

EMPOWERING RURAL COMMUNITIES: FOOD SECURITY AND SUSTAINABILITY IN BENGHOH RESETTLEMENT SCHEME AREA, SARAWAK

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Abstract: This case study investigates hydroponic farming within the Bengoh Resettlement Scheme (BRS) as a means to enhance food security and increase income for four villages situated in challenging terrain in Sarawak, East Malaysia. Considering the unique cultural and geographical challenges faced by these communities, a participatory social action research approach was employed to engage locals and foster their acceptance of this innovative farming method. In particular, hydroponic farming offers significant advantages, including consistent yields and production rates that can be up to five times greater than traditional methods on the same land area. Despite these benefits, initial participation rates were low due to resistance to unfamiliar practices. As such, many households struggled during the adaptation phase, encountering difficulties in measuring liquid fertiliser, and concerns about electricity usage led some to turn off water pumps, resulting in minimal yields. Moreover, it is anticipated that as the economic benefits of hydroponic farming, measured in Ringgit Malaysia, become clear and success stories emerge, more households will adopt this method, ultimately improving food security and income stability in the region.

Keywords: Empowerment, food security, sustainability, hydroponic farming, community engagement.

Introduction

Income inequality presents a significant challenge, affecting both social justice and underlying economic stability. It contributes to economic inefficiencies, hinders growth, and impacts labour participation rates (United Nations, 2013). While international inequality has decreased since the 1990s, it remains pronounced in developing and less developed nations. Key factors contributing to this decline include expanded access to education and government support for low-income groups (Dabla-Norris *et al.*, 2015). Notably, the World Bank's designation of Sarawak as a high-income state reflects its economic progress, with a Gross National Income (GNI) per capita exceeding US\$13,205, well above the World Bank's high-income threshold (Borneo Post, 2023).

Despite this progress, many rural households in Malaysia, particularly in Sarawak,

continue to depend heavily on primary sectors such as agriculture, forestry, and fisheries (Tedong *et al.*, 2022). Particularly, rural peasants in Sarawak are primarily engaged in farming and represent a considerable portion of the low-income demographic (Ibid). This situation highlights a significant gap between the state's overall economic achievements and the struggles of its rural population. Although many government programmes aim to encourage small farmers to engage in agribusiness (Jaafar *et al.*, 2022), their effectiveness in remote areas hinges on farmers' ability to market their products and generate income.

Sustainability integrates ecological, social, economic, and governance dimensions (Soini & Dessein, 2016). Specifically, a central challenge for rural farmers revolves around land use. As the competition for land intensifies due to population

growth and industrial development, policymakers and planners alike face increasing challenges (Godschalk, 2004). Sarawak, the largest state in Malaysia at 124,450 km², with a population of 2,907,500 as of 2020 (The Official Portal of Sarawak Government, n.d.-a; n.d.-b), experiences significant competition for land, even in its hinterlands, as its economy heavily relies on the primary sector. In remote areas, Indigenous communities engage in farming and hunting in the rainforest. At the same time, urbanisation further complicates land use in rural areas, dramatically altering usage patterns (Feng *et al.*, 2019). As a vital resource for agriculture, housing, commerce, and conservation, land pressures escalate with population growth, driven by human decisions. Consequently, physical changes occur as part of land development. To meet the rising need for infrastructure in housing, industry, commerce, and community facilities, towns expand rapidly, encroaching upon rural areas (Phang *et al.*, 2007).

This research investigates critical themes in rural community development, emphasising

hydroponics as an innovative farming method and the empowerment of women through agricultural advancements, which can stimulate economic growth and promote social equity. It also examines food security challenges, emphasising access to nutritious food and the role of sustainable practices in fostering long-term resilience. Additionally, the study explores the significance of social and cultural sustainability in preserving community identity while supporting economic and environmental objectives. Collectively, these themes offer a comprehensive approach to enhancing rural livelihoods through integrated and sustainable development strategies.

This paper specifically explores food security in rural areas by examining hydroponic farming within the Bengoh Resettlement Scheme (BRS) in Sarawak. Established to resettle communities displaced by the construction of the Bengoh Dam, the BRS faces numerous challenges addressed through an interdisciplinary approach (Lang *et al.*, 2012). The research objectives are as follows:

1. To analyse how villagers in the four affected communities, Taba Sait, Rejoi, Pain Bojong, and Semban, adapt farming practices, achieve self-sufficiency, and transition to new lifestyles.
2. To explore potential social issues by applying a social life cycle assessment to identify indicators relevant to social sustainability in this remote area.
3. To propose strategies for enhancing women's empowerment and improving food security, thereby supporting the overall social sustainability of the villages within the BRS.

Background

The construction of the Bengoh Dam began in 2007 and was completed in 2012. It is located 40 km south of Kuching, Sarawak. Nestled within a narrow valley and rugged terrain, the dam offers extensive reservoir storage capacity and a substantial surface area, effectively providing significant upstream volume despite its modest size. This regulating reservoir scheme is designed to supply raw water, thereby improving the low-flow regime at the Batu Kitang intake downstream and meeting the increasing water demand in Kuching and the larger Samarahan area (Heng *et al.*, 2014).

The villages impacted by the dam's construction, Taba Sait, Rejoi, Pain Bojong, and Semban, were relocated to the mountainous BRS area, situated approximately 5 km from Kampung Semadang and 42 km from Kuching (Borneo Post, 2014). Note that each family in the BRS received a detached concrete house on a quarter-acre plot of land (25 points), with homes featuring three bedrooms, a kitchen, and two bathrooms (Borneo Post, 2014). Spanning approximately 1,000 acres, the BRS includes 300 acres designated for residential use, which encompasses 204 houses, an Anglican Church, an SIB Chapel, and four public halls, one for each

village. The remaining 700 acres are reserved for agricultural activities (Malaysian Communications and Multimedia Commission, 2024). Simultaneously, the newly built school serves the children of the villagers and is located near Taba Sait village.

