribution to the national economy (Harzell, 2010). This need for improved productivity of small scale farmers has not gone unnoticed by the Thai King or the government. The government has implemented development initiatives in Thailand to promote sustainable and self-sufficient agricultural practices including a focus on a Sufficiency Economy and sustainable development plans (Amekawa, 2010; Piboolsravut, 2004). If these farmers are able to achieve self-sufficiency, the individual and the country as a whole could benefit.

There are multiple initiatives in place to increase the self-sufficiency of small scale farmers in Thailand. Small scale farmers face challenges in the areas of self-sufficiency and sustainability. Small scale farmers face competition with large scale farmers, have a limited market reach, and face challenges with achieving optimum production (Hazell, 2010; Amekawa, 2010). Additionally, small scale farmers can increase their self-sufficiency by taking into consideration sustainable approaches to pesticide use, and water and soil conservation to increase yield (Giovannucci, 2006).

The Hydroponic Demonstration Center (HDC) founded by the Chaipattana Foundation is a social entrepreneurship organization focusing on working towards the goal of self-sufficiency for small scale farmers. The HDC promotes the use of hydroponic agriculture as a means to increase sustainability and self-sufficiency for small scale farmers. Hydroponics is an agricultural technique that uses nutrients dissolved in water to replace the use of soil in traditional farming practices (Dreschel, 2014). Hydroponics as an alternative method of agriculture can be beneficial to local small

scale farmers due to low pesticide usage, potential increase in productivity, and decreased water consumption (Resh, 2012). The HDC has implemented a demonstration farm using hydroponics to grow various vegetables to serve as a learning center as well as generating income for the center. However, the HDC is facing challenges in becoming self-sufficient. The HDC is working on improving both the technical and business aspects of the organization. If these issues are improved it will allow the center to become more self-sufficient and generate more economic value. This economic value can in turn aid to increase the social value generated by the HDC in assisting local small scale farmers.

The goal of this project is to aid the Chaipattana Foundation in their mission to increase the self-sufficiency of the HDC by providing recommendations pertaining to its operations. Our team will accomplish this goal by addressing the following three objectives:

1. Collect information about current operations at the HDC
2. Identify areas of improvement
3. Develop recommendations

Our team believes that if we can increase the productivity of the HDC that it will eventually reach a state of self-sufficiency. Once self-sufficiency has been attained the HDC will become a paragon for local farmers to emulate their practices after. (Tie into social entrepreneurship) It is our hope that through imitating the hydroponic techniques of the HDC that local small scale farmers can also obtain self-sufficiency and ultimately improve their standard of living.

2 Background

This chapter provides relevant information to the project including the significance of agriculture in Thailand, developmental approaches to self-sufficiency, and an overview of hydroponics as an alternative farming method.

2.1 Significance of Agriculture in Thailand

The agricultural sector of Thailand is the backbone of the country's economy because it provides employment and income to most of the Thai population (Singhapreecha, 2014). In 2013, 46% of the 39 million Thai in the labor force worked in agriculture and the sector contributed 12% to the country's GDP (FAO, 2014). Thailand primarily exports its agricultural products to Asian countries, indicating the sector's importance in the region. (FAO, 2014). Agriculture stimulated the industrial based economy of Thailand to develop in the 1970s (Singhapreecha, 2014.) In reaction, industries generated more demand and income for the agricultural sector. As a result, the national poverty rate was reduced from 57% in 1962 to 10% in 2002 (Kasem & Thapa, 2011). Thailand's present development is credited to the agricultural sector.

2.1.1 Small Scale Farmers in Thailand

Agriculture in Thailand is primarily composed of small-scale farmers, who rely on agriculture as a basis for their livelihood (Singhapreecha, 2014). A small scale farmer differentiates from large scale farmers because they produce to self-support their families. To small scale farmers, agriculture is more than business, it is their profession, culture, tradition, and values (Jitsanguan, 2001). In Thailand, the average small scale farmer holds a 2-4 hectare plot of land per household. Thai small scale farmers are the poorest group due to the limited resources and opportunities to progress. They are under pressure to commercialize their produce with the competition of large scale farmers (Singhapreecha, 2014). Small scale farmers search for appropriate farming systems to be in harmony with the environment and the rural way of life (Jitsanguan, 2001). Because they are self-supporting, small scale farmers need to be self-sufficient in their farming practices to sustain their basic needs. Government assistance and policies promote self-sufficient and sustainable farming systems to better their quality of life (Jitsanguan, 2001).

