



The 1st ASEAN University Symposium for **Sustainable Food System**

Faculty of Economics, Kasetsart University, Bangkok, Thailand

April 18th-19th, 2024

PROCEEDING





PROCEEDINGS of The 1st ASEAN University Symposium for Sustainable Food and Hybrid Systems

Organizing Institutions:

- Department Agricultural and Resource Economics, Faculty of Economics, Kasetsart University (KU), Thailand
- Department of Agricultural Economy and Development, Faculty of Agriculture, Chiangmai University (CMU), Thailand
- School of Economics, Can Tho University (CTU), Vietnam
- Faculty of Economics, IPB University, Indonesia
- Institute for Population and Social Research, Mahidol University (MU), Thailand
- Faculty of Economics and Business Management and Department of Rural Economics and Food Technology, Faculty of Agriculture, National University of Laos (NUOL), Laos PDR
- Faculty of Agriculture, Sultan Sharif Ali Islamic University (UNISSA), Brunei
- Department of Agribusiness and Bioresource Economics, Faculty of Agriculture and Institute of Ecosystem Science Borneo, Universiti Putra Malaysia (UPM), Malaysia
- Dept of Agricultural and Applied Economics, College of Economics and Management, University of Philippines at Los Banos (UPLB), Philippines
- Department of Agricultural Economics and Policies, and Department of Resource and Environmental Economics, Faculty of Economics and Rural Development, Vietnam National University of Agriculture (VNUA), Vietnam
- Department of Agricultural Economics, Yezin Agricultural University (YAU), Myanmar

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Faculty of Economics, Kasetsart University, Bangkok, Thailand
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Venue: Faculty of Economics, Kasetsart University, Bangkok
Symposium dates: 18–19 April 2024

Concept Note

Background:

Important emerging issues challenging agriculture and the food system, such as climate change, an aging population, and environmental degradation, place increasing demands on the global society for responsible consumption, particularly in ASEAN member states. These critical issues urgently necessitate additional research and deeper knowledge to sustainably increase agricultural production, ensure efficient access to nutritious food, and improve regional supply chains. The UN Sustainable Development Goals (SDGs) advocate concentrated actions related to sustainable agriculture to achieve zero hunger, food security, nutrition and good health. Indeed, SDG goals promoting quality education are aligned with initiatives in research and education focusing on agricultural policy, agribusiness, agricultural economics, natural and environmental economics, and related fields. These are the key drivers to generate evidence and knowledge necessary for policy making and food system transformation.

Higher education institutions play important roles in generating knowledge addressing these issues and challenges. Sharing knowledge globally is important, yet public forums intended to achieve the desired outcomes, even at the regional level, have been somewhat limited, partly due to language barriers and partly due to inefficient communication channels. Moreover, access to venues where knowledge can be effectively shared is often economically prohibitive for young scholars. As a result, the progress to achieve certain SDGs, such as food system transformation, has been slow. There is clearly a need to accelerate the process for research and knowledge sharing.

This symposium provides an effective platform for knowledge sharing by providing opportunities to young academics and university students, who will be invited to hear from experts, exchange their knowledge, and share their experience. It will generate new perspectives, fill research gaps, and



lead to opportunities for collaborative research intended to resolve the issues that commonly challenge countries across the Southeast Asia region.

Objectives:

1. To empower universities that offer academic training in agricultural economics, agribusiness, agricultural and food policies, and related fields to play a greater role in capacity building supporting a younger generation of scholars
2. To motivate graduate students and young researchers in Southeast Asian professions to engage in good quality research focusing on the sustainable food system
3. To provide a platform for sharing research outputs, and the exchange of knowledge and experiences related to food system analysis

Expected benefits:

1. The symposium will share existing knowledge needed to attain critical Sustainable Development Goals (SDGs) related to enhanced food security, improved nutrition, sustainable agriculture, and food system transformation.
2. It will help identify critical issues and fill research gaps related to the challenges commonly confronting nations across the Southeast Asia region.
3. It will give graduate students and young researchers an opportunity to share knowledge and experience, and to build a research network for future collaborative research.