As of 2021, the resettlement area housed 41 households in Taba Sait, 25 in Rejoi, and 36 and 55 in Pain Bojong and Semban, respectively (Table 1). The BRS is equipped with essential facilities, including a reliable water supply, 24-hour electricity, two churches, a primary school,

four multi-purpose halls, and a football field. In addition, each family received 1.2 hectares of land for cultivation (New Straits Times, 2016). The local government, through the Agriculture Department, provided significant non-financial assistance to households, including topsoil, fertilisers, seeds, and nets to facilitate the conversion of the rocky land into small-scale farms. Building on this, households primarily cultivate chillies, cangkuk manis (a local vegetable), water spinach, and sweet potatoes, both for their leaves and tubers.

Table 1: BRS: Number of households in villages and relative size of villages

Villages	Number of Households	Relative Size of Villages (%)
Taba Sait	41	26
Rejoi	25	16
Pain Bojong	36	23
Semban	55	35
Total	157	100

Households in the BRS area tend to be larger than those in urban settings, often encompassing up to three generations. It is customary for children to remain with their parents even after establishing their own families. Over the years, many younger family members have migrated to urban areas, abandoning traditional economic activities. They often find employment in the public sector, taking on roles as clerical or technical staff, with some working as teachers in nearby villages or towns. In contrast, older generations primarily rely on agriculture as their main source of livelihood or as supplementary work to ease their household's financial burdens. Meanwhile, the family farms are predominantly managed by the women within these households.

Problems Faced by BRS Households

The resettlement area is located on rocky land with very minimal fertile soil, making it suitable for traditional agriculture and farming. Consequently, arable land for the villagers is limited. Although the Agriculture Department provided topsoil and fertiliser when the land was initially converted, the villagers were unable to

grow sufficient vegetables for consumption and sale over time. Soil replenishment rates are slow due to high fertiliser and transportation costs. The land productivity of backyard farms and cash crop farms declines over time, as the soil depletion rate exceeds the replenishment rates. Consequently, harvests of vegetables, fruits, hill rice, and other cash crops decline, leading to shortages of staple food and a fall in income. For instance, although some villagers had an excess of approximately 20 kg of hill rice for sale before 2019, the harvest was sufficient for their households' consumption only in 2022.

Villages in remote areas experienced limited "trickle-down" effects of economic growth and technology transfer due to the location of the villages and the communities' passion for their traditional farming method. Notably, the hydroponic project at BRS aims to provide sustainable income opportunities to the local community while enhancing their standard of living. Thus, by integrating hydroponic farming with traditional agricultural practices, the project seeks to maximise food production and achieve food security (Lobillo-Equibar *et al.*, 2020; Sousa *et al.*, 2024).

Literature Review

Hydroponics: Alternative Farming Method

Hydroponics is a technique of growing plants utilising water-based nutrient solutions as a substitute for soil. This study introduces hydroponic farming to rural communities, highlighting its advantages as a more cost-effective, safer, and efficient alternative to conventional agriculture. Note that hydroponics requires no pesticides or soil replenishment, and plants grow faster in a controlled environment. Additionally, this method reduces the financial burden on local governments while creating job opportunities for women and younger generations. Over the past two decades, technological advancements have led to the development of various alternative agricultural practices. This includes container farming, aquaculture, and hydroponic and aeroponic techniques (Stump, 2018).

Among these, hydroponics is set to play a pivotal role in sustainable agriculture (Reddy *et al.*, 2023). This innovative farming technique allows plants to thrive without soil, enabling precise control over the essential nutrients delivered directly to their roots. It is also applicable to plants with shorter germination and fertilisation cycles. Furthermore, hydroponic farming can be conducted on a small scale and is not weather-dependent. Unlike traditional farming, which typically allows for only two or three planting and harvesting cycles each year, hydroponics permits continuous operation to maximise yields (Suryaningprang *et al.*, 2021).

Global Solution Networks (2017) recommended that modern agricultural practices empower rural communities to generate jobs and produce food for their own consumption. However, sustainable farming methods must adapt to various factors, including climate, economic conditions, social dynamics, and land use. As contextual changes become more prevalent, effective farming requires flexibility to address unique regional challenges (Martin, 2015). Furthermore, the complexity of adapting farming systems necessitates an interdisciplinary

approach that integrates insights and methods from both natural and social sciences (Giller *et al.*, 2008). The role of science is to coordinate diverse knowledge and perspectives, making stakeholder participation crucial to integrate various backgrounds, values, knowledge, and interests (Giller *et al.*, 2015).

Considering the limited land size and poor soil quality in BRS, hydroponics offers a practical and viable alternative to conventional farming. It is both efficient and sustainable, as the equipment used is recyclable and supports continuous crop production (Kozai, 2013). It also consumes 70% to 90% less water than traditional farming methods (Patel *et al.*, 2020).

The Empowerment of Women in Rural Communities

The Government Transformation Programme (GTP) identifies poverty eradication as one of its seven key national priorities. Other critical focus areas include rural infrastructure development, managing the cost of living, and improving access to education, all of which support the goal of reducing poverty. Moreover, the GTP coordinates various agencies in the fight against poverty, implementing initiatives such as the Rural Development Master Plan (2012-2020). It aims to involve 30% of rural residents, particularly women, in entrepreneurial activities by 2020 (Mohd Zin & John, 2015).

In many developing countries, women in rural communities frequently engage in farming activities, providing food for their households, while supplementing and increasing household income by selling surplus produce (Mougeot, 2000; Van Veenhuizen & Danso, 2007). Empowerment involves developing individuals' capabilities (Rowlands, 1995). Hence, by facilitating knowledge transfer, empowering women enables them to adopt innovative agricultural methods and access additional sources of income. Accordingly, this study

focuses on women's financial and social empowerment, emphasising their ability to make financial decisions and access more resources, including income and information.