2.2 Challenges Faced by Small Scale Farmers in Becoming More Self-Sufficient

In Thailand, the small scale farmers currently endure a number of different challenges that hinder their ability to achieve self-sufficiency. In order to further explore the challenges faced, it is important to define the terms self-sufficiency and sustainability.

- Self-Sufficiency: able to maintain oneself or itself without outside aid: capable of providing for one's own needs (Self-Sufficient, n.d.).
- Sustainability: to create and maintain the conditions under which humans and nature can exist in productive harmony, that permit fulfilling the social, economic and other requirements of present and future generations (Sustainability, n.d.).

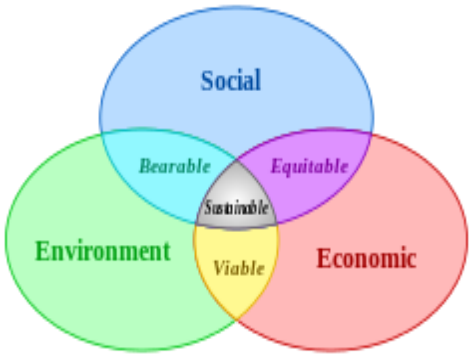

Figure 2-1: Components of Sustainability

Source: http://www.sustainablecampus.cornell.edu/sust

This project aims to promote the self-sufficiency of small scale farmers through sustainable practices. With the above definitions, this means aiding farmers in producing necessary produce to provide for their household as well as generating any income necessary for day-to-day life. This production will be enabled by sustainable practices that conserve natural resources as well as protecting the needs of future generations. The obstacles faced by small scale farmers in achieving this goal are outlined in this section.

2.2.1 Self-Sufficiency Challenges

Some of the challenges faced by small scale farmers to achieve self-sufficiency include competition with large scale farmers, limited market reach, and issues in productivity. Small scale farmers may be disadvantaged when it comes to new agriculture technologies, especially when compared to large scale farmers. New technologies require access to information, machinery, or higher capital input, and many high value crops require considerable up-front cash investment in seeds, fertilizers, and pesticides. Small scale farmers face challenges in obtaining this capital since they cannot obtain credit and input on the same terms of larger operators (Hazell, 2010). Additionally, in the last decade, a decline of small scale farmers was caused by the minimum access of resources, trade related rights, and sanitation standards (Amekawa, 2010).

The market reach of large scale farmers is significantly larger than that of small scale farmers. Small scale farmers also have a lack of knowledge about modern markets, modern technology and proper use of modern inputs (Van Der Meer, 2006). These inadequacies significantly hinder the ability of small scale farmers' opportunity in high-end, supermarket supply chains. In order for small-scale farmers to participate in these supply chains, they require traders and processors to be the "middle man." This middle man is required due to the nature of the small scale farmers' business and their individual production (Van Der Meer, 2006). Traders and processors would have to draw upon a number of farmers in hopes of meeting the demand of a high end market. The willingness of the middle man to work with the small scale farmer in this regard is low because of the risk involved. Supermarkets may also need to trace consignments back to source and to affirm the conditions under which they have been produced, in terms of pesticide applications, organic cultivation, use of child labor, or animal welfare. Meeting the requirements for these

"credence" characteristics, which cannot be proved by examining the produce, can be particularly onerous for smallholders (Hazell, 2010).

Productivity is an additional consideration to increase the self-sufficiency of small scale farmers. If farmers can produce an increased amount of food they increase their market sales as well as provide additional produce to their families. The best yields that can be obtained locally depend on the capacity of farmers to access and use, among other things, seeds, water, nutrients, pest management, soils, biodiversity, and knowledge (Godfray, 2010). It has been estimated that in those parts of Southeast Asia where irrigation is available, average maximum climate-adjusted rice yields are 8.5 metric tons per hectare, yet the average actually achieved yields are 60% of this figure (Cassman, 1999). Low yields occur because of technical constraints that prevent local food producers from increasing productivity or for economic reasons arising from market conditions.

2.2.2 Sustainability Challenges

If small scale farmers are able to increase the sustainability of their practices they would reduce risk by encouraging localized input production, fostering soil and water conservation and encouraging the diversification of production. (Giovannucci, 2006). These benefits directly relate to increased productivity and economic savings for small scale farmers.