Submissions are open to graduate students and young researchers who are affiliated with the organizing institutions:

- Department Agricultural and Resource Economics, Faculty of Economics, Kasetsart University (KU), Thailand
- Department of Agricultural Economy and Development, Faculty of Agriculture, Chiangmai University (CMU), Thailand
- School of Economics, Can Tho University (CTU), Vietnam
- Faculty of Economics, IPB University, Indonesia
- Institute for Population and Social Research, Mahidol University (MU), Thailand
- Faculty of Economics and Business Management and Department of Rural Economics and Food Technology, Faculty of Agriculture, National University of Laos (NUOL), Laos PDR
- Faculty of Agriculture, Sultan Sharif Ali Islamic University (UNISSA), Brunei



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- Department of Agricultural Economics, Yezin Agricultural University (YAU), Myanmar

Important dates

Call for paper: 15 October 2023–31 January 2024

Full-paper submission deadline: 31 January 2024

Announcement of the selected papers: 16 February 2024

Final draft submission: 28 February 2024

Deadline to register for onsite participation at Kasetsart University:
28 February 2024

Conference dates: 18–19 April 2024

Selected full papers will be published on

<https://ageconsearch.umn.edu/search?cc=2550&ln=en&c=2550>

Organizing partners:

Kasetsart University, Thailand (Host)

Chiangmai University, Thailand

Can Tho University, Vietnam

IPB University, Indonesia

Mahidol University, Thailand

National University of Laos, Laos PDR

Sultan Sharif Ali Islamic University, Brunei

Universiti Putra Malaysia, Malaysia

University of Philippines at Los Banos, Philippines

Vietnam National University of Agriculture, Vietnam

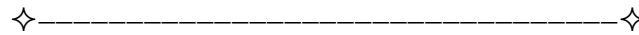
Yezin Agricultural University, Myanmar



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<https://kasets.art/ZojZIY>.



**Report of the Organizing Committee
The 1st ASEAN University Symposium
for Sustainable Food and Hybrid Systems
by
Assoc. Prof. OrachosNapasintuwong, Ph.D.
Chair of the Organizing Committee**



President Chongrak Wachrinrat,
Dean Visit Limsombunchai,
Invited Speakers, Presenters,
ASEAN university network for sustainable food systems representatives
All participants, colleagues and students

I wish to begin by extending my personal welcome to each of you to this first **ASEAN University Symposium for Sustainable Food and Hybrid Systems**. It is my distinct privilege to present the Report of the Organizing Committee.

To offer a little background, the symposium is the product of conversations between colleagues, faculty members and researchers from various universities within the ASEAN region who shared concern about the critical issues covered in this symposium.

The concept for this event, which emerged from these conversations, was to encourage intensive research into key issues surrounding challenges towards sustainable food system, and to share the results of that research in a collaborative setting with our Southeast Asian higher education institutes. The key drivers were to generate reliable evidence to derive the knowledge necessary for concrete policy making and to promote food system transformation.

The primary challenges and issues are critically important to all sectors of our societies—such as impacts of climate change, environmental degradation, and an aging population. It was determined that research to be undertaken should focus on sustainable agricultural production, access to nutritious food, and regional agricultural value chain chains.

These goals are directly aligned with the United Nation's Sustainable Development Goals, which advocate concerted actions related to sustainable agriculture in order to achieve zero hunger and to improve food security, nutrition, and good health.



Institutions of higher education, particularly research universities, have the responsibility to engage in innovative research that generate the evidence and knowledge needed to address these challenges and meet the UN's SDGs.

To accelerate the process for research and knowledge sharing, the Organizing Committee decided to plan public forums, focusing particularly on the next generation of talented researchers.

This symposium provides an effective platform for knowledge sharing. The format intentionally provides opportunities to young academics and university students, who have been invited to engage in research, hear from experts, and to collaboratively exchange their experience and knowledge. These perspectives fill research gaps that promote to policy development and actions that we all hope will to resolve the issues that commonly challenge countries throughout the Southeast Asia region.

