

Production Efficiency of Hydroponic Farming in Sorsogon, Philippines

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Abstract. Demand for food increases simultaneously with the growing global population. However, traditional agriculture struggles to meet this need due to land and water limitations. Traditional farming also poses a higher carbon footprint, contributing to global warming and greenhouse gas emissions. An alternative solution for this is hydroponic farming, which uses nutrient-rich water to grow plants with less water and labor, yielding higher outputs and reducing environmental impacts. It is especially suitable for urban settings, making it ideal for countries with rapid population growth like the Philippines. This study is qualitative research, utilizing a modified questionnaire. It explored hydroponic farming in Sorsogon through structured interviews with 22 respondents. Findings showed that technical aspects were “Implemented” but still require enhancement. Farmers have adhered to operational requirements, yet opportunities remain for improving water and nutrient recycling. Production methods were “Widely Applied,” reflecting effective practices that result in higher yields, better crop quality, and sustainability. An illustrative farm demonstrated strong production efficiency, achieving a net income of ₱596,800.00 in 2024 and a return on investment of 198.93%. For every peso invested, farmers earn almost ₱2.00 profit, resulting in excellent cost management and profitability. Challenges faced by farmers must be addressed, while opportunities like expanding operations and improving practices can enhance productivity and sustainability. Scaling hydroponic farming could improve food security in Sorsogon and other regions, ensuring a reliable supply of healthy food and generating livelihoods. Hydroponic farming is a promising venture for sustainable agriculture and environmental stewardship.

Keywords: Agripreneurs; Green entrepreneurship; Hydroponics; Production efficiency; Sorsogon.

1.0 Introduction

The growing global population, projected to reach 9.7 billion by 2050 (United Nations, 2019), poses a critical challenge to global food security and nutrition. Traditional agricultural practices are increasingly unable to meet the rising demand for food, threatening the ability to feed the world’s population adequately. This situation highlights the urgent need to address gaps in food production systems, develop sustainable agricultural innovations, and enhance global nutrition. Issues in food systems, like production, harvesting, transportation, distribution, processing, marketing, and consumption, increase carbon footprints and contribute to global warming and climate change. Other factors affecting food security include economic distress, war, rising fertilizer prices, biodiversity loss, soil degradation, and limited land and water resources.

Food insecurity and environmental issues can be addressed by vertical farming. Unlike traditional horizontal farming, in vertical farming, plants are stalked vertically to maximize space (Marfal, 2023). This method creates

optimal growing conditions, ensures consistent quality and quantity, protects plants from hazards and pests, and uses resources efficiently. A key type of vertical farming is hydroponics, which grows plants in nutrient-rich water, either with or without a growing medium like sand or gravel, thus eliminating the need for soil (Casey et al., 2022; Britannica, 2024). Hydroponics shares similarities with traditional farming but has distinct advantages, such as using up to 90% less water and effectively addressing space limitations, making it ideal for urban areas and regions with low soil fertility (Gonzalez et al., 2022). This method can be set up on rooftops and inside buildings, reducing environmental impact with lower greenhouse gas emissions, minimal soil erosion, and preventing water contamination (Vyshnavi et al., 2023). Furthermore, hydroponic plants are free from soil-borne pests and diseases, simplifying pest and disease management (Alipio et al., 2022). Ultimately, hydroponics preserves vital natural resources like soil and water, offering a controlled, efficient, and environmentally friendly approach to agriculture, contributing significantly to food security and sustainability, especially in urban areas or regions with low soil fertility (Sanchez & Sarmiento, 2023). This study on hydroponics would contribute to answering the question of food security, offer a sustainable livelihood to farmers, and promote environmental preservation.

Hydroponics, derived from the Greek words "hydro" (water) and "ponos" (labor), is the method of growing plants without soil by submerging roots in nutrient-rich water. Since the discovery of Dr. William Frederick Gericke in 1924, hydroponics has consistently advanced and been accepted as sustainable farming, responding to the increasing need for food, especially in urban areas.