Food Security and Challenges

According to the United Nations' Food and Agriculture Organisation (FAO), food security is achieved when all individual consistently have the physical, social, and economic means to access enough safe and nutritious food that meets their dietary needs and preferences for a healthy, active life (FAO, 2010).

Nevertheless, food security faces significant challenges both locally and globally. Various factors, including climate change and different development types, have deteriorated soil conditions worldwide, affecting the four dimensions of food security. In addition, excessive commercial agricultural practices have altered environments and landscapes, potentially rendering future agriculture unsustainable (Gupta, 2019). Consequently, smallholder farmers often struggle to produce due to environmental and technological factors (Cotula *et al.*, 2011). As such, hydroponics presents an economically viable option to achieve food security and sustainability by reducing resource requirements by integrating technology with the surrounding environmental conditions. Concurrently, by leveraging the benefits of technology, it can offset and minimise adverse factors such as infertile land, thereby supporting food sources, generating additional income, and improving the living conditions of smallholder farmers in rural areas.

Sustainability: Social and Culture

Cultural sustainability is linked to sustainable development. As United Nations Educational, Scientific and Cultural Organisation (UNESCO) highlights, "culture provides the necessary transformative dimension that ensures the sustainability of development processes" (UNESCO, 2019). Similarly, Soini and Dessein

(2016) advocated for the integration of culture into sustainable development, noting that its goals are influenced by human actions, behaviours, and cultural contexts. Their study identified three roles of culture in sustainable development:

Culture in sustainability: Cultural sustainability is considered a component of sustainable development.

Culture for sustainability: Culture acts as a mediator for ecological, social, and economic sustainability.

Culture as sustainability: Sustainability is inherently embedded within cultural practices.

In the context of this study, culture is perceived as a way of life that interacts with nature, highlighting its role in complementing sustainable development initiatives. In 2009, UNESCO introduced a new cultural policy profile to acknowledge and support the role of culture in promoting sustainable development (UNESCO, 2009).

Sustainability encompasses the interrelationships among society, the environment, and economic development. While economic sustainability has been extensively addressed and environmental sustainability has gained traction in recent years, social sustainability remains less clearly defined (Hutchins & Sutherland, 2008). Nevertheless, social sustainability has gained ground in various business practices. For instance, advanced practices in the supply chain include product or process designs that target reducing consumers' health risks as well as a supply chain strategy that focuses on working with communities (Marshall *et al.*, 2015). Additionally, social sustainability often comprises legislative issues, health and safety concerns, and other socio-cultural factors influenced by implemented policies. As a result, indicators of social sustainability are often not directly measurable and tend to be subjective in nature.

Materials and Methods

The study of rural communities and their development is particularly complex due to their culture and resistance to change. Note that imposing frameworks or structures from the broader world may lead to misleading results (Madsen & Adriansen, 2004). Therefore, this research employs a case study methodology that incorporates both quantitative and qualitative approaches to investigate food security and social sustainability within the BRS in Sarawak.

This approach facilitates an in-depth exploration of the relocation's impact on villagers, focusing on their adaptation to new lifestyles and agricultural practices. Furthermore, the case study method is well-suited for this research, as it provides a comprehensive understanding of the community's intricate social dynamics and challenges, which are inherently qualitative in nature. Thus, by examining hydroponic farming, the study aims to identify strategies that promote self-sufficiency and food security.

Among the criteria for sustainable development, which include economic growth, social well-being, and environmental protection (Farjana *et al.*, 2021), hydroponic farming aligns with goals for improved eco-efficiency and reduced greenhouse gas emissions. Correspondingly, this farming method allows for

increased food production without reliance on industrial fertilisers and pesticides.

This study involves face-to-face interviews with women leaders to elicit and identify potential social issues and opportunities for women's empowerment within the community. Building a rapport with the leaders and community members is essential. Therefore, the researchers engaged in casual, ongoing communication prior to implementing the project. Recognising the cultural differences between the rural communities and the investigators, the principal investigator took 16 months to learn about the community's culture and lifestyle and to acquire basic proficiency in the native language, ensuring effective cross-cultural communication.

Moreover, to establish rapport, the principal investigator actively participated in the community's daily life through household visits. This includes offering assistance in the form of household items and participating in celebrations such as Women's Day, Children's Day, Gawai, and Christmas. Following approximately two years of fostering friendships and building trust, community members felt comfortable discussing the challenges they faced, their former lifestyles that were reliant on the forest, and the new lifestyles they were striving to adopt. The process of cross-cultural communication in this project is as follows:

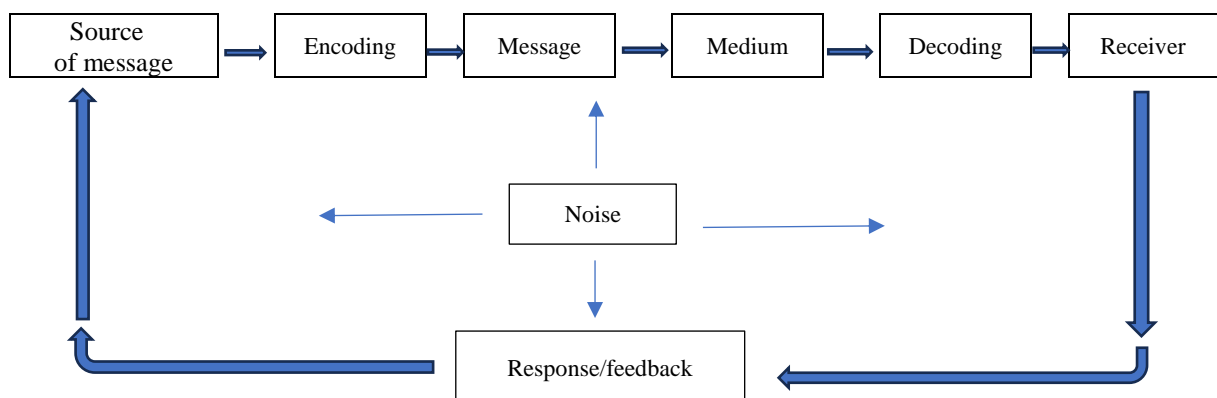


Figure 1: The process of cross-cultural communication

Source: Kotler (2003)

Meetings were held in a hall in the resettlement area to facilitate the participation of leaders and women from all four villages. The early stage of this project involves the investigators conveying the benefits of hydroponic farming to community leaders and women. Due to differences in the investigators' and the rural communities' languages, Bahasa Malaysia is selected for communication. However, the native language of Bidayuh was used occasionally to ensure the rural communities' understanding of the message, that is, to minimise noise that may lead to misunderstanding of the message.