The universities who have contributed to the central planning and implementation of this symposium have each achieved wide regard for their leadership in promoting high quality education and research, particularly in areas involving food policy development, food systems, agricultural and resource economics, environmental economics, agribusiness and related fields.

This is the first symposium addressing these challenges in our region, but it is not the last.

The eleven research universities, from diverse ASEAN member countries, will sign a Letter of Intent to collaboratively pursue the following objectives:

1. To offer academic training in agricultural economics, agribusiness, agricultural and food policies, and related fields to play a greater role in capacity building supporting a younger generation of scholars;
2. To motivate graduate students and young researchers in Southeast Asian professions to engage in good quality research focusing on the sustainable food system; and
3. To provide a platform for sharing research outputs, and the exchange of knowledge and experiences related to food system analysis.

I wish to acknowledge the contributions of the organizing institutions:

- Department of Agricultural Economy and Development, Faculty of Agriculture, Chiangmai University, Thailand
- School of Economics, Can Tho University, Vietnam
- Faculty of Economics, IPB University, Indonesia
- Institute for Population and Social Research, Mahidol University



- Faculty of Economics and Business Management and Department of Rural Economics and Food Technology, Faculty of Agriculture, National University of Laos, Laos PDR
- Faculty of Agriculture, Sultan Sharif Ali Islamic University, Brunei
- Department of Agribusiness and Bioresource Economics, Faculty of Agriculture and Institute of Ecosystem Science Borneo, Universiti Putra Malaysia, Malaysia
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- Department of Agricultural Economics, Yezin Agricultural University, Myanmar
- Department Agricultural and Resource Economics, Faculty of Economics, Kasetsart University, Thailand

The technical committee representing all member universities is committed to ensuring high quality research in the papers presented here. In total, 31 papers have been selected.

Finally, the Organizing Committee wishes to thank Kasetsart University, particularly the Department of Agricultural and Resource Economics, Faculty of Economics, for its support in hosting the symposium. We also thank the speakers and students for their creativity and participation ... your hard work and time devoted to your research are greatly appreciated. And, I want to thank my colleagues and the staff in the Faculty of Economics for their assistance.

Thank you.



Opening Remarks
by
Dr. Chongrak Wachrinrat, Ph.D.
President of Kasetsart University
✧-----✧

Researchers and representatives from partner universities,
Faculty colleagues, Distinguished guests and students

Good morning!

On behalf of Kasetsart University, I am pleased to have this opportunity to extend a warm welcome to all of delegations and participations to the ASEAN University Symposium for Sustainable Food and Hybrid Systems.

I wish to give a special welcome to our presenters, who are young scholars and dedicated researchers, from 11 different ASEAN universities.

Today's event, the first ASEAN University Symposium for Sustainable Food and Hybrid Systems, addresses important issues that confront all of us ... related to food production and access to healthy food. We are all aware that many of the challenges are caused by climate change and damage to our environment ... which has placed great demands on our food production systems.

Since Kasetsart University was established, more than 80 years ago, the university has taken steps to become the leading university in Thailand and in the region, by promoting quality education, teaching and research, focusing on agricultural production and processing. The Faculty of Economics has undertaken to integrate economic analysis into agricultural development ... seeking to promote the health and well-being of all sectors of the global community.

The University's diverse academic programs are aligned with the United Nation's Sustainable Development Goals and are intended to promote sustainable agriculture production to achieve zero hunger, better nutrition, and good health.

Kasetsart University is respected for its research, but we are aware that our success has often been achieved in collaboration with partners from across the world. So I wish to express great gratitude to our many ASEAN partner universities, particularly to the talented graduate students and researchers for presenting your research and for entering into a dialogue with us.



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I also wish to recognize the creative team representing the many ASEAN universities who collaborated to plan this symposium. And, of course, many thanks to the faculty and staff from the Faculty of Economics for your many hours of hard work.

To all of you, thank you very much for joining us today at Kasetsart University. We all hope this is merely the first in a long series of symposiums, with a high impact.
Welcome!



Welcome Address
by
Asst. Prof. Visit Limsombunchai, Ph.D.
Dean, Faculty of Economics, Kasetsart University

✧—————✧

Good Morning!