The first commercial farm was established in 1981 (YCP Solidiance, 2023), and the 1990s saw the National Agriculture and Fisheries Modernization Plan (NAFMP) promote hydroponics. 2005 the Simple Nutrient Addition Program (SNAP) was created for low-cost hydroponic systems. Senate Bill 1105, passed in 2010, further promoted hydroponics for food security. Dr. Chito F. Sace of CLSU established the Hydroponic Household Garden (HHG) in 2011, and ICCEM at CLSU developed the CHAT demo farm (Department of Science and Technology, 2021), advancing hydroponics and aquaponics. Research and initiatives of UPLB and CLSU contributed much to the spread of the adoption of hydroponics.

Currently, there are 120 registered hydroponics farms nationwide (Jagdish, 2022; YCP Solidiance, 2023), a number that is steadily increasing due to factors such as ease of production, rapid return on investment, government and private sector support, and technological innovations. In the Bicol region, approximately 20 farms are engaged in vertical farming, but in Sorsogon, only one registered farm—Redhill Nature Farm & Learning Site, Inc.—exists. Many hydroponic farmers in Sorsogon view their operations as small-scale backyard endeavors but look forward to expansion. Despite the promising growth of hydroponics in the country, its adoption remains uneven, particularly in provinces like Sorsogon, where the potential of hydroponics to enhance food security and agricultural productivity is underutilized. This emphasizes the need for research to investigate the barriers, opportunities, and strategies for expanding hydroponic farming in areas with untapped potential, thereby contributing to the broader goals of food security and sustainable agriculture in the Philippines.

Hydroponics is an environment-friendly farming method that adopts green entrepreneurship. Green entrepreneurship involves adopting practices that reduce environmental degradation, such as waste reduction, reusing materials, cutting non-renewable fuel use, and using renewable energy sources. In agriculture, this includes genetic engineering, digitalization, sustainable practices, agroecology, and innovative farming techniques (Gautam et al., 2023). Ecopreneurs use recycled technology to address environmental challenges while creating economic value (Khoirunnisa & Nugroho, 2021). Hydroponic farmers exemplify green entrepreneurship by promoting environmental preservation and assessing economic activities through cost, revenue, return on investment (ROI), break-even point, and payback period. Their environmental impact is measured by carbon footprint, GHG emissions, waste disposal, and nutrient recycling.

While global research on hydroponics is extensive, with significant investments in technology and infrastructure, and institutions like UP and CLSU leading in the Philippines, hydroponics in Sorsogon remains underdeveloped. The Provincial Agriculture Office and LGUs recognize their potential but lack comprehensive support programs and systematic studies. Due to limited knowledge and resources, local farmers are often unaware of its benefits. The only notable study in Sorsogon by Sanchez and Sarmiento (2023) developed an Arduino-based system but did not address production efficiency.

This study aims to bridge this gap by examining hydroponic farming's production efficiency in Sorsogon, enhancing resource use, crop yields, and eco-friendly practices, and supporting educational programs and policy development. The study aimed to determine hydroponic farming attributes along technical aspects, operational requirements, production methods, and lettuce production efficiency, identify challenges and opportunities, and recommend improvement strategies. Findings will support the broader adoption of hydroponics in the region.

2.0 Methodology

2.1 Research Design

This study utilized a descriptive method to analyze the production efficiency of hydroponic farming of lettuce (*Lactuca sativa* L.), in Sorsogon Province, documenting and describing the current state of hydroponic farming in the region. This method provides a comprehensive overview of practices, conditions, and outcomes. The purpose is to capture a detailed picture of hydroponic farming attributes such as technical aspects, operational requirements, production methods, challenges, opportunities encountered by the farmers, and production efficiency.

2.2 Research Locale

The study was conducted in Sorsogon Province, the second smallest province in the Bicol Region, highlighting challenges such as poverty, food insecurity, land scarcity, and frequent natural disasters. Limited land and typhoon damage hinder traditional farming and affect farmers' productivity. Hydroponic farming offers a sustainable solution by requiring less space and enabling year-round production in controlled environments. It reduces risks from climate conditions and can help alleviate poverty by improving productivity and income. (Food and Agriculture Organization of the United Nations, 2020).