Subsequently, meetings were organised to transfer knowledge of hydroponic farming to community leaders and women. These meetings aimed to collect data from participating households and observe changes in the well-being of children and women, particularly regarding their food intake. By focusing on a single case, this study provides valuable insights and recommendations that can be applied to similar resettlement scenarios. This, ultimately, contributes to the broader discourse on rural development and sustainability.

All participating households received a hydroponic kit, along with seeds and fertiliser, funded by the Swinburne Strategic Research Grant (SSRG) from Swinburne University of Technology, Sarawak Campus. After disseminating information, participating households planted vegetables and recorded their harvests. The collected data included the weight of the harvest in kilograms and any challenges encountered while trialling the new farming method.

The principal investigator collected primary data on individual households and their lifestyles before and after relocation to the resettlement area, which were gathered through

casual conversations within the villages. Many villagers were willing to share their thoughts and personal information, which has been incorporated into this project.

Results and Discussion

Most of the heads of families were unable to provide data on their household's annual income due to the unpredictability of vegetable prices, which leads to fluctuating incomes. Additionally, many individuals expressed a preference for their traditional lifestyle on ancestral lands, where they gather food and hunt in the jungle.

Figure 2 presents data on household engagement and interest in hydroponic agriculture across four villages: Pain Bojong, Semban, Rejoi, and Taba Sait. Each village exhibits variations in the number of households, survey response rates, and interest in adopting hydroponic farming practices. In particular, Pain Bojong comprises 36 households, with a response rate of 39%. However, only 5% of these households expressed interest in hydroponics. Meanwhile, in Semban, out of 55 households, only 27% responded to the survey. Following this, Rejoi demonstrated the highest engagement, with 25 households and an impressive 80% response rate, although only about 8% of those households exhibited interest in hydroponics. Moreover, in Taba Sait, which has 41 households, only two households (1%) indicated interest in hydroponic farming (see summary statistics in the Appendix).

Overall, the average response rate among the 157 households surveyed across all villages is 34%, with 34 households (22%) expressing interest in hydroponics. This suggests a moderate level of engagement. However, with only 22% demonstrating interest, there may be barriers to adoption, such as a lack of awareness, perceived benefits, or availability of resources.

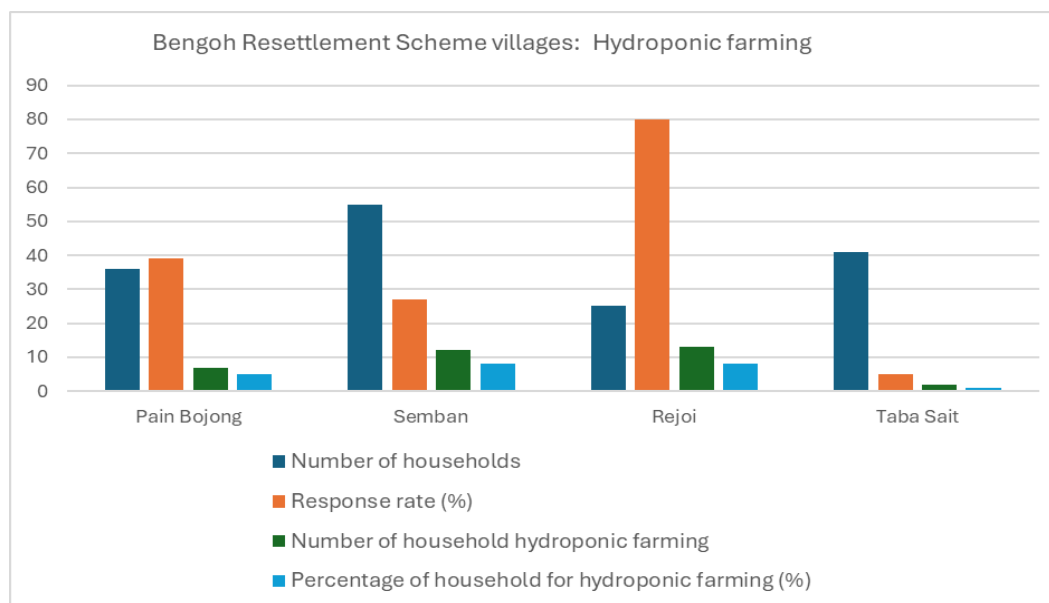


Figure 2: Numbers of households, response rates, number of households for hydroponic farming, percentages of households for hydroponic farming: Across BRS villages

The process and outcomes at the introductory stage of hydroponic farming can be summarised as follows:

Table 2: Data collection process

Stages	Process	Outcomes
Stage 1: Before distribution of hydroponic kits		
Message deliveries	a. Hydroponic farming: Benefits and costs. b. Agriculture Department, Division Kuching: Knowledge on hydroponic farming.	a. The principal investigator informed the village leaders about the benefits and costs of hydroponic farming. b. Engagement of an instructor to train participating households.
Responses/feedback	Leaders of villages communicate with their respective villagers.	Data collection: a. Number of households that agree to participate. b. Reasons households do not wish to participate.
Stage 2: After distribution of hydroponic kits		
Message deliveries	a. Knowledge transfer: The use of a hydroponic kit. b. Hands-on: Planting of vegetables.	a. Villagers learn the new farming method. b. Villagers plant vegetables and record their harvests.
Responses/feedback	a. Leaders and villagers provide data on their harvests.	a. Almost all participating households did not have a significant harvest because: <ul style="list-style-type: none"> (i) Either too much or too little liquid fertiliser is used. (ii) Vegetables dried up as some villagers attempted to conserve electricity by switching off the water pump at night.