One of the obstacles for small scale farmers in Thailand is the overuse of pesticides. The risks of using illegal pesticides and antibiotics by small scale farmers are high due to the extensive markets for cheap illegal pesticides and illegal antibiotics (Van Der Meer, 2006). This increased use of illegal agriculture inputs results in both sustainability and self-sufficiency issues. This misuse of pesticides is due in part to the lack of government regulation on small scale, non-commercial farmers. The illegal use of pesticides by small scale farmers continues to be a limiting factor in allowing these small scale farmers to be a viable contributing factor to high end markets. Additionally, it is a rising concern that pesticides as a whole are not being used safely, in terms of the farmers themselves, their consumers, and the environment (Panuwet, 2011). A case study from Phitsanulok, Thailand confirms the issue of unsafe pesticide practices. Out of the 130 small scale farmers that volunteered to participate in this study, 123 used pesticides in their process of producing crops. When asked about chemicals they used, respondents reported various harmful yet legal chemicals as well as illegal chemicals. No participants in this study claimed to have precisely followed directions while applying the pesticides to their crops. Also, no farmers fully utilized protective equipment during application (Plianbangchang, 2009).

The use of water is essential for crop production. Having a secure water supply is therefore imperative for the success of farmers. Agriculture currently accounts for around 70% of annual use of global water resources (WRI 2005). The production of food can drive over-abstraction and pollution of groundwater and freshwater ecosystems in many water-scarce parts of the world. Decisions on the use of water for irrigated agriculture are therefore increasingly moral and ethical choices, as well as economic ones (Baulcombe, 2009). As Kofi Annan, previous UN Secretary General, declared, 'we need a Blue Revolution in agriculture that focuses on increasing productivity per unit of water—more crop per drop' (UN 2000). The sustainable use of water is therefore critical to the self-sufficiency of the small scale farmer.

The use of soil in agriculture also significantly impacts the productivity and self-sufficiency of small scale farmers. Soil is a non-renewable resource that is fundamental to sustainable crop production. Soil is subject to loss by erosion through the action of wind and water. This has serious consequences for crop productivity (Baulcombe, 2009). Soil can also be damaged by industrial pollutants and physical compaction, and a substantial area of high quality agricultural soil is destroyed. Soil degradation is of paramount importance and all present production and future predictions of crop yield depend upon the maintenance and improvement of soil quality. If a farmer can maximize their soil quality and use they will help optimize their yield.

2.3 Development Initiatives to Improve Self-Sufficiency of Small Scale Farmers

As noted in the previous section, small scale farmers in Thailand have faced challenges in achieving self-sufficiency. This section explores initiatives and programs enacted in Thailand to increase the self-sufficiency and sustainability of small scale farmers including the self-sufficiency economy, governmental and Royal initiatives for small scale agriculture, and impact of the Chaipattana Foundation.

2.3.1 Sufficiency Economy

The Sufficiency Economy is the framework for many developmental initiatives in Thailand. Self-sufficiency is a "middle-of-the-road" economic strategy designed by the King in order to keep the Thai economy growing while protecting it from the rise and fall nature of increased dependency on global markets (Piboolsravut, 2004). This theory is the high-level goal in which all further policies and initiatives stem from. The Royal King states that "The important thing is for us to have a sufficient economy. A sufficient economy means to have enough to support ourselves…we have to take a careful step backward…each village or district must have relative self-sufficiency" (Philosophy, 2014). The Sufficiency Economy encapsulates the King's mission for a people-centric development plan for Thailand of increasing people's participation, self-sufficiency, alleviating poverty, and protecting the environment (Amekawa, 2010). The King developed this theory to pave the way for a recovery leading to a more resilient, balanced, and sustainable development, better able to meet the challenges arising from globalization and other changes. This method of development stresses the distribution of income to build the overall economic foundation and stability of the country before going on to a higher level of development (Philosophy, 2014).

The Thai government has implemented several government policies developed from the Sufficiency Economy to target small scale farmers to increase the self-sufficiency of the individual and the community. This has been done by using sustainable methods as a mean to achieve self-sufficiency. Sustainable agriculture is defined as agricultural practices that are ecologically sound, socially beneficial, and economically viable. These three components work together in order to meet the needs of the present without compromising the ability of future generations to meet their own needs (Feenstra, 2014). Thailand began to prioritize sustainable agricultural development in the Seventh National Economic and Social Development Plan published in 1992 (Kasem, 2012). This development plan stresses the importance of maintaining a sustainable level of economic growth as well as the sustainable management of environmental and natural resources. In line with the

philosophy of the sufficiency economy, the plan advocates a shift from traditional mono-culture to crop diversification for its social benefits of enhanced food security, increased employment opportunities, and reduced vulnerability to market price fluctuation (Kasem, 2011). Additionally, it has been shown that crop diversification can improve resilience by engendering a greater ability to suppress pest outbreaks and dampen pathogen transmission as well as by buffering crop production from the effects of greater climate variability and extreme events (Lin, 2011).

