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Research Article

Understanding the Perceptions of Small-Scale Farmers Towards Hydroponics: A Thematic Analysis

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Abstract: This study examines small farmers' perceptions regarding hydroponic farming systems' utilization. The objectives are to identify key themes and patterns that emerge from farmers' perceptions, understand the factors influencing acceptance or resistance to hydroponics, gain insight into this modern farming technique's potential advantages and challenges, and create informative material to enhance farmers' perceptions of hydroponics. The study aims to provide valuable information to policymakers, researchers, and agricultural industry stakeholders, contributing to a better understanding of hydroponics' feasibility and potential adoption among small-scale farmers. A series of interviews were conducted, and a thorough thematic analysis was employed to identify recurring themes and trends in the perspectives of small-scale farmers on hydroponics. Findings reveal that hydroponics is not accessible to all farmers, with only a tiny percentage familiar with this farming method and its associated benefits. This knowledge is crucial for developing strategies to integrate hydroponics into existing agricultural systems, promote sustainable practices, and support small-scale farmers to improve their living conditions and access food resources. The study's outcomes aim to fill the knowledge gap surrounding small farmers' perceptions of hydroponics, contributing to informed policies, research advancements, and industry practices. By bridging this gap, stakeholders can make informed decisions and create targeted interventions that encourage the adoption of hydroponics as a viable farming technique among small-scale farmers. This research seeks to promote sustainability, resilience and address challenges small farmers face, ensuring their welfare and food security within the agricultural sector.

Keywords: Agricultural Systems; Environmental Impact; Sustainable Agriculture; Sustainable Development Goals (SDGs).

1. Introduction

Hydroponics is a soilless cultivation method that involves growing plants using mineral nutrient solutions in water [1]. The term "hydroponics" originates from the Greek words *"hydro"* (meaning water) and *"ponos"* (meaning labor), reflecting its reliance on water as a growing medium [2]. This alternative farming approach is a progressive method of achieving sustainable agriculture [3]. In hydroponics, "medium" refers to materials such as coco-peat, rock wool, perlite, vermiculite, and sawdust, supporting the plant's root system [3], [4]. The nutrient solution used in hydroponics should contain all the necessary micro and macro elements for plant growth and development. Essential features required in larger quantities include nitrogen, phosphorus, potassium, calcium, sulfur, and magnesium, while zinc, boron, iron, and manganese are needed in smaller amounts [2], [5]. It is crucial to include nitrogen, phosphorus, and potassium to create nutrient solutions for hydroponics, as they play vital roles in plant growth, tissue formation, and reproduction. As a result, 30% of the nutrient solution consists of these macronutrients, with the remaining 70%

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comprising water, micronutrients, and other beneficial compounds for plant growth [6], [7].

One of the significant advantages of adopting hydroponics is the ability to cultivate crops in controlled environments that provide optimal growing conditions, thanks to Controlled Environment Agriculture (CEA) technology [8]. Hydroponics is suitable for various plants, including vegetables, herbs, fruits, and flowers. Urban farming techniques, including hydroponics, have a positive environmental impact, as they reduce the release of carbon dioxide into the atmosphere, with plants capturing carbon dioxide for photosynthesis [9]. However, it is essential to note that hydroponic systems, relying on water as their foundation, can lead to increased humidity through water evaporation, particularly in arid environments [10]. Hydroponic farms offer a pathway toward a more sustainable food production system, as highlighted [11]. Additionally, in a country like the Philippines, where water scarcity and supply interruptions are frequent challenges, the low water consumption of hydroponic systems becomes another advantage [12].

Instead, it is crucial to maintain the proper environmental conditions for hydroponics to thrive [13]. As a soilless system reliant on water, hydroponics is vulnerable to waterborne diseases, as the circulating water within the hydroponic system can carry these pathogens, posing risks to the plants [14].