	(iii) Most households gave up trying after a few failed attempts.
b. Leaders and villagers informed investigators of the problems encountered.	<p>b. Problems encountered:</p> <p>(i) Unable to measure the amount of liquid fertiliser needed for different types of vegetables.</p> <p>(ii) Electricity charges are significant for households with low income.</p> <p>(iii) The cost of hydroponic farming is higher than that of the conventional farming method, which depends mainly on rainwater and natural nutrients in the soil.</p>

Using Sawi farm as a benchmark, Table 3 below summarises the benefits and costs of hydroponic farming compared to conventional farming on an 11,700 cm² plot of land. The data indicate that the yields from hydroponic farming

are more than double those of conventional farming. For example, when vegetable market prices are at their lowest, hydroponic farming yields returns of RM24.00, while conventional farming generates only RM9.80.

Table 3: Comparisons of hydroponic farming and conventional farming: Benefits and costs of growing *Sawi*

Hydroponic		Benefits (RM)	Costs (RM)
Rotation	25 to 30 days		
Land size	30 pots x 3 tiers (approx. 180 cm x 65 cm)		
Harvest	30 pots x 200 gm @ RM1.50 ^b per 100 gm	90.00	
	@ RM0.60 ^c per 100 gm	36.00	
Inputs	Liquid fertiliser, electricity, water, seeds, rockwool		12.00
Conventional		Benefits (RM)	Costs (RM)
Rotation	25 to 30 days		
Land size	Approx. 180 cm x 65 cm		
Harvest ^a	Uncertain. Influenced by weather and pests		
	18 'trees' x 100 gm @ RM1.50 ^b per 100 gm	27.00	
	@ RM0.60 ^c per 100 gm	10.80	
Inputs	Fertiliser, water, seeds, pesticides		1.00

Notes:

The estimations of benefits and costs of hydroponic farming and conventional farming are based on farming of *sawi*, one of the most popular vegetables in Sarawak.

^aEach tree is planted about 20 cm apart from each other.

^bhigh market price.

^clow market price.

Sources:

Benefits and costs of hydroponic farming: Authors' estimations based on the experiments conducted.

Benefits and costs of conventional farming: Ts. K.A. Rabai Nasip, Northern Region Agriculture Research Centre, Department of Agriculture, Sarawak.

The projected increases in the income of individual and aggregate incomes, are summarised in Table 4. The income projections, participating households, along with changes in

based on estimated increases from the sale of Sawi, suggest that hydroponic farming could raise a household's annual income by approximately 4% at high prices and 1% at low prices. In addition, the estimated increase in aggregate income for the BRS area may range from 3% to 10%, assuming an average household annual income of RM24,000.00. Furthermore, the greater increase in aggregate income compared to

individual household income indicates that the marginal social benefits are higher than the marginal private benefits. Consistent with this, it is anticipated that an increase in the number of households adopting this new farming method will significantly boost community income, highlighting the crucial contributions of women to both their households and the wider community.

Table 4: Estimated GDP contribution: Ringgit (RM) and percentage (%)

Prices	Participating households' income change per year (RM)	Participating household income ^a change (%)	BRS area's GDP change (RM)	BRS area's GDP ^b change (%)
High	+936	+3.9	31,824	+10
Low	+312	+1.2	10,608	+3

Notes:

^aIt is assumed that household annual income is RM24,000.00.

^bExpected total income of all 157 households.

To address the issue of low participation rates, it is recommended that outreach efforts focus on villages like Rejoi, where engagement is already high. Accordingly, these villages can serve as model communities, using success stories to inspire others. At the same time, increasing awareness and understanding of the benefits of hydroponics in villages with low response rates, such as Taba Sait, can be achieved through demonstrations, workshops, and community meetings, which can help generate interest.

Identifying barriers to adoption in certain villages is crucial and can be determined through surveys or focus groups. Thus, providing necessary resources and support, including financial assistance, training, and ongoing technical guidance, will facilitate the transition to hydroponic farming. Additionally, engaging local leaders and influencers to advocate for hydroponics and address community-specific concerns can further bolster adoption efforts. Moreover, by analysing the data and implementing strategic actions, the initiative can

effectively enhance awareness and adoption of hydroponic farming in these rural communities.

Statistically, the smallest village, Rejoi, has the highest response rate and the largest number of households receptive to this alternative farming method. Many households have reported that they are unable to provide their average income, citing "uncertainty" due to fluctuations in rainfall and pest issues. Although residents acknowledge these uncertainties, many remain resistant to hydroponics, primarily attributed to the fact that they feel more comfortable with traditional farming practices that have been passed down through generations.

Further face-to-face interviews and informal conversations indicate that villagers tend to follow their leaders. As a result, those leaders who are actively engaged in social activities often inspire more households to accept new ideas. Therefore, it is essential for project leaders or government agencies to reach out to village leaders. This ensures they are well-informed and gain their support prior to implementing any projects.

A Direction for Future Plans

Hydroponic farming supplements villagers' incomes and optimises land use, effectively utilising underused spaces (Govender, 2019). The primary market for these hydroponic products includes customers in Kuching, focusing on food outlets such as restaurants, cafes, and local markets. Thus, establishing partnerships with grocery stores and restaurants can create a consistent demand for hydroponic produce, ensuring reliable sales and support for the community (Dewi *et al.*, 2024).

Moving forward, the following strategies and recommendations are proposed, which involve collaboration among three key stakeholders: Villages, academics, and government entities, in line with Giller *et al.* (2015). This project adopted a hybrid approach that combines both hard and soft methodologies. In particular, the hard approach emphasises decision-making, goal achievement, and the publication of selected methods for practical application (Giller *et al.*, 2015).