2.3 Research Participants

The study's respondents were farmers and hobbyists in Sorsogon Province who used lettuce hydroponics and sold their produce. The research utilized the Snowball or chain-referral technique to identify the respondents. The researcher made every effort to consider all the hydroponic farmers in each municipality to ensure a clear and transparent analysis of the current state of hydroponic farming in Sorsogon; however, 3 farmers refused to be interviewed and were excluded. Excluded are those lettuce farmers who are using traditional methods. The total respondents was 22; 6 from Sorsogon City, 3 from Gubat, 2 from Bulan, Irosin, and Juban, and 1 from Barcelona, Casiguran, Castilla, Donsol, Magallanes, Matnog, and Sta. Magdalena. There are no hydroponic farmers from Bulusan, Pilar, and Prieto Diaz. Of these 22 respondents, 10 use Kratky, 6 use NFT, three use Semi-NFT, 1 use DFT, and 2 use both NFT and Kratky. The majority, or 19 respondents, use cocopeat for growing medium because of the abundant supply. Three farmers individually use rice hull, foam, and sawdust. Cocopeat, rice hull, and sawdust offer sustainability and environmental benefits. These materials recycle agricultural and industrial by-products, conserve resources, and enhance soil health, promoting more sustainable and environmentally friendly farming practices.

2.4 Research Instrument

This study used a modified questionnaire from some research. Farming attributes on technical aspects, operational requirements, and production methods were adapted from Yerukola and Narendra (2024), while challenges and opportunities were taken from Kumar et al. (2021). The researcher prepared other questions. The modified questionnaire fits the specific objectives and enhances its validity and reliability. A four-point Likert scale was used to assess the hydroponic farming attributes.

2.5 Data Gathering Procedure and Analysis

For this study, the most effective method for identifying respondents was through referrals from the participants. After each interview, the researcher inquired if the respondent knew anyone else in the province who was also into hydroponics. Respondents were interviewed using the survey questionnaire, with follow-up questions for clarification. Other approaches, like visiting the Facebook page of hydroponic farmers in Bicol, and contacting and messaging hydroponic farmers, resulted in a minimal positive outcome.

The results of the interviews were tabulated and analyzed, ensuring a comprehensive understanding of hydroponic farming practices. Observations and clarifications during interviews added depth to the data. For the first objective, the Likert scale and mean were used. The findings for the second objective were derived from a hydroponic farmer's financial statement. For the third objective, frequency and ranking were utilized. All the information or data gathered has been analyzed descriptively.

2.6 Ethical Considerations

The study strictly observed the Data Privacy Act of 2021 (Republic Act No. 10173) to warrant respondents' confidentiality and ethical treatment. Further, this research meets ethical standards and was approved by the research ethics committee of the University of Santo Tomas-Legazpi. Dr. Flor A. Jenkin was in charge of Research Ethics in this study.

3.0 Results and Discussion

3.1 Hydroponics Farming Attributes

This study determined the three attributes of hydroponics: the Technical aspect, Operational requirements, and Production methods based on how the farmers have executed their hydroponic system. The following are the results of the farming attributes:

Technical aspects

Technical aspects encompass various critical systems and practices essential for optimizing farming operations. Table 1 provides a detailed overview of the technical aspects:

Table 1. Technical Aspects		
Indicators	Mean	Adjectival Description
Nutrient Supply Management	3.02	Implemented
Water and Temperature Control	2.85	Implemented
Lighting and Energy Management	2.68	Implemented
Pest and Disease Control	3.60	Widely Implemented
Advanced Monitoring System	1.23	Least or not Implemented
Overall Mean	2.67	Implemented

Legend: 1.0-1.49 - Least or not Implemented; 1.50-2.49 - Seldom Implemented; 2.50-3.49 - Implemented; 3.50-4.0 - Widely Implemented