2.3.2 Sustainability Initiatives

One focus of the sustainable agriculture development policies is the promotion of safe and healthy foods. This comes as a sharp contrast to the previous promotion of using inorganic pesticides and fertilizers. The Hazardous Substances Act of 1992 regulates the application of pesticides (Kasem, 2012). In addition to increased regulation of pesticides, the Thai Government has implemented several initiatives to promote organic produce. The Ninth Economic and Social Development Plan implemented in 2002 promoted the shift from the use of toxic inputs with organic and safe inputs. Additionally, in 2004 the Thai Cabinet passed a "Road Map of Food Safety" as a framework for the control of food and agricultural products throughout the food chain. The Thai Cabinet also declared 2004 as "Thailand's Food Safety Year" (Roitner-Schobesberger, 2008). One of the outcomes of these pro-organic initiatives is the labeling of pesticide-free produce to increase consumer awareness. Although there are many policies directed towards the self-sufficiency and sustainability of small scale farmers, there is still work needed to be done. For example, out of the 5.6 million registered small scale farmers, only 4% currently practice sustainable agriculture (Amekawa, 2010). There are multiple centers across Thailand working on promoting sustainable agriculture as a route to self-sufficiency (Sathirathai, 2004).

2.3.3 Social Entrepreneurship and the Hydroponics Development Center

The current government initiatives are not sufficient in addressing the current challenges faced by small scale farmers in Thailand. There is a need to connect small scale farmers to the knowledge and resources necessary to adopt increased sustainable agricultural methods in order to increase farmer self-sufficiency. One such framework to address this need is the idea of social entrepreneurship. The term "social entrepreneurship" is used to refer to the rapidly growing number of organizations that have created models for efficiently catering to basic human needs that existing markets and institutions have failed to satisfy (Seelos, 2005). The Chaipattana Foundation is a social entrepreneurship organization focusing on working towards the goal of self-sufficiency for small scale farmers. This foundation is a non-governmental organization created by the Royal Thai King in 1988 envisioned to "provide prompt, timely and necessary responses to problems affecting the Thai people through various development projects" (Chaipattana, 2014). Holding true to the theory of self-sufficiency, the foundation focuses on improving the social welfare of small scale farmers and their capacity to become self-reliant (Chaipattana, 2014). Other areas of focus include environmental quality improvement, social development, and cultural conservation. The Chaipattana Foundation has centers and projects in provinces throughout Thailand. One of the centers started by the Chaipattana Foundation is the Hydroponic Demonstration Center (HDC) located in the Muang district of the Prachinburi province (Figures 2-3 and 2-4). The Chaipattana

Foundation built the HDC because Princess Maha Chakri Sirindhorn asked the foundation to develop a Hydroponics project with the objective of extending technical transference to enable income diversification (Pamornsood, n.d.). This center aims to aid farmers in being self-sufficient by exploring the sustainable aspects of using hydroponics as an agricultural technique.

These goals fit the social entrepreneurship archetype of organizations acting as agents of societal change by seizing opportunities missed by other organizations and improving systems, inventing new approaches, and creating solutions to change society for the better (McCarty, 2011). However, the HDC is currently facing challenges to be fully effective in achieving their goals. The HDC is working on expanding the product range of the farm as well as improving productivity. These two goals are important to ensure the self-sufficiency of the HDC in order to provide support to local farmers. In addition to improving the technical aspects of the HDC, the center is currently developing a method to increase market expansion both locally and internationally. This project focuses on researching potential solutions to the problems faced by the HDC. In social entrepreneurship, social value creation is the primary objective, while economic value creation is often a by-product that allows the organization to achieve sustainability and self-sufficiency (Seelos, 2005). Therefore, if the self-sufficiency of the HDC can be improved, the center will be better equipped to increase the self-sufficiency of local small scale farmers.