The study emphasizes the importance of public environmental awareness and education, as it reflects people's understanding of the current ecological situation and the level of environmental education [15]. The public outreach campaigns to raise awareness have identified creating instructional materials such as studies, papers, and infographics as one of the most effective methods of promoting awareness of Sustainable Development Goals (SDGs) [16].

The study primarily benefits small-scale gardeners in Bulacan, a province vulnerable to storm surges and flooding, challenging the sustainability of small-scale gardening [17]. Hydroponics offers a solution by avoiding the limitations associated with soil-based gardening [18]. Hydroponics efficiently enhances crop production, resulting in a significant yield of fruits or vegetables with minimal effort [19]. Moreover, hydroponics utilizes limited resources, requiring a small land area, less water, and no application of artificial chemicals, thereby minimizing environmental harm [20].

2. Statement of the Problem

The problems small-scale gardeners face, including the challenges posed by inclement weather conditions and the health risks associated with the COVID-19 pandemic [21], necessitate exploring sustainable solutions. This study aims to raise awareness among small-scale gardeners in Bulacan about the environmental benefits of hydroponic farming, offering potential solutions to resource shortages at an affordable cost and highlighting the importance of hydroponics [22]. Through qualitative analysis, the researchers seek to investigate the level of awareness of hydroponic farming among small-scale gardeners in Bulacan. The study aims to address the following research questions: (1) What is the participants' knowledge of hydroponic farming in terms of its definition, location, containers, materials, and procedures, and where did they acquire this knowledge?; (2) What financial and environmental benefits do participants perceive hydroponic farming to offer? (3) What challenges do participants identify regarding the financial and environmental aspects of hydroponic farming?; (4) What factors influence participants' decision to consider hydroponic farming?; (5) Based on the gathered data and analysis results, what information dissemination materials can be developed to enhance small-scale farmers' perception of hydroponics?

3. Material and Methods

3.1. Research Design

The study utilized a qualitative research method to provide researchers with more detailed information about the selected participants. Qualitative research is a subset of social science research that collects and analyzes non-numerical data to understand better social life within specific populations or locations [23]. Its objective is to comprehend research questions from a humanistic or idealistic perspective. By expanding the understanding of people's experiences, researchers can gain a more comprehensive understanding. This method also enables participants to provide more accurate and honest responses, making it the most suitable approach for this study.

Therefore, the qualitative research method was chosen for this study due to its intrinsic nature, which allows researchers to gain insight into the participants [24] [24]. Qualitative researchers are interested in understanding the meaning individuals attribute to their experiences and the wisdom they have gained from them [25]. Consequently, the researchers employed the qualitative method to comprehend better how the general public perceives hydroponics.

In qualitative research, the role of the researcher is to explore the sentiments of study participants [26]. Researchers must delve into the phenomena or situations that elicit responses from participants. Rather than focusing on statistical analysis, qualitative methods

emphasize identifying themes [27]. Participants were expected to provide clear and accurate answers using the qualitative research method.

3.2. Participants' Selection and Sample Size

The participants in this study consisted of small-scale farmers located in Bulacan, Philippines. The researchers contacted various agricultural associations, cooperatives, and local farming communities in Bulacan to select the participants. However, despite concerted efforts to obtain a diverse sample, the researchers acknowledged that the sample size might not fully represent the entire spectrum of small-scale farmers in Bulacan.

The study included 15 small-scale farmers who practiced traditional farming methods rather than hydroponics. The study aimed to understand the perceptions of small-scale farmers who had not yet adopted hydroponics. By excluding farmers already engaged in hydroponic farming, the research aimed to gain insights into the barriers, concerns, and perceptions of non-adopters. This focus allowed for a better understanding of why some farmers had not embraced hydroponics and identified potential areas for intervention or support to encourage wider adoption. Each district, except for District 6, had one participant included in the study. The researchers faced challenges during participant recruitment, including limited access to specific farming communities and a lack of response from some potential participants, which hindered their ability to achieve optimal diversity in the sample.