As shown in Table 1, pest and disease control is “Widely implemented”, which implies that farmers have controlled the pests and diseases well. The wide implementation of pest and disease control suggests that the hydroponic systems of farmers in Sorsogon are well-equipped to handle these issues, ensuring plant health and productivity. This wide implementation can lead to sustainable practices, improved environmental management, and more resilient agricultural systems. Nutrient supply management, water and temperature control, and lighting and energy management were “Implemented”, implying that farmers have managed these aspects appropriately. Hydroponic systems require a precise balance of nutrients for optimal plant growth, development, and yield; if not, crops may suffer stunted growth, nutrient deficiencies, and even death (GrowDirector, 2024). For advanced monitoring technologies, having “Least or not Implemented”, it is validated that indeed, only a few are using advanced monitoring technologies and automation systems. Most farmers are in their second to third year of hydroponic operation, requiring additional investment for advanced technology. Furthermore, most farmers used the Kratky method, where automation was not required. As Lovely (2022) indicated, Kratky is low-tech, needing no complicated water delivery systems or constant monitoring. The overall mean score of 2.67 indicates that the technical aspects are generally implemented, but there is room for improvement. It is suggested that advanced monitoring systems be adopted to enhance efficiency and effectiveness. Through this, the system can achieve higher integration and performance, leading to better outcomes and increased sustainability.

Operational Requirements

Operational requirements for a hydroponic system encompass several critical aspects: Water management, Nutrition management, environmental control, labor and skills availability, and infrastructure and facilities. These elements are essential for maintaining an efficient and productive hydroponic setup. Table 2 highlights the operational requirements.

Table 2. Operational Requirements

Indicators	Mean	Adjectival Description
Water management	3.12	Adhered
Nutrient management	3.26	Adhered
Environmental control	3.05	Adhered
Labor Availability and Skills	3.93	Fully Adhered
Infrastructure and facilities	3.50	Fully Adhered
Overall Mean	2.59	Adhered

Legend: 1.0-1.49, Least or not Adhered; 1.50-2.49, Seldom Adhered; 2.50-3.49, Adhered; 3.50-4.0 Fully Adhered

Table 2 revealed that Water management, Nutrient management, and Environmental control were “Adhered”. While Labor availability and skills, and Infrastructure and facilities were “Fully Adhered”. Hydroponics farming requires skilled work and know-how requirements (Pomoni et al, 2022), which hydroponic farmers have mastered by watching YouTube, attending trainings and seminars, and through experience. Preparing a hydroponic farm involves choosing a sunny location, clearing and leveling the area, ensuring proper drainage, setting up water and electricity supplies, selecting appropriate growing beds or containers, and installing lights and ventilation systems for indoor setups (Kryzen, 2024). The overall mean score of 2.59 as "Adhered" suggested that while the core practices are generally followed, there are significant opportunities for improvement, especially in areas like water and nutrient recycling. Focusing on these areas can lead to better resource management, cost savings, and enhanced sustainability. By continuing to refine and optimize these practices, the farming system can achieve higher levels of efficiency and productivity, contributing to long-term success and sustainability in agriculture.

Production Methods

The efficiency and success of hydroponic farming operations are closely tied to the production methods employed, such as Seed selection and preparation, Specialized propagation techniques, Transplanting and spacing, and Crop management and harvesting handling. Table 3 below provides a detailed analysis of Production methods.

Table 3. Production Method

Indicators	Mean	Adjectival Description
Seed selection and preparation	3.98	Widely Applied
Specialized propagation techniques	3.89	Widely Applied
Transplanting and spacing	3.62	Widely Applied
Crop management and harvesting handling	3.99	Widely Applied
Overall Mean	3.87	Widely Applied

Legend: 1.0-1.49 - Least applied or not applied; 1.50-2.49 - Fairly applied; 2.50-3.49 - Applied; 3.50-4.0 - Widely applied