Figure 2-2: Prachinburi Province

Source: http://en.wikipedia.org/wiki/Prachinburi_Province#mediaviewer/File:Thailand_Prachinburi_locator_map.svg

Figure 2-3: Muang District

Source: http://en.wikipedia.org/wiki/Mueang_Prachinburi_District#mediaviewer/File:Amphoe_2501.svg

2.4 Hydroponics as an Alternative Farming Technique

The HDC used hydroponics as a means to achieve self-sufficiency because the techniques have a number of significant advantages of soil-based methodologies. There are multiple hydroponic techniques, with different ranges of complexity, and each one can be customized. Small scale farmers can therefore adapt a hydroponic technique to meet their agricultural needs based on the products grown, availability of materials, cost, and other relevant factors. This advantage is

primarily due to the range of complexity between successful hydroponic systems, as summarized in the following quotation:

> "...from a single plant supported above an aerated jar of nutrient solution to thousands of plants supported above a large area of flowing solution in which pH, temperature, and nutrient concentrations are controlled by using a sophisticated computer system and automated chemical analysis" (Dreschel, 2014).

Even though soil based farming is considered to be a traditional agricultural method throughout history for small scale farmers, soil less agricultural practices such as hydroponics date back to the ancient Hanging Gardens of Babylon and the floating gardens of the Aztecs in Mexico (Jones, 2014). Professor W.F. Gericke, from the University of California, coined the commercial use of hydroponics for the first time in an article for a scientific magazine in 1937 (Jones, 2014). Since the 1980s, the global commerce of hydroponic vegetables has expanded. In Thailand, by 2010, a total of 188 hydroponic farms were registered or commercial production and home consumption (Wattanapreechanon & Sukprasert, 2012). The five major hydroponic systems implemented in Thailand are: Nutrient Film Technique (NFT), Dynamic Root Floating Technique (DRFT), Deep Flow Technique (DFT), Aeroponics, and Substrate Culture (Wattanapreechanon & Sukprasert, 2012).

2.4.1 Comparison of Soil-Based Practices and Hydroponics

A comparison of soil-based practices and hydroponics techniques with regard to self-sufficiency and sustainability features are described in Table 2-1 below:

Self Sufficiency	
Plant Nutrition	The ability to control precise nutrition for plants in Hydroponics, in comparison to soil based agriculture, permits small scale farmers to produce healthy products (Resh, 2012).
Product Quality and Yield	Hydroponic produce output yield can be 50% greater and higher quality than soil based agriculture. This feature can increase the profitability of a small scale farm (Resh, 2012).
Plant Maturity	Since the plant's growth is controlled in the right conditions with hydroponics, the fruit matures faster than in soil based agriculture (Jones, 2014). Therefore, small scale farmers can produce at a faster rate and market their produce before soil based agriculture products.
Investment	Due to the technical aspects of hydroponics, the initial investment is higher in infrastructure and trained labor than in soil based farming (Jones, 2014). Since hydroponic yield is greater, plant maturity rates are faster, and the products are of higher quality than soil based agriculture products, small scale farmers profitability will be greater with hydroponics in the long term.
Sustainability	
Soil Degradation	In soil based agriculture, the soil is degraded due to over-farming, which results in decreased nutrient content and crop yield. In hydroponics, soil degradation is not an issue. Moreover, the system only needs to be sanitized between crops (Resh, 2012).
Pest Control	Soil based products need pesticides to protect the plant from diseases and

	insects. Pesticides can be harmful to the environment as well as farmers and consumers. Since hydroponic products grow in a more controlled environment, there is a reduced need to use pesticides (Resh, 2012).
Fertilizer	Hydroponics does not requires a large amount of fertilizer because the necessary nutrients are supplied through the nutrient solution. Soil based farming requires more fertilizer to nourish the soil with the appropriate nutrients for the plants (Resh, 2012). Fertilizer salts can contribute to pollution in waterways because salts can be carried by rain water into storm drains and surface waters (Traunfeld & Nibali, 2013).
Water Consumption	Hydroponics recycles 95% of the water used in the system (Carruthers, 2005). Whereas, in soil agriculture water is inefficiently used and must be constantly re-supplied.

Table 2-1: Comparison of Soil-Based Practices and Hydroponics

2.4.2 Analysis of Hydroponic Techniques at the HDC

The HDC implements the Nutrient Film Technique (NFT) and Dynamic Root Floating Technique (DRFT) systems to produce morning glory, celery seed, kale, Chinese flowering cabbage, and other vegetables (Pamornsood, n.d.). An explanation of these hydroponics techniques is given below.