3.3. Goals of the Study

The study's main objective was to assess the awareness and support of hydroponic systems among small-scale gardeners, particularly concerning their environmental benefits. The researchers aimed to determine whether the participants, who were chosen explicitly as plant growers, were knowledgeable about the availability and simplicity of hydroponics.

The study focused exclusively on small-scale gardeners in Bulacan. The sample size was determined based on the research's type and design, ensuring the study's validity. In determining the sample size, the researcher must consider the participants' relevant experience and ability to address the research questions [28]. Therefore, the target sample size for this study was set at fifteen individuals who could provide the necessary information to meet the study's objectives.

3.4. Data Collection

The data collection process began with the researchers carefully selecting the small-scale gardeners who would participate in the study. Before the interviews, each participant was given a consent letter outlining the study's purpose, and their signatures were required. The researchers employed interviews and observations as the primary methods of data collection. The participants were informed that the researcher would serve as the instrument for the interviews, and to ensure data accuracy; the face-to-face interviews were audio recorded. The researchers needed to approach the information without biases or preconceived judgments, enabling them to review the data objectively and comprehensively based solely on the participants' experiences.

During the interviews, the participants answered questions regarding gardening and hydroponics. Additionally, they were given an educational pamphlet, which was explained and given to them. The researchers cared to accurately word the interview questions and facilitate discussions to minimize misunderstandings. The interview questions were designed to assist the participants in understanding and recalling their responses. The data collection procedure involved the initial selection of prospective participants, obtaining their signed consent forms, arranging face-to-face interviews, conducting the interviews, transcribing the discussions, and finally, gathering and analyzing the data.

The researchers anticipated that the interview questions could be answered relatively quickly. Each interview was scheduled to last between 15 and 30 minutes, providing ample time for participants to become acquainted and comfortably share their responses. The audio recording was utilized to maintain data accuracy.

Upon receiving permission to conduct the interviews, the researchers coordinated specific dates and times with the participants. The participants were selected using a combination of purposeful, referral, and convenience sampling methods. Purposeful sampling aimed to limit and gather participants who could purposefully provide the necessary information for the study. It involves selecting samples based on specific purposes rather than particular levels or areas. The sample size was initially determined as fifteen participants [29].

3.5. Data Analysis

In data analysis, researchers employ a thematic analysis approach to identify patterns or themes within qualitative data. The collected data is organized based on the emerging themes derived from the research questions or the data itself. Once the themes are determined, the data is organized according to these themes, and the emerging patterns, connections, and methods are analyzed [30]. The process of thematic analysis involves becoming familiar with the data, coding the data units, identifying themes, checking for consistency, and presenting findings through

narratives or matrices [30], [31]. Researchers also conduct cross-theme analysis to explore the relationships between different themes and identify broader patterns [32]. Researcher transparency and reflexivity are crucial in ensuring the validity and accuracy of the analysis [33].

4. Result and Discussion

4.1. Emerging Themes

The emerging themes from the data collection process revolve around the participants' knowledge of hydroponic farming, its benefits and challenges, and their decision to adopt it. The researchers used four primary and supplementary interview questions to gather comprehensive data. The participants' statements, originally in another language, have been translated into English for presentation purposes. These emerging themes will provide valuable insights into the participants' perspectives and inform the study's findings.

Theme 1: Awareness of Hydroponic Farming

As indicated in Table 1, fourteen out of fifteen responses supported the theme that the participants are aware of hydroponic farming. The participants at least have some knowledge of hydroponics.

Participant 3 elaborated,

> "*Hydroponics is a method of cultivation that does not use soil, and plant feeding is done through a nutrient solution in water. It can be conducted indoors or in a greenhouse. The climate control technology is utilized to ensure optimal conditions for plant growth*." (P3)

On the other hand, Participant 14 does not know precisely what hydroponics is, but she picked up from the word and some online recollections that it involves using water to grow plants.