Presented, Table 3 revealed that all variables: Seed selection and preparation; Specialized propagation technique; Transplanting and spacing; and Crop management and harvesting, all had been “Widely applied”. The result revealed that farmers have mastered the Production method. Farmers have proven the variety of seeds suited for the climatic conditions of the province, as well as disease-resistant seeds. Seed selection is essential for successful growth; choosing seeds that perform well ensures optimal growth and yield (Hydroponic Horizons, 2023). Proper transplantation techniques are crucial to minimize transplant shock, significantly impacting plant health and growth. Widely applying these practices helps seedlings adapt well to their new environment and continue to thrive. Optimizing plant spacing ensures that each plant receives adequate light, airflow, and nutrients. A 6-10” plant spacing is recommended by Stewart (2024) to allow proper air circulation, nutrient intake, and optimize plant growth. Farmers used barbecue sticks for transplanting and were extra careful not to damage the roots. Using proper tools and techniques during transplantation reduces the risk of root damage, which is vital for successfully establishing seedlings. This ensures that plants have a strong foundation for growth. The overall mean score is 3.87, indicating that these practices are "Widely Applied". These widely applied practices ensure crops reach the market optimally, enhancing marketability and profitability. These practices collectively contribute to the efficient and successful operation of hydroponic systems. Farmers can achieve higher yields, better crop quality, and sustainable agricultural outcomes by following these ideal practices.

3.2 Production Efficiency of an Illustrative Sample Hydroponic Farm

Production efficiency in this study was determined based on the operation of a hydroponic farm. The productivity and effectiveness of the hydroponic farming operation were determined by analyzing the income statement. The income statement of Lettuce Farm A below provides a thorough overview of the farm's financial performance for

2024. This statement underlines the gross sales, net sales, various expenses incurred, and the resulting net income, giving valuable insights into the hydroponic farm's economic viability and operational efficiency.

LETTUCE HYDROPONIC FARM A			
Income Statement			
For the period January 2024 to December 2024			
Gross Sales		₱	820,000.00
Less: Sales Returns, Discounts and Allowances			10,000.00
Net Sales		₱	810,000.00
Less: Expenses:			
Seeds	₱	76,800.00	
Nutrients & Fertilizers		37,200.00	
Packing Materials		1,000.00	
Labor		42,000.00	
Depreciation Expense		2,000.00	
Transportation Cost		7,200.00	
Repairs and Maintenance		12,000.00	
Registration and Licenses		5,000.00	
Miscellaneous		30,000.00	213,200.00
Net income		₱	596,800.00

The Income Statement for 2024 of Lettuce Hydroponic Farm A shows a net sales of ₱810,000.00, after deducting all the expenses amounting to ₱213,200.00, resulting in a net income of ₱596,800.00. The net sales indicate a strong demand for lettuce. At the same time, expenses account for around 26.3% of net sales, indicating effective cost management, leaving a significant portion of sales as profit. In contrast, the farm's net income of ₱596,800.00 showcases a high profitability, with approximately 73.7% of the revenue, which is an excellent profit margin, indicating a well-optimized operation. This further indicates that Lettuce Hydroponic Farm A is operating efficiently, maintaining a healthy balance between revenue generation and cost control.

To compute the Return on Investment (ROI), net income is divided by the initial investment in the hydroponic system and related infrastructure amounting to P300,000.00. The ROI is calculated as follows:

Return on Investment		
Net Income		₱ 596,800.00
Divide by: Investment		300,000.00
Return on investment		198.93%
Break-even point calculation		
Fixed costs		₱ 7,000.00
Divide by: Contribution margin ratio		74.54%
Break-even revenue		₱ 9,390.93

A remarkable ROI of 198.93% reveals that for every peso invested, the profit is almost 2 times the initial investment, signifying that Lettuce Hydroponic Farm A has effectively managed its costs and realized substantial profitability, making it a viable and potentially lucrative venture. The break-even analysis for Lettuce Hydroponic Farm A provides valuable insights into its financial stability. With fixed costs amounting to ₱7,000.00 and a contribution margin ratio of 74.54%, the farm's break-even revenue is calculated to be ₱9,390.93. This means that the farm needs to generate at least ₱9,390.93 of sales to cover its fixed costs and profit.