Dear distinguished speakers and participants,

It is my great honor to welcome you, on behalf of Kasetsart University Faculty of Economics, to the ASEAN University Symposium for Sustainable Food and Hybrid Systems, organized by a team of dedicated academics and researchers from 11 ASEAN universities, who have worked together to plan and implement this symposium.

The Faculty of Economics has two central missions: to train undergraduate and graduate students in the methods and ideas of modern economics and also to conduct innovative and applied research. Our goals are to provide, through teaching and research, a better understanding of the economic issues that confront our global society and to push forward the frontier of knowledge in a variety of fields related to economics.

This Symposium focuses on challenges shared within ASEAN nations regarding sustainable food systems. I am confident that the presentations will present solid evidence-based research that will strengthen agricultural economics, agri-business, and agri-food policy. These insights and knowledge seek to ensure more sustainable agricultural production and improved access to healthy foods for all within the ASEAN region.

We are honored that many talented, young researchers have joined together for this Symposium from 11 ASEAN universities. It is an outstanding group: I am aware that the participating universities are top-ranked in the field of agriculture or health sciences in their respective country or region.

The participants provide a wide scope of expertise based on their studies and research in various aspects of sustainable food production and food systems. I am confident that their findings provide practical insights and realistic solutions to real-world, Southeast Asian issues.

These presentations advance the educational goals of the Faculty of Economics. We greatly appreciate your contributions. I am confident that all of us will find the presentations thoughtful and instructive. We look forward to hearing from each of you.



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Before we begin the proceedings, I wish to specifically thank the team of scholars from the organizing ASEAN universities, and the staff from our own Faculty of Economics, for your hard work and thoughtful planning. As academic institutions, we look forward to supporting the next generation of scholars to build skills and gain experience related to sustainable food system in our region.

To all of you. thank you for attending and again, welcome!
Thank you.

ASEAN University Symposium for Sustainable Food System



CONTENTS

	Page
Concept Note	i
Plenary session	
Report of the Organizing Committee	iv
Opening Remarks	vii
Welcome Address	ix
CONTENTS	xi
PROCEEDINGS	
Track 1: Towards sustainable production	1
Cost-Efficiency of Small and Semi-Commercial Broiler Farms in Peninsular Malaysia	2
Economic Analysis of Direct Seeded Rice Production in Zeyarthiri Township, Nay Pyi Taw Union Territory	13
Track 2: Resilience of food system	26
Determinants of food waste behavior on Muslim Generation Z in Padang City, Indonesia	27
Determinants of Using Cold Storage Technology: Insights from Onion Farmers in Bongabon and San Jose City, Nueva Ecija, Philippines	39
The Potential of Vertical Farming in Brunei Darussalam	51
Assessment of the Economic Effect of Value-Adding Activities in the Production and Marketing System of Salt in Ilocos Norte, Philippines: The Case of Pagnasahan Norte Agas Asin Association	70
Track 3: Coping with vulnerability and risk	81
Structural Price Fluctuation Caused by Oil Price Variation in China's Mutton and Beef Market	82
Spatial Price Transmission in the Retail Rice Markets of the Philippines	92
Cointegration Analysis of the World's Black Pepper Export Market among Major Producers	113
Attitudes towards Risk and Optimal use of Inputs in Maize Production in the Mekong Delta, Vietnam	127
Track 4: Natural resource and nature positive system transformation	144
Study on Marketable Rice Varieties, Strength, Weakness of Rice Marketing and Value Added Products in Nay Pyi Taw Union Territory, Myanmar	145
The Impact of Climate Change on Indonesian Rice and Coffee Sectors	157
Valuation of Reef Tourism: A Preliminary Review and Lessons Learned for a Study in the Philippines	169
Economic Valuation of Water Provisioning Services in the Recharge Area of Ciburial Spring, Bogor Regency	182