The standard NFT, shown in Figure 2-7, pumps the nutrient solution from a reservoir to a container. The plants are supported above the container and the dangling roots come in contact with the nutrient solution. The container is slightly angled to drain the nutrient solution back into the reservoir for reuse (Dreschel, 2014).

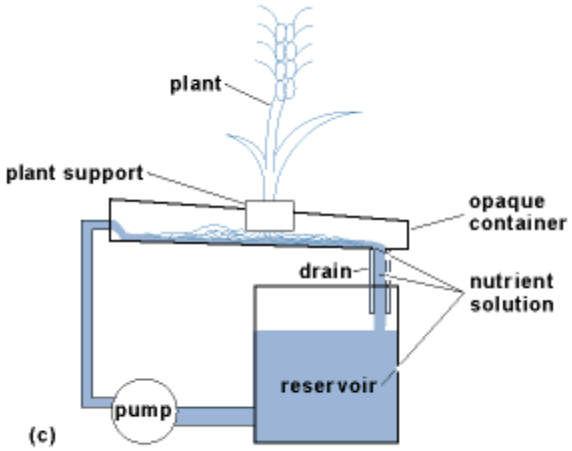

Figure 2-4: Nutrient Film Technique

Source: Dreschel, 2014

The DRFT demonstrates that hydroponic systems can be customized because it is a hybrid of several hydroponic techniques. An illustration of the system is shown in Figure 2-8 (Dreschel, 2014). Similar to the NFT, this system pumps nutrient solution from a reservoir to a container that supports the plants. In this system, the roots are basically submerged in the nutrient solution. The pump turns

off when the nutrient solution reaches a certain depth. Then, the nutrient solution is circulated back to the reservoir through the overflow pipe or drain to be reused (Kao, 1991).

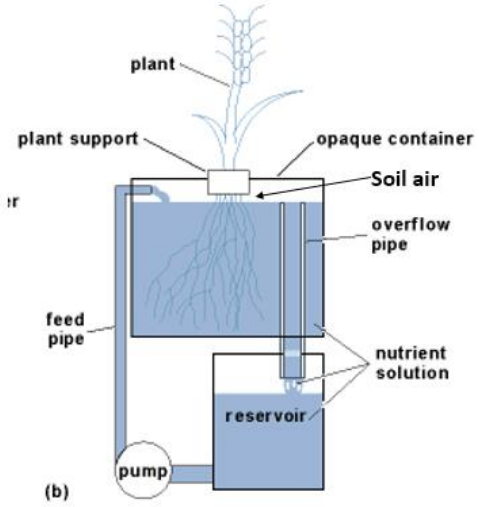

Figure 2-5: Dynamic Root Floating Technique

Source: Dreschel, 2014

2.5 Background Summary

This background section reveals that there is further work to be done to increase the self-sufficiency of small scale farmers in Thailand. Small scale farmers face multiple challenges in increasing their self-sufficiency including limited market reach, lowered productivity and improper pesticide use. Although there have been development initiatives intended by the Thai government to increase the self-sufficiency and sustainability of small scale farmers, a way to connect the policies the small scale farmers. The HDC is a social entrepreneurship organization devoted to increasing the self-sufficiency of small scale farmers through sustainable agriculture such as hydroponics. However, the HDC is facing operational problems of their own. This project focuses on increasing the self-sufficiency of the HDC in order to better enable the HDC to aid local small scale farmers.

3 Methodology

The goal of this project is to aid the Chaipattana Foundation in their mission to increase the self-sufficiency of the HDC by providing recommendations pertaining to its operations. Our team will accomplish this goal by addressing the following three objectives:

- Collect information about current operations at the HDC
- Identify areas of improvement
- Develop recommendations

It is intended that this increased self-sufficiency will better enable the HDC to help small scale farmers become more self-sufficient through the implementation of sustainable practices. An overview of our methodology is outlined in Figure 3-1.