Lettuce Hydroponic Farm A exhibits a highly profitable venture, as evidenced by its remarkable financial metrics. With net sales amounting to P810,000.00 and total variable costs of P206,200.00, the farm realizes a considerable contribution margin of P603,800.00. The contribution margin ratio, computed at approximately 74.54%, further emphasizes the farm's efficiency in generating profit from sales. Fixed costs, including depreciation and registration expenses, total P7,000.00. Using these figures, the break-even revenue resulted in P9,390.93. This low break-even point implies that the farm can quickly cover its fixed costs, warranting financial stability. Additionally, the ROI is calculated at an impressive 198.93%, indicating that the farm's profitability is nearly twice the initial investment. These figures highlight the farm's effective cost management and operational efficiency, making Lettuce Hydroponic Farm A, a viable and lucrative enterprise poised for sustainable growth.

3.3 Challenges, Opportunities, and Strategies of Hydroponic Farming Challenges

Table 4 represents the challenges encountered by the respondents. The listed challenges are subdivided into eight categories: *Technical knowledge and skills*, *Access to Inputs*, *Water and Energy Management*, *Labor and Skills Availability*, *Infrastructure and Facility Management*, *Market Access and Distribution*, *Regulatory and Legal Issues*, and *Financial and Economic Viability*.

Table 4. *Challenges of Hydroponic Farming*

Indicators	Frequency	Rank
Availability of local suppliers for necessary materials	22	1
Cost of seeds, nutrients, and other essential items.	22	1
Maintaining greenhouses/other facilities and keeping up with maintenance costs.	22	1
Cost of production compared to traditional farming methods.	22	1
Return on investment and profitability of hydroponic farming operations.	22	1
Access to financing, credit, and insurance options for hydroponic farmers.	22	1
Access to renewable energy solutions.	16	7
Accessing financing to upgrade facilities.	14	8
Sourcing sustainable or organic inputs.	9	9
Competition from conventional farming and imported products	9	9
Managing energy costs for running equipment and lighting.	9	9
Dealing with power outages.	9	9
Limited distribution networks and transportation infrastructure.	6	13
Availability of water throughout the year and managing water usage efficiently.	4	14
Availability/finding workers with the right skills and enough workers during peak times.	2	15
Access to local/regional markets for hydroponic produce.	2	15
Implementing safety measures for workers.	1	17
Compliance with regulations and licensing requirements for hydroponic farming.	1	17
Uncertainty or complexity of regulatory frameworks governing inputs, water usage, and food safety.	1	17

As shown in the Table 4, Availability of local suppliers for necessary materials, Cost of seeds, nutrients, and other essential items, Maintaining greenhouses/other facilities and keeping up with maintenance costs, Cost of production compared to traditional farming methods, Return on investment and profitability of hydroponic farming operations and Access to financing, credit, and insurance options for hydroponic farmers are the top challenges encountered by the respondents, variables in which all entail costs. According to Brahlek (2023), the challenges and limitations encountered by hydroponic farmers are high initial setup costs, complexity of operation, reliance on electricity, precise nutrient management, risk of system malfunctions, limited organic hydroponics, crop suitability, and reliance on external inputs. *Access to renewable energy solutions* is a challenge for farmers using semi-NFT, NFT, and DFT because the majority rely on the electricity supply and would want a solar system for their operation. *Accessing financing to upgrade facilities* is also a challenge, as limited capital, government, and other institutions rarely grant loans to hydroponic farming, as this is considered backyard gardening. *Sourcing sustainable or organic inputs* is challenging for some because the source of coco peat as their growing medium is far away from their area. Other inputs, although available online, are not immediately accessible. *Competition from traditional and imported products* is challenging since they have established markets. *Managing energy costs for running equipment and lighting*, and *dealing with power outages* are challenges because of high energy costs, and insufficient supply of nutrients caused by power outages would affect growth and plant morphology (Balcony Crops, 2022).

Challenges like *Limited distribution networks and transportation infrastructure*, *Availability of water throughout the year and managing water usage efficiently*, *Availability/finding workers with the right skills and enough workers during peak times*, *Access to local/regional markets for hydroponic produce*, *Implementing safety measures for workers*, *Compliance with regulations and licensing requirements for hydroponic farming*; and *Uncertainty or complexity of regulatory frameworks governing inputs, water usage, and food safety* were perceived by few farmers. These challenges, if addressed, will also add to the productivity of hydroponic farmers.