Meanwhile, the soft approach accommodates a broader range of specific circumstances (Ibid). This study adopts this framework to evaluate the effectiveness of resource allocations and policies aimed at improving socio-economic conditions and quality of life. This framework is applicable in several areas: assessing how different resources impact societal outcomes to guide policymakers on optimal distribution. This includes measuring the success of specific initiatives in achieving health, economic, and social objectives, and identifying needs to effectively allocate resources that enhance living standards and equity within communities, as presented below:

- (a) Villager engagement: Village leaders in resettlement areas should provide inputs and insights into their communities' challenges to inform academic research.
- (b) Interdisciplinary academic involvement: Academics from various disciplines, such as economics and marketing, should conduct

- (c) Interviews with villagers to gain a deeper understanding of common household issues and tailor solutions accordingly.
- (d) Government collaboration: Academics should collaborate with the Agriculture Department in Kuching to access agricultural knowledge and assistance. This partnership can help identify communication gaps between villagers and government agencies while determining available resources. Note that bridging these gaps through effective communication and a clear understanding of bureaucratic processes will aid in the implementation of study recommendations.

To initiate these efforts, forming a coalition of stakeholders, including local agricultural agencies, non-profits, universities, and private sector partners, can provide a framework for collaboration with regard to funding, resources, and technical expertise. Following this, training materials and curricula should be developed to cover essential hydroponic concepts, including system types, nutrient management, and plant selection, along with practical skills such as setup, maintenance, and troubleshooting. This development should occur in consultation with agricultural agencies to ensure relevance.

Additionally, organising interactive sessions, such as workshops, will offer hands-on experience and enhance participants' understanding of hydroponic farming. Furthermore, to ensure ongoing support, establishing a local farming cooperative or association with the assistance of local government and agricultural agencies is crucial. As a legal entity, this cooperative can seek grants and programmes to finance infrastructure and training initiatives.

By examining these relationships, stakeholders can gain insights into optimising resource allocation to achieve specific development goals. This approach allows rural communities to recognise the benefits and opportunities associated with hydroponic farming. Additionally, the model facilitates an understanding of the necessary inputs, expected

outputs, and potential impacts on health, equity, and quality of life. In essence, this structured framework fosters informed decision-making and encourages community participation in adopting sustainable agricultural practices.

In addition to the outreach project, developing a marketing strategy for the end product is essential. One effective strategy involves segmenting distribution channels, targeting key market segments through partnerships with local retail stores and collaborations with existing distribution networks (Dunning *et al.*, 2015). Similarly, business-to-business partnerships should focus on food outlets that offer catering services and collaborate with event planners (Schmidt *et al.*, 2011). Meanwhile, for business-to-consumer segments, prioritising collaboration with retail stores that support local community projects is vital (Dunning *et al.*, 2015).

The project's unique value proposition lies in its local community identity and the sustainable aspects of hydroponic farming, including reduced water usage and minimal environmental impact (Wagner *et al.*, 2021). Thus, the marketing mix should include cultivating crops that meet market demand, offering bundled products and discounts to encourage larger purchases, and utilising digital platforms to promote the project and highlight its positive impacts (Miller *et al.*, 2017; Swain *et al.*, 2021). Additionally, participating in local agricultural events and fairs organised by governmental bodies and Non-governmental organisations (NGOs) can expand networking opportunities and raise awareness of the project's benefits (Brown & Miller, 2008; Morris & James, 2017). Notably, the overall strategy will focus on product (community-driven local produce), price (affordability supporting community needs), and promotion (collaborations with NGOs and the private sector).

The findings reveal that villagers in the BRS area encounter significant challenges in adapting to their new environment and achieving

self-sufficiency. Despite these obstacles, hydroponic farming presents a promising solution for improving food security and promoting sustainable agriculture. However, social issues such as limited access to resources and inadequate support systems hinder the full potential of these farming methods.

The study emphasises the significance of collaboration among stakeholders, including village leaders, academics, and government agencies, to bridge communication gaps and enhance resource availability. Hence, empowering women through targeted initiatives, such as training and capacity-building programmes, is identified as a crucial factor in advancing the social and economic development of the villages. Correspondingly, the study recommends establishing outreach projects involving stakeholders to foster sustainable practices and provide villagers with necessary technical assistance. Simultaneously, continuous monitoring and evaluation of these initiatives are essential for assessing their impact and making adjustments as needed. Note that the BRS area has the potential to serve as a model for other resettlement schemes, contributing to sustainable development and social equity through collaborative efforts.

Finally, the projected and estimated statistics assume an average household annual income of RM24,000.00 and that the primary vegetable harvested is Sawi. Since households may cultivate various types of vegetables using hydroponic methods, the income generated can differ across these crops. Nevertheless, this study demonstrates that hydroponic farming could significantly increase the income of households and communities.

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Conflict of Interest Statement

The authors agree that this research was conducted in the absence of any self-benefits, commercial or financial conflicts, and declare that they have no conflict of interest.