CONTENTS

	Page
Track 5: Consumer behavior	200
Per Capita Fish Consumption in Nay Pyi Taw Union Territory, Myanmar	201
Healthy Rice Consumption Behaviour in Nay Pyi Taw, Myanmar	208
Track 6: Agribusiness and sustainable management	223
SWOT Analysis of Myanmar Indigenous Chicken (MIC) Enterprises in Nay Pyi Taw, Myanmar	224
Factors Influencing Access to Formal Credit by Pottery Households: Case Study in Bat Trang Village, Hanoi, Vietnam	236
Bio-fertilizers from Food Wastes for Sustainable Agriculture in Brunei Darussalam	250
Social Return on Investment of Chiang Mai's Urban Pesticide-free Vegetable Production System Development Project	264
Track 7: Food and nutrition security	274
Food and Nutrition Security Vulnerability to the Don Sahong Hydropower Dam	275
Household Food Security, Diet Diversity, and Nutritional Status of Preschool Children (36 to 59 Months) of Fishing Households from the Seven Lakes in San Pablo City, Laguna, Philippines	290
Track 8: Food system and innovation	305
Drinking Water and Beverage Intake after COVID-19: Case Study in Nay Pyi Taw Council Area, Myanmar	306
Innovation Models in Agriculture and Rural Development in the Lao PDR	315
Appendix	331
Organizing Committee	332
Local organizing committee	333
Technical Committee	334
Program agenda	337



Track 1

Towards sustainable production



Cost-Efficiency of Small and Semi-Commercial Broiler Farms in Peninsular Malaysia

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Abstract

The broiler industry in Peninsular Malaysia faces significant challenges, including escalating production costs influenced by volatile feed prices, supply dependencies, and disruptions such as the COVID-19 pandemic. A comprehensive investigation was undertaken on 105 small and semi-commercial broiler farms in Peninsular Malaysia, employing structured questionnaires and a stratified random sampling approach. The study aimed to estimate the cost-efficiency of broiler farming and determine the factors affecting farm-level cost inefficiency. The findings confirm the presence of cost inefficiencies in small and semi-commercial broiler production in the area studied. Specifically, the research identified an operational inefficiency of approximately 7.1% above optimal costs among surveyed farms, suggesting a potential 7.1% reduction in production costs through enhanced management strategies. The findings indicate day-old chicks, feed, medicine, miscellaneous inputs, output, and capital significantly influenced cost function. Additionally, the study explored the significant role of extension services in reducing cost inefficiencies, with farms benefiting from such services exhibiting lower inefficiencies. In conclusion, this research provides critical insights into the complex relationships between efficiency drivers and inefficiencies within the broiler farming sector in Peninsular Malaysia. These identified factors offer valuable information for stakeholders to formulate effective strategies, optimize production processes, and enhance the competitiveness and sustainability of the industry.

Keywords: broiler, cost efficiency, stochastic frontier

JEL code: D24, Q12

SDG goals: Zero Hunger, Decent Work and Economic Growth, Responsible Consumption and Production

Introduction

Livestock is one of the most important industries in Malaysia's agricultural sector. The livestock industry in Malaysia includes ruminant animals (small and large), swine and poultry. The Malaysian poultry industry, comprising broilers, layers, ducks, quail, and geese, plays a crucial role in the nation's agricultural landscape. In 2022, Malaysia secured the 21st global rank and emerged as Southeast Asia's third-largest poultry producer (Food and Agriculture Organization Statistics, 2024). With an impressive ex-farm value of MYR 13,031.21 million (USD 272,790.66) in 2022, this sector significantly contributes to Malaysia's Gross Domestic Product (GDP) and addresses domestic food security concerns (Department of Veterinary Services Malaysia, 2024). Chicken production dominates at 95%, followed by ducks at 3.8% and other poultry species at 1.07%. As production and consumption have steadily risen, the industry has explored export opportunities to neighbouring countries.