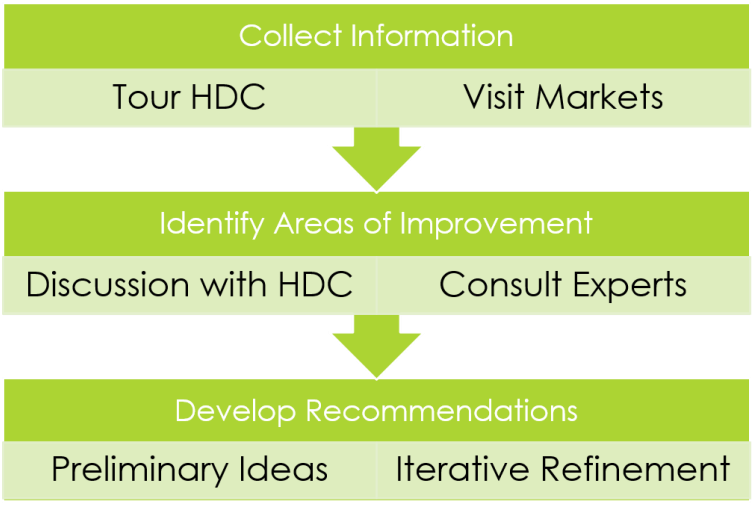

Figure 3-1: Methodology Overview

For each objective, this section will include the purpose, required information, how that information will be gathered, and how we will analyze the gathered information. A project timeline that shows when each objective will be completed is also included.

3.1 Objective 1: Collect information about current operations at the HDC

We will begin by collecting information about the current operations and market reach of the HDC to use as a basis for identifying areas that can be improved. The types of information we will collect include[1]:

Operations

- Different hydroponics techniques currently used by HDC
- Technical process from seed drop to harvest

[1] This list outlines our preliminary ideas for what information might be relevant to our project. If we come across other relevant information on the tour or visit, it will also be included in our analysis.

- Source of nutrients and raw materials for constructing the hydroponics structures
- Current management structure
- Daily routine and responsibilities of each worker
- Waste management procedures
- Transportation logistics for bringing produce to market

Market Reach

- Current market reach of HDC (who is consuming produce)
- Current demand for hydroponically grown produce

This information will be collected through a tour of the HDC operations, and a visit to the local market where the HDC sells its produce.

3.1.1 Tour HDC Operations

On our first visit to the HDC, we will ask the farm manager to give us a tour of the HDC so we can directly observe the farm processes and day-to-day operations. On the tour, we will ask our guide to walk us through each process at the farm, and we will take notes and pictures to document the information. Throughout the tour, we will ask questions to clarify any aspects of the operations that may be unclear. Our Thai partners will accompany us on the tour, so if there are no guides available that speak English, they will be able to translate for us.

3.1.2 Visit Local Markets

We will also ask for a representative from the HDC to take us to visit the markets where the hydroponics produce is sold. Assuming the markets are close enough to the HDC to visit, we will follow a similar procedure of taking notes and pictures at the market with our Thai partners to obtain enough information to understand of the current state of the HDC's market penetration. If the markets are too far away or otherwise inaccessible, we will instead ask them to describe the markets and discuss the process of selling the produce.

3.2 Objective 2: Identify areas of improvement

In order to identify potential areas of improvement at the HDC, we will start by holding a discussion about the information we learned in Objective 1 with the manager and other employees. We will then consult experts with relevant backgrounds to validate and refine our ideas.

3.2.1 HDC Discussion

The goals of the HDC discussion will be to:

- Clarify any questions that may not have been answered on the tour or market visit
- Identify operations that the manager and employees think work well and why
- Identify operations that the manager and employees think can be improved and how
- Discuss what may have been tried in the past to improve productivity and the potential reasons they were not successful

The discussion format will be in-depth, qualitative, and semi-structured because we want to foster informal communication with a combination of questions and prompts. Also, this style will

allow us to ask additional questions in order to clarify a response or obtain more details. The discussion will be held at the HDC if possible, or over the phone or Skype if necessary. With permission, we also intend to record the interviews to ensure that no responses are lost in translation.

After the discussion with the HDC manager, we will categorize the information from the tour and discussion by operation. For each operation identified, we will write a description of the process that includes all of the details we have for that process about how it works in the context of the HDC. We will compile this information into a document which will be referenced when talking to experts about the HDC operations. We are assuming that the HDC will allow us to discuss their operations with an outside source. If this is not the case, it will be difficult for us to know if the problems identified and discussed with the farm manager are worth **exploring potential solutions for**. Also, the outside source will provide a different perspective on potential issues that could potentially bring up areas of concern that were overlooked.