She shared her insights,

> "*To be honest, it feels like I just heard about it now, so I have no idea what this is. But I think what I saw before might be hydroponics because of the word "hydro" which means water, and farming, which means planting*." (P4)

Table 1. Theme 1 Awareness of Hydroponic Farming

No.	Responses'	Participants	References
1	Uses water instead of soil	14	
2	Can be done both indoors and outdoors	5	2
3	Uses anything that can hold water, even plastic bottles	8	1
4	Can start with the necessary things such as seedlings, a container, water, a structure to anchor the plants, nutrients, and light	9	2
5	Internet or television is used for information	13	1

Out of the total participants, 14 individuals are aware of hydroponics, with only one participant having a limited understanding of the concept. Five participants know that hydroponics can be practiced indoors and outdoors, while another five know its suitability for outdoor cultivation. Additionally, eight participants mentioned that any container capable of holding water, including plastic bottles, can be used for hydroponics. However, only seven participants provided practical examples of containers.

Furthermore, nine participants know the necessary materials for hydroponics, with five participants demonstrating familiarity with these requirements, while one participant lacks knowledge in this area. Regarding the sources of information, eight participants obtained their learning from the Internet, three from school, two from television, and two from personal contacts.

Theme 2: Evaluation of Practice

As indicated in Table 2, 2 responses and five references expressed the evaluation of practice in determining the participants' awareness of hydroponics farming.

Participant 3 stated,

> "*As I have said, it is efficient and sustainable. Aside from this, it can maintain the crop cycle through Hydroponic farming. Since the environment is controlled and much the crops grow much faster. Moreover, it does not attract insects*." (P3)

Participant 13 mentioned,

> "*I don't have much knowledge about the actual materials*." (P13)

Table 2. Theme 2 Evaluation of Practice.

No.	Responses'	Participants	References
1	Efficient Production	14	3
2	Uncertain	1	2

In Table 2, participants' responses and references related to the evaluation of hydroponic practice are presented. Fourteen out of the fifteen participants mentioned the efficiency of hydroponic production. Only one participant expressed uncertainty or had limited knowledge about the financial impact of hydroponics.

Theme 3: Issues Concerning Hydroponics

As indicated in Table 3, four responses and ten references identified the struggles in implementing the hydroponic system as a modern way of farming.

Participant 4 mentioned,

> *"Hydroponic farming needs equipment and tools that can be costly and the system should be well-equipped with the needed supply of oxygen and nutrients that the plants need."* (P4)

Participant 11 mentioned,

> "*After all, I don't see any detrimental effects of hydroponics in the environment since it contains no chemicals*." (P11)

Table 3. Theme 3 Issues Concerning Hydroponics.

No.	Responses'	Participants	References
1	Cost of Materials	10	2
2	Water & Electricity Supply	2	3
3	Waterborne Diseases and Pests	5	11
4	No Environmental Issues	6	4

In Table 3, participants' responses and references related to issues concerning hydroponics are presented. Ten participants identified the cost of materials as a financial issue associated with hydroponics. Two participants mentioned concerns regarding the availability of water and electricity supply. Five participants expressed concerns about the potential for waterborne diseases and pests in hydroponics. On the other hand, six participants stated that hydroponic farming has no harmful environmental issues.

Theme 4: Perception of Observed Guidelines

Only 14 mentioned factors to consider in hydroponic farming, such as availability of resources, financial knowledge, the crop produced, time and effort, health risk and self-drive. One respondent does not know what things/factors to consider in hydroponics farming.