While achieving self-sufficiency in poultry meat production in the 1970s marked a significant milestone for Malaysia, the industry continues to grapple with persistent challenges. Despite technological advancements and research and development (R&D) efforts fuelling growth, issues of production accessibility, sustainability, and suboptimal resource utilization persist. Shamsudin (2013) and Benaliwa et al. (2018) have highlighted these challenges, particularly concerning the high cost of production and profitability. High production costs, primarily driven by feed expenses constituting approximately 70% of total broiler production costs (Mallick et al., 2020; Ariffin et al., 2014; Firdaus and Komalasari, 2010), pose a significant hurdle. The industry's heavy reliance on imported feed ingredients exacerbates this challenge, exposing it to price volatility and global market fluctuations (Shaban and Alabboodi, 2019). The COVID-19 pandemic further aggravated these issues, causing supply chain disruptions and economic upheaval (Ijaz et al., 2021; Tortajada and Lim, 2021), directly impacting operational costs for broiler farms and diminishing profitability, particularly for small-scale farmers (Abro et al., 2020; Md. Isa et al., 2019). Recognizing these challenges underscores the significance of cost efficiency in ensuring the industry's sustainability (Kelly et al., 2012) and necessitates the development of strategies to address them effectively.

While previous research in Peninsular Malaysia has predominantly focused on technical efficiency (Yunus, 2012; Gabdo et al., 2017), there remains a notable gap regarding the assessment of specific cost inefficiencies within the broiler industry in this region. According to Etuah et al. (2020), research examining broiler production from a cost-efficiency perspective is limited, and a sole focus on technical efficiency might be misleading. Furthermore, there has been limited investigation into the factors influencing cost inefficiencies, such as contract farming participation, housing systems, and extension visits, within the Peninsular Malaysia broiler industry. Understanding these factors is crucial for developing effective strategies to enhance cost efficiency. Therefore, this study aims to analyze the cost efficiency of broiler farming and investigate the factors affecting farm-level cost inefficiency. The findings are expected to provide actionable insights for policymakers and industry stakeholders, facilitating the implementation of measures to reduce production costs, ensure industry sustainability, and align with national agricultural policies.

Methodology

Data Collection

This study employed a comprehensive survey across 105 small and semi-commercial broiler farms in Peninsular Malaysia, utilizing structured questionnaires and a stratified random sampling technique. Stratified random sampling involves dividing the population, in this case, regions in Malaysia, into subgroups or strata based on specific criteria. In this study, the strata were defined based on the scale of broiler farms, with a particular focus on small (<10,000 birds) and semi-commercial (10,000-49,999 birds) operations due to their prevalence and significance within the industry. Subsequently, samples were randomly selected from each stratum, ensuring representation from different scales of broiler farming operations across the region, with an emphasis on small and semi-commercial farms. This targeted approach allows for a more in-depth analysis of cost efficiency factors within these specific segments of the broiler farming industry, providing valuable insights for policymakers and industry stakeholders. Primary data were gathered through surveys by using questionnaires administered directly to broiler farmers, focusing on information related to each cycle of broiler production.



The structured questionnaires used in this study were designed to gather detailed information on various aspects of broiler farming practices. Broiler farmers were asked about their cost and usage of inputs such as feed, day-old chicks, medicine, and capital, as well as their output levels and production cycles. Additionally, questions related to participation in extension services, contract farming arrangements, and housing systems were included to capture the broader context of farm management practices and their potential influence on cost efficiency.

Model Specification

In this study, the Stochastic Cost Frontier Analysis employing the Cobb-Douglas functional form is conducted using the one-stage maximum likelihood estimation method. The choice of the Cobb-Douglas functional form for modelling the stochastic cost frontier is based on its established utility in agricultural economics and its ability to capture the complex relationships inherent in broiler farming (Kumbhakar & Lovell, 2000). By incorporating the one-stage maximum likelihood estimation method, the study aims to simultaneously estimate the parameters of the production function and the variance components of the error term, providing a comprehensive analysis of cost efficiency in broiler farming.

The one-stage maximum likelihood estimation method streamlines the estimation process by jointly estimating the parameters of the production function and the variance components, making it computationally efficient and statistically robust (Greene, 2008). This methodological approach accommodates the complexities of broiler farming by allowing for the representation of production relationships involving multiple inputs and outputs while accounting for stochastic variation in cost efficiency across firms (Kumbhakar & Lovell, 2000). Furthermore, employing the one-stage maximum likelihood estimation method within the stochastic cost frontier analysis framework ensures compatibility with existing literature and enhances the interpretability and reliability of our analysis regarding cost efficiency in broiler farming. By leveraging this well-established methodology, we can assess inefficiencies in broiler cost functions and identify opportunities for improving cost efficiency within the industry.