3.2.2 Consult Experts

We will also visit ACK Hydro in Bangkok, the largest commercial hydroponics farm in Thailand, and tour their operations and hydroponics techniques. The purpose of this visit will be to gain another perspective on how hydroponics farms are run in Thailand, and identify resources that can be used to evaluate the current operations of the HDC. We will ask ACK Hydro to conduct the tour in the same manner as the HDC tour. After the tour, we will set up a meeting with one of their managers and hydroponics experts to discuss the general operations and identified areas of improvement obtained from the discussion with the HDC manager and employees. At this meeting, we will first present the goals of our project, and then provide an overview of the HDC operations (with permission from the HDC). Then we will discuss where the experts believe the HDC operations can be improved, and potential methods by which that can be accomplished. This discussion will also be in-depth, qualitative, and semi-structured for the same reasons stated for the HDC discussion. Using the information obtained from the HDC and recommendations made by experts at ACK Hydro, we will then develop a list of areas at the HDC to focus on for improvement. If we are unable to speak with a representative at ACK Hydro to complete this objective, we will ask them to recommend another resource.

3.3 Objective 3: Develop Recommendations

Once a list of areas of focus has been created, we will begin to develop recommendations to improve the processes. First, we will prioritize the areas of focus to decide what the most important areas are to be focused on. From that list, we will develop preliminary solutions, which will subsequently be refined in iterations to result in our final list of recommendations.

3.3.1 Prioritize Potential Areas of Improvement and Develop Preliminary Solutions

The criteria for prioritization will be based on the perceived significance of each area on the productivity of the HDC. This prioritization will enable us to use our time effectively to work on the most important problems at the HDC, which should result in the maximum increase in productivity

if we are successful. To prioritize the areas of focus, we will have another discussion with the HDC manager. At this time, we will present the list of proposed issues to the HDC manager. During this discussion, we will also determine the relative importance of each item on the list based on the opinion of the HDC manager. We intend to work with her to create a numerical ranking system so that we can easily organize the areas of improvement identified at the HDC. A potential ranking system could be from 1-5 (shown in Figure 3-2), where 1 is an area of lowest concern and 5 is an area of highest concern. The aforementioned areas of concern will directly relate to how the specific problem might affect farm productivity.

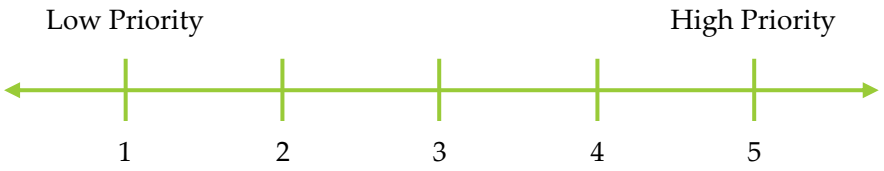

Figure 3-2: Example of Prioritization Scale

We will then begin developing preliminary improvement plans in the order in which they have been ranked by the HDC manager in an attempt to maximize the positive impact on HDC productivity. To develop these plans, we will use our background research, suggestions from the HDC, and the recommendations from the ACK Hydroponics Farm.

3.3.2 Iterative Refinement of Preliminary Solutions

For each plan that we develop, we will need to obtain feedback from our expert contacts at ACK Hydro or other resource to refine them and ensure that our improvements are technically sound. The ideal situation would be to meet with our sources of expertise if possible. Should this not be possible, we will need to contact them by phone or through Skype. We will present our ideas for potential solutions to the expert and request their thoughts on the matter. We will ask them if they have seen other solutions to the same problem and whether they were successful or not. Also, we will ask that they look into our projected cost and benefits to implementing our proposed change to ensure that we will be presenting accurate information to the HDC when the time comes.

After consulting experts for the second time, we will present our ideas to the HDC manager for evaluation in another discussion. We will utilize the same discussion format as the previous discussions, and go through our list of preliminary ideas one-by-one. Each solution will first be described in the following terms:

- Which issue our solution pertains to and what the rank of that issue is
- What changes will be constituted if our solution is used
- What the positive impacts are projected to be (productivity, sustainability, efficiency, etc.)
- What the potential negative tradeoffs are projected to be, if any

After this discussion, we will ask the HDC manager for her feedback. We will need to know whether or not our proposed solutions are economically feasible for the HDC. We will request that the HDC manager review our projected cost and benefits to ensure our accuracy. Also, we will need to know if the HDC manager has enough time to put forth certain changes.

Once the economic feasibility, time considerations, and cost vs. benefits have been assessed by the HDC manager, we will finalize our list of recommendations. We intend to break our list into two categories. The first category will encompass the feasible recommendations under the current HDC conditions and resources. The second category will include the future considerations that the HDC should explore once productivity has increased and more resources are available to reinvest in HDC operations. This list of recommendations will be the final project deliverable that we provide to the HDC.

3.4 Project Timeline

Figure 3-3: Methodology Timeline

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