Participant 8 stated,

> "*We should consider if it has access to a light source, electricity, and location of where the hydroponic farming should be placed*." (P8)

Participant 5 stated,

> "*I don't have the Idea; I don't have any idea on what are the things that should be considered before proceeding in hydroponic farming*." (P5)

Participant 2 stated,

> "*We should consider first the container itself – if it contains any poisonous content.? Second is the possibility for the area where hydroponic is placed - as it can be the insect breeding ground. Ultimately, we succeed in farming but also get infected with dengue. That is all*." (P2)

Table 4. Theme 4 Perception of Observed Guidelines

No.	Responses'	Participants	References
1	Resources Availability	6	7
2	Financial	5	2
3	Personal Interest	5	1
4	Projected Outcome	3	0
5	Risk	2	1

Table 4 summarizes the factors mentioned by participants about hydroponic farming. A total of 23 responses and references were identified. Six participants said the availability of resources was a factor to consider, while five highlighted financial aspects. Personal interest was mentioned by five participants, indicating its significance. Three participants said knowledge and crop production as factors to consider, while two mentioned the importance of time and effort, health risks, and self-drive in hydroponic farming.

Figure 1. Pamphlet, Let us learn hydroponics!

To improve how small-scale farmers perceive hydroponics, the researchers utilized the insights from interviews to create a comprehensive pamphlet. The brochure thoroughly explains the concept of hydroponic gardening and provides a step-by-step implementation guide. The paper emphasizes both the economic and ecological advantages of adopting hydroponics.

This pamphlet proves to be a valuable resource as it presents all essential hydroponic terms and concepts in straightforward language. The main goal of this guide is to familiarize farmers with the necessary tools and supplies required to establish a sustainable hydroponic farming system. Additionally, the brochure offers detailed instructions on setting up and caring for a hydroponic garden.

The pamphlet emphasizes the numerous benefits of hydroponics, especially the potential cost savings resulting from reduced water and fertilizer consumption and increased crop yields. Moreover, hydroponics positively impacts the environment by eliminating or significantly reducing the need for harmful pesticides and other chemicals.

The researchers hope that by providing easily accessible information, they can enhance small-scale farmers' understanding of hydroponics and encourage its adoption. Armed with the knowledge from this pamphlet, farmers will be better equipped to make informed decisions regarding integrating hydroponics into their farms.

4.2. Discussion

The study's detailed discussion section delves into Filipino consumers' knowledge and opinions regarding hydroponics. One key finding is that only a small percentage of people are familiar with hydroponics and its positive environmental impact. This lack of awareness is attributed to insufficient information about hydroponics. While consumers may have some basic knowledge of hydroponics, they lack a deep understanding of this farming method. However, they do recognize its potential for long-term sustainability.

The study identifies hydroponics' price as a significant area where consumers lack understanding. Concerns about waterborne diseases, pests, and the high cost and limited availability of hydroponic farming supplies were raised by participants, which could potentially slow down the adoption of hydroponics. Nevertheless, respondents remain open to using hydroponics because they recognise its benefits for both consumers and the environment.

The study emphasizes the importance of considering various factors before implementing hydroponic farming, including access to necessary materials, cost, familiarity with crop production, health risks, personal initiative, and the time and energy required. Adopting hydroponics is seen as a significant step or threat for consumers.

Furthermore, the study underscores the significance of seeking innovative solutions to the sustainability challenges associated with small-scale gardening, especially considering factors such as inclement weather and the COVID-19 epidemic. Modern agricultural methods like hydroponics could present a low-cost and rapid approach to help consumers and the environment cope with resource scarcity. Given that hydroponics is not widely known or understood by Filipino consumers, the study highlights the need for increased education and information dissemination to encourage its use and adoption.

5. Conclusion

In conclusion, raising awareness and providing information about hydroponic systems and their environmental benefits are essential for small-scale gardeners in Bulacan. By collaborating with educators, environmentalists, and local government, it will be possible to address their urban agriculture knowledge gaps, develop plans for adopting hydroponics towards sustainable development, and tackle their current gardening challenges.

Moreover, creating a pamphlet as an information dissemination tool is necessary to ensure that even laypeople can understand the information about hydroponics. This pamphlet will be a reader-friendly guide, providing easily understandable information to help them grasp the terminology and processes involved in hydroponics.

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