The frontier cost function serves as a metric for assessing inefficiencies in broiler cost functions. Efficiency with respect to cost is gauged by the proximity of firms to the cost frontier, a concept delineated by Etuah et al. (2020). Performance, as elucidated by Kumbhakar and Lovell (2000), pertains to the minimization of costs associated with producing a specific product, factoring in input prices and external variables shaping the operational milieu. Consequently, the degree of divergence of a farm or firm from its cost frontier signifies its level of cost inefficiency, as highlighted by Lovell (2008).

Following the theoretical framework outlined by Kumbhakar and Lovell (2000), the implicit stochastic cost frontier model is expressed by the equation:

$$C = (f(y, w; \beta) \cdot \exp\{v\}) \cdot \exp\{v + u\} \quad (1)$$

Here, C represents the total cost, y signifies the output level, w represents the vector of input prices, and β stands for the vector of estimated parameters. In this equation, $f(y, w; \beta) \cdot \exp(v)$ describes the minimum frontier cost, where v represents the random effect beyond the variable, and u reflects the level of cost inefficiency.



To accurately estimate the model, a functional form is necessary to differentiate between the two error terms. Several functional forms commonly employed include the Cobb-Douglas, constant elasticity of substitution, quadratic, normalized-quadratic, generalized Leontief, and trans-log functions. However, for simplicity, this study adopts the Cobb-Douglas (log-linear) functional form over more complex alternatives. This decision offers practical advantages in statistical estimations. Utilizing the available technology, producer-specific cost efficiency (CE) scores can be derived by computing the ratio of observed cost (C^{obs}) to the corresponding minimum cost (C^{min}). This computation can be represented as follows (Etuah et al., 2020):

$$CE = \frac{C^{obs}}{C^{min}} = \frac{f(y_i, x_i; \beta) \cdot \exp(v_i + u_i)}{f(y_i, x_i; \beta) \cdot \exp(v_i)} = \exp(u_i) \quad (2)$$

In the literature, cost efficiency is represented in two distinctive ways. The first way involves cost efficiency (CE) values equal to or greater than one, where one signifies a cost-efficient farm, as demonstrated by Aji et al. (2023), Etuah et al. (2019), Ogandari et al. (2006) and Coelli (1996). If $CE = 1$, it denotes a cost-efficient farm positioned on the frontier. Conversely, if $CE > 1$, it indicates a less cost-efficient farm situated above the frontier. The second way employs CE values constrained between 0 and 1, as outlined by Kumbhakar and Lovell (2000). This range encompasses farms with efficiencies varying from complete inefficiency (0) to total efficiency (1). A smaller ratio indicates greater inefficiency, as highlighted by Battese and Coelli (1995).

By employing the Cobb-Douglas (log-linear) functional form, the implicit stochastic cost frontier model can be specified in an explicit form as follows:

$$\ln(C_i) = \beta_0 + \sum_{k=1}^7 \beta_k \ln P_{ki} + \alpha \ln y_i + (v_i + u_i) \quad (3)$$

Where:

$\ln$ = natural logarithm

C_i = Total production cost by i th broiler farms per cycle (MYR/farm)

P_1 = The average price per kilogram of feed (MYR/kg)

P_2 = The average price of a day-old chick (MYR/chick)

P_3 = The wage rate (MYR/man-day)

P_4 = The average price of medicine (MYR/chick)

P_5 = The average price of capital input (MYR), measured as the straight-line method's depreciated cost of fixed-cost items

P_6 = The average price of utilities per production cycle (MYR)

P_7 = The average price of miscellaneous inputs per production cycle (MYR) (i.e. transportation, bedding cost, maintenance and catcher charges); and

y_i = Output level (kilograms of broilers produced per cycle)

β = Parameters to be estimated and expected to have positive signs

i = i th farm in the sample, $i=1,2,\dots,n$ where n is the number of the farm.