Hydroponic farmers believed that *Technical knowledge and skills*, *Labor costs concerning farm operations*, and *managing worker productivity and retaining workers for long-term farming operations* are not challenges. Other problems, challenges, and difficulties identified by hydroponic farmers are the additional capital or budget, weather, finding

other varieties and crops suitable to the province's climate, awareness of consumers on hydroponics, issues with traceability, and far-to-market roads.

Opportunities

Farmers have enthusiastically embraced several opportunities to enhance agricultural practices and ensure sustainable growth. They see numerous potential in adopting new technologies, improving production methods, expanding market reach, diversifying crop varieties, and seeking training and support. These opportunities offer numerous benefits, like increased efficiency, higher yields, better market positioning, and improved resilience against several challenges.

Farmers utilize new technologies, like automated systems and sensors, to monitor plant growth and optimize resources (Shamshiri et al., 2018). Working with experts and implementing integrated pest management strategies are important to improve farming practices. Targeting niche markets with specialized crops, improving product packaging and branding, and collaborating with restaurants, supermarkets, and food processors are strategies farmers use to expand their market reach. These efforts help them attract more consumers, add value to their products, and increase profitability (Kumar & Kalita, 2017).

Experimenting with new and high-value crops allows farmers to adapt to changing market demands and consumer preferences. This diversification enhances their competitiveness and reduces their reliance on a single crop, mitigating risks. Participating in workshops, partnering with local government programs, and networking with other hydroponic farmers provide valuable learning opportunities and resources. These activities equip farmers with the skills and knowledge to implement best practices and improve their operations.

However, one significant finding is that while all farmers desire an association or cooperative to access grants, loans, and other support from the government or NGOs, none want to initiate it. They are willing to collaborate and cooperate, but none want to lead, seeing it as taxing and having other concerns to focus on. As a result, they may prefer to manage input purchases individually, focusing on other strategies that have proven more effective in enhancing their farming operations. The primary goals of agricultural cooperatives are collective marketing, access to resources, risk mitigation, and knowledge sharing. In contrast, the benefits include enhanced bargaining power, resource access, market opportunities, risk mitigation, and knowledge sharing (TAD Admin, 2023).

Other opportunities perceived by hydroponic farmers are the installation of insulation, and tarpaulin, misting equipment, construction of another greenhouse, automation of the system, having a dripping method, solar source of energy, forming a cooperative or association, propagation of other lettuce varieties and high-value crops such as herbs, leafy greens, and strawberry; to be a technical consultant on hydroponics; to have a local store for inputs and other hydroponic needs; to improve packaging and branding and to have hydroponics in all schools and communities in Sorsogon Province. This proactive approach shows farmers' commitment to continuous improvement and innovation in hydroponics. These efforts collectively contribute to more resilient, efficient, and profitable hydroponic farming practices.

Strategies

Strategies are suggested to enhance hydroponic farming for the four key groups: farmers and agripreneurs, beginners/enthusiasts/wannabes, government and private institutions, and consumers. Each group tackles particular needs and contributions to promote an effective and sustainable hydroponic farming community.

For hydroponics farmers and agripreneurs, they must apply cost reduction and sustainable technologies by utilizing local, sustainable organic products like cocopeat, rice hull, and sawdust to lessen production costs; investing in sustainable energy solutions, such as the use of rainwater and solar energy; developing innovative pest management strategies with organic products; and investing in advanced technologies like IoT sensors or AI for better monitoring and yield prediction. In addition, they can build strong networks with local government, universities, and private institutions to foster collaboration and knowledge exchange. Hydroponic farmers and agripreneurs must prioritize customer satisfaction and expand market reach to help secure a stable demand for agricultural products; diversify crop varieties and improve resilience. Lastly, they must form cooperatives or

associations to empower farmers by providing collective bargaining power and shared resources, leading to more sustainable and prosperous agricultural practices.