References

- Borneo Post. (2014, February 16). *Bengoh settlement scheme suits current trend: Part one*. The Borneo Post. <https://www.theborneopost.com/2014/02/16/bengoh-settlement-scheme-suits-current-trend-part-one/>
- Borneo Post. (2023, November 5). *World Bank lead economist sees Sarawak as major economic contributor*. The Borneo Post. <https://www.theborneopost.com/2023/11/05/world-bank-lead-economist-sees-sarawak-as-major-economic-contributor/>
- Brown, C., & Miller, S. (2008). The impacts of local markets: A review of farmers markets and community supported agriculture (CSA). *American Journal of Agricultural Economics*, 90(5), 1296-1302. <https://doi.org/10.1111/j.14678276.2008.01220.x>
- Cotula, L., Vermeulen, S., Mathieu, P., & Toulmin, C. (2011). Agricultural investment and international land deals: Evidence from a multi-country study in Africa. *Food Security*, 3(S1), 99-113. <https://doi.org/10.1007/s12571-010-0096-x>
- Dabla-Norris, E., Kochhar, K., Suphaphiphat, N., Ricka, F., & Tsounta, E. (2015). *Causes and consequences of income inequality: A global perspective*. International Monetary Fund.
- Dewi, N. M. G. S., Susrusa, K. B., Arisena, G. M. K., & Bakhtiar, A. (2024). Collaboration among farmers and intermediary traders in marketing of greenhouse hydroponic products in Greater Malang. *Agrisocionomics: Jurnal Sosial Ekonomi dan Kebijakan Pertanian*, 8(1), 322-335.
- Dunning, R., Bloom, J. D., & Creamer, N. (2015). The local food movement, public-private partnerships, and food system resiliency. *Journal of Environmental Studies and Sciences*, 5, 661-670. <https://doi.org/10.1007/s13412-015-0295-z>
- Farjana, S. H., Mahmud, M. A. P., & Huda, N. (2021). Chapter 1 - Introduction to life cycle assessment. In Farjana, S. H., Mahmud, M. A. P., & Huda, N. (Eds.), *Life cycle assessment for sustainable mining* (pp. 1-13). Elsevier. <https://doi.org/10.1016/B978-0-323-85451-1.00001-9>
- Feng, W., Liu, Y., & Qu, L. (2019). Effect of land-centered urbanization on rural development: A regional analysis in China. *Land Use Policy*, 87, 104072. <https://doi.org/10.1016/j.landusepol.2019.104072>
- Food and Agriculture Organization (2010). *The state of food insecurity in the world: Addressing food insecurity in protracted crises*. Rome, Italy: Food and Agriculture Organization.
- Giller, K. E., Andersson, J. A., Corbeels, M., Kirkegaard, J., Mortensen, D., Erenstein, O., & Vanlauwe, B. (2015). Beyond conservation agriculture. *Frontiers in Plant Science*, 6, Article 870. <https://doi.org/10.3389/fpls.2015.00870>
- Giller, K. E., Leeuwis, C., Andersson, J. A., Andriessse, W., Brouwer, A., Frost, P., Hebinck, P., Heitkonig, I., van Ittersum, M. K., Koning, N., Ruben, R., Slingerland, M., Udo, H., Veldkamp, T., van de Vijver, C., van Wijk, M. T., & Windmeijer, P. (2008). Competing claims on natural resources: What role for science? *Ecology and*

- Society*, 13(2), Article 34. <https://doi.org/10.5751/es-02595-130234>
- Global Solution Networks. (2017, October 11). *Rural areas key to economic growth*. Retrieved August 16, 2024, from <https://gsnetworks.org/blog/rural-areas-economic-growth/>
- Godschalk, D. R. (2004). Land use planning challenges: Coping with conflicts in visions of sustainable development and livable communities. *Journal of the American Planning Association*, 70(1), 5-13. <https://doi.org/10.1080/01944360408976334>
- Govender, N. (2019). Subsistence farmers' knowledge in developing integrated critical pedagogy education curricula. *Education as Change*, 23. <https://doi.org/10.25159/1947-9417/5841>
- Gupta, G. S. (2019). Land degradation and challenges of food security. *Review of European Studies*, 11(1), 63. <https://doi.org/10.5539/res.v11n1p63>
- Heng, H. H., Hii, C. P., & Kho, K. T. (2014). An assessment of Bengoh dam overtopping scenario. *Geomatics, Natural Hazards and Risk*, 5(2), 115-131. <https://doi.org/10.1080/19475705.2013.781547>
- Hutchins, M. J., & Sutherland, J. W. (2008). An exploration of measures of social sustainability and their application to supply chain decisions. *Journal of Cleaner Production*, 16(15), 1688-1698. <https://doi.org/10.1016/j.jclepro.2008.06.001>
- Jaafar, M., Jayabalan, S., Ramasamy, N., & Suffarruddin, S. H. (2022). A four-level agropreneurship training evaluation model for rural communities. *Journal of Business and Social Development*, 10(1), 41-58.
- Kotler, P. (2003). *Marketing management* (11th ed., International ed.). Prentice Hall.
- Kozai, T. (2013). Resource use efficiency of closed plant production system with artificial light: Concept, estimation and application to plant factory. *Proceedings of the Japan Academy, Series B*, 89(10), 447-461. <https://doi.org/10.2183/pjab.89.447>
- Lang, D. J., Wiek, A., Bergmann, M., Stauffacher, M., Martens, P., Moll, P., Swilling, M., & Thomas, C. J. (2012). Transdisciplinary research in sustainability science: Practice, principles, and challenges. *Sustainability Science*, 7(Suppl 1), 25-43. <https://doi.org/10.1007/s11625-011-0149-x>
- Lobillo-Eguíbar, J., Fernández-Cabanás, V. M., Bermejo, L. A., & Pérez-Urrestarazu, L. (2020). Economic sustainability of small-scale aquaponic systems for food self-production. *Agronomy (Basel)*, 10(10), 1468. <https://doi.org/10.3390/agronomy10101468>
- Madsen, L. M., & Adriansen, H. K. (2004). Understanding the use of rural space: The need for multi-methods. *Journal of Rural Studies*, 20(4), 485-497. <https://doi.org/10.1016/j.jrurstud.2003.12.005>
- Martin, G. (2015). A conceptual framework to support adaptation of farming systems – Development and application with Forage Rummy. *Agricultural Systems*, 132, 52-61. <https://doi.org/10.1016/j.agsy.2014.08.013>
- Marshall, D., McCarthy, L., McGrath, P., & Claudy, M. (2015). Going above and beyond: How sustainability culture and entrepreneurial orientation drive social sustainability supply chain practice adoption. *Supply Chain Management*, 20(4), 434-454. <https://doi.org/10.1108/SCM-08-2014-0267>
- Miller, S., Tait, P., Saunders, C., Dalziel, P., Rutherford, P., & Abell, W. (2017). Estimation of consumer willingness-to-pay for social responsibility in fruit and vegetable products: A cross-country comparison using a choice experiment. *Journal of Consumer Behaviour*, 16(6), e13–e25. <https://doi.org/10.1002/cb.1650>