For Beginners/enthusiasts/wannabes, they should benchmark, consult experts, collaborate with practitioners/experts, and seek a mentor. They should master the technology of hydroponics before venturing into business. They should start small by using the Kratky method first. They should know the market and find appropriate training/education resources and new farming practices.

Government and private institutions should provide training and capability building on improving the hydroponic technology, packaging, branding, and developing value-added products. They must encourage backyard hydroponic farmers to register their farms to enjoy the benefits afforded to them, like tax incentives. The government may provide space or location for agri-tourism products; offer grants, loans, and insurance to farmers needing starter kits, greenhouses, seeds, solutions, and other inputs; establish a learning center and hydroponic systems in schools and communities; organize trade fair; assistance in the formation of cooperatives or associations of hydroponic farmers. Programs of DA on hydroponics like Plant, Plant, Plant Program, and Hydroponic Fodder Production be cascaded to the provinces; and public-private partnerships be done.

Supporting local agricultural products, particularly hydroponic products, presents numerous benefits for consumers and the community. Consumers are assured of having access to fresh, healthy, and nutrient-rich produce (Saldinger et al., 2023). It promotes better health and lessens the environmental impact of long-distance food transportation, thus lowering carbon footprints. By patronizing local hydroponic products, consumers can considerably increase the income of entrepreneurs and farmers, thus boosting the community's economic growth. This support sustains small businesses, creates jobs, and strengthens the local economy. Moreover, the increased demand for locally grown hydroponic produce encourages farmers to adopt sustainable and innovative agricultural practices, leading to a more resilient food system. Supporting local hydroponic farming initiatives educates consumers about modern farming techniques, the benefits of hydroponics, and the importance of sustainable agriculture. This knowledge fosters more informed and conscious purchasing decisions, encouraging environmental stewardship. Moreover, consumer support drives investment in hydroponic farming, advancing technology and infrastructure, and enhancing efficiency and productivity. By choosing local hydroponic products, consumers help agricultural communities flourish and reduce the environmental impact of long-distance food transportation. This collective effort addresses modern agriculture's challenges and ensures a healthier, more prosperous future.

4.0 Conclusion

This study highlights the productivity, sustainability, and profitability of hydroponic farming in Sorsogon, emphasizing its potential to inspire more farmers and agripreneurs to adopt this innovative approach. The findings suggest a strong case for government and private institutions to promote hydroponic farming. Key areas of support include providing financial assistance, grants for greenhouses, and subsidies for essential farm inputs to address primary challenges faced by farmers. Additionally, the study highlights growth opportunities, such as adopting advanced technologies, optimizing production methods, expanding market reach, diversifying crop offerings, and investing in training and capacity-building programs. Embracing these measures could empower farmers to elevate their practices while promoting consumer awareness of modern farming techniques, the environmental benefits of hydroponics, and the value of sustainable agriculture. This, in turn, could encourage informed purchasing behaviors and foster environmental stewardship. Lastly, the research emphasizes the environmental advantages of hydroponic farming, such as efficient resource utilization and reduced carbon emissions, reinforcing its role in promoting eco-friendly and responsible agricultural practices.

Future related studies could focus on conducting feasibility studies for economic improvements by establishing local stores dedicated to hydroponic supplies to ensure availability and affordability, and forming cooperatives to reduce costs, enhance purchasing power, and improve collective bargaining for resources and inputs. For technical improvements, develop low-cost automation equipment tailored for hydroponic farming to streamline operations and enhance efficiency, and experiment with innovative technologies for hydroponic systems to optimize processes and improve scalability. Lastly, for agricultural improvement, explore and evaluate different lettuce varieties and other crops suitable for the local climate to diversify production and investigate the use of

organic nutrients and pesticides to promote eco-friendly and sustainable farming practices. These measures collectively aim to strengthen the hydroponic farming industry, ensuring resilience and sustainability in the long term.

5.0 Contribution of the Author

This study is authored by a sole researcher and is confirmed to be an original work, integrating previously published material with proper citation and acknowledgment.

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7.0 Conflict of Interest

The author declares no conflict of interest regarding the publication of this paper.

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