- Mohd Zin, M., & John, A. X. (2015). Poverty alleviation strategies and new economic model in Malaysia. *International Academic Research Journal of Economics and Finance*, 3(3), 17-31.
- Morris, W., & James, P. (2017). Social media, an entrepreneurial opportunity for agriculture-based enterprises. *Journal of Small Business and Enterprise Development*, 24(4), 1028-1045. <https://doi.org/10.1108/JSBED-01-2017-0018>
- Mougeot, L. J. A. (2000). *Urban agriculture: Definition, presence, potentials and risks, and policy challenges* (Cities Feeding People Series; Report No. 31). International Development Research Centre.
- New Straits Times (2016, April 24). *From dense forest to model village*. Retrieved August 16, 2024, from <https://www.nst.com.my/news/2016/04/141184/dense-forest-model-village>
- Patel, J. A., Nielsen, F. B. H., Badiani, A. A., Assi, S., Unadkat, V. A., Patel, B., Ravindrane, R., & Wardle, H. (2020). Poverty, inequality and COVID-19: The forgotten vulnerable. *Public Health (London)*, 183, 110-111. <https://doi.org/10.1016/j.puhe.2020.05.006>
- Phang, S. N., Singaravelloo, K., & See, B. L. (2007). Urbanisation and impact on development in Malaysia. *REKAYASA - Journal of Ethics, Legal and Governance*, 3, 26-42.
- Reddy, K. J., Mishra, R., Sreekumar, G., & Saikanth, D. R. K. (2023). Future of hydroponics in sustainable agriculture. In *Advanced farming technology* (1st ed.). Scripown Publications.
- Rowlands, J. (1995). Empowerment examined. *Development in Practice*, 5(2), 101-107. <https://doi.org/10.1080/0961452951000157074>
- Schmidt, M. C., Kolodinsky, J. M., DeSisto, T. P., & Conte, F. C. (2011). Increasing farm income and local food access: A case study of a collaborative aggregation, marketing, and distribution strategy that links farmers to markets. *Journal of Agriculture, Food Systems, and Community Development*, 1(4), 157-175. <http://dx.doi.org/10.5304/jafscd.2011.014.017>
- Soini, K., & Dessein, J. (2016). Culture-sustainability relation: Towards a conceptual framework. *Sustainability*, 8(2), 167. <https://doi.org/10.3390/su8020167>
- Sousa, R. D., Bragança, L., da Silva, M. V., & Oliveira, R. S. (2024). Challenges and solutions for sustainable food systems: The potential of home hydroponics. *Sustainability*, 16, 817. <https://doi.org/10.3390/su16020817>
- Stump, D. (2018). *Routledge handbook of landscape and food*. *Landscapes*, 19(1), 80-81. <https://doi.org/10.1080/14662035.2019.1571821>
- Suruhanjaya Komunikasi dan Multimedia Malaysia. (2024). *Bengoh, Sarawak*. Retrieved August 16, 2024, from <https://bengoh.pimaxis.my/komuniti.html>
- Suryaningprang, A., Suteja, J., Mulyaningrum, M., & Herlinawati, E. (2021). Hydroponic: Empowering local farmer knowhow to gain value added on agriculture commodity. *Budapest International Research and Critics Institute-Journal (BIRCI-Journal)*, 4(1), 787-796.
- Swain, A., Chatterjee, S., Viswanath, M., Roy, A., & Biswas, A. (2021). Hydroponics in vegetable crops: A review. *The Pharma Innovation Journal*, 10(6), 629-634.
- Tedong, P. A., Zyed, Z. A. S., Jani, R., & Fazlie, F. A. (2022). Rural residents' perceptions on the poverty alleviation and governance in Sarawak, Malaysia. *International Journal of Business and Society*, 23(2), 649-664. <https://doi.org/10.33736/ijbs.4831.2022>

- The Official Portal of Sarawak Government. (n.d.-a). *The geography of Sarawak*. Retrieved August 16, 2024, from https://sarawak.gov.my/web/home/article_view/159/176/?id=159#:~:text=The%20Geography%20of%20Sarawak&text=It%20stretches%20some%20800%20kilometres,area%20of%20124%2C449.51%20square%20kilometres
- The Official Portal of Sarawak Government. (n.d.-b). *Sarawak population*. Retrieved August 16, 2024, from https://sarawak.gov.my/web/home/article_view/240/175
- UNESCO. (2009). *Culture and sustainable development: Powering culture across public policies*. Retrieved August 16, 2024, from <https://www.unesco.org/en/sustainable-development/culture>
- UNESCO. (2019). *Culture and sustainable development: Powering culture across public policies*. Retrieved August 16, 2024, from <https://www.unesco.org/en/sustainable-development/culture>
- United Nations. (2013). *Inequality matters: Report of the world social situation 2013*. United Nations.
- Van Veenhuizen, R., & Danso, G. (2007). *Profitability and sustainability of urban and periurban agriculture* (Agricultural Management, Marketing and Finance Occasional Paper No. 19). Food & Agriculture Organization.
- Wagner, N., Morrish, D., & Juarez, M. (2021). Identifying the influential factors, benefits, and challenges of hydroponic shipping container farm businesses: A snapshot of farmers' perceptions. *Renewable Agriculture and Food Systems*, 36, 519-526. <https://doi.org/10.1017/S1742170521000211>

Appendix

Summary statistics: Villages' size, numbers of households, and response rates for hydroponic agriculture

Villages	Number of households in villages	Response rate (%)	Number of households for hydroponic agriculture percentage
Pain Bojong	36	39	7 5%
Semban	55	27	12 8%
Rejoi	25	80	13 8%
Taba Sait	41	5	2 1%
Total Average	157		34 22%