The logarithm or natural logarithm transformation of both sides of the implicit model is imperative for linearizing the Cobb-Douglas functional form with respect to the parameters. This procedural step streamlines the estimation process by eliminating the exponent and segregating the two error terms from the cost function of the implicit stochastic cost frontier model.



In addition to the generic stochastic cost frontier model, an inefficiency model (u_i) is required to represent the influence of managerial ability factors on cost inefficiencies. The empirical specification of the u_i model of inefficiency is as follows:

$$u_i = \alpha_0 + \alpha_1 \text{Contract Farming} + \alpha_2 \text{Extension} + \alpha_3 \text{Housing system} + e_i \quad (4)$$

The dependent variable in the cost inefficiency model is the cost inefficiency variable (u_i), and the explanatory variables are the factors that are thought to have an impact on cost inefficiency. "Contract farming" is represented by a dummy variable, taking the value of 1 if the farmer participates in contract farming and 0 otherwise. The variable "extension" denotes the frequency of veterinary service visits, while the "housing system" is indicated by a dummy variable: 1 if the farmer uses a closed-house system and 0 if the farmer uses an open-house system." Contract farming is incorporated into the model due to its pivotal role in fostering efficient broiler farming practices, resulting in increased production, enhanced market efficiency, and added value potential while reducing costs (Gabdo et al., 2017). Participation in contract farming may influence cost efficiency by affecting input quality, access to markets, and risk-sharing arrangements, thereby impacting overall farm profitability (Key & Runsten, 1999; Gabdo et al., 2017).

The inclusion of veterinary contact aims to assess the impact of technical advice provided by veterinarians on cost inefficiency. Guidance from professionals like veterinarians enables broiler farmers to effectively manage disease conditions, reducing bird mortality rates and minimizing costs associated with disease-related deaths. Access to technical advice and information through extension services can help farmers adopt best practices, optimize resource utilization, and mitigate production risks, thereby reducing inefficiencies and enhancing profitability. Moreover, the housing system variable is included to account for the efficiency disparity between farmers using closed and open systems. Closed systems tend to exhibit higher efficiency due to their utilization of advanced technology and superior management practices, as indicated by studies such as Gabdo et al. (2017).

Results and discussion

The descriptive statistics provided in Table 1 offer insights into various aspects of broiler farming in the studied area. On average, the total production cost for broiler farming is MYR 295,540.65 (USD 61867.42), with a notable standard deviation of MYR 180,610.37 (USD 37808.32), indicating substantial variability in production costs across farms. The cost of feed per kilogram averages MYR 2.66 (USD 0.56), showing relatively consistent pricing among suppliers, whereas day-old chicks (DOC) are priced at an average of MYR 2.46 (USD 0.51), with some variability noted in chick prices. Labour costs, represented by the average wage rate per man-day of MYR 70.63 (USD 14.79), exhibit variability across farms, as indicated by the standard deviation of MYR 24.89 (USD 5.21). Similarly, medication costs per chick show variability, with an average cost of MYR 0.24 (USD 0.050) and a standard deviation of MYR 0.60 (USD 0.13). Capital inputs display significant variability, with an average cost of MYR 2,962.72 (USD 620.21) and a high standard deviation of MYR 3,887.59 (USD 813.81), reflecting differences in capital investment among farms. Utilities and miscellaneous inputs also show variability in costs, with average expenditures of MYR 3,927.27 (USD 822.12) and MYR 8,072.68 (USD 1689.91), respectively. The average output level, measured in kilograms of birds produced, is 49,259.17, with variability observed among farms. Contract farming is prevalent, with 76% of farms participating in such arrangements, while the mean frequency of veterinary visits is 3.70, indicating variability in the provision of veterinary support.



Additionally, around 40% of farms use a closed-house system for broiler production, with the remaining 60% employing an open-house system.

Table 1. Descriptive statistics for the variables employed

Variable	Mean	Std. Deviation
Total production cost (MYR)	295,540.65	180,610.37
Feed cost per kg (MYR)	2.66	0.15
Price of a day-old chick (MYR)	2.46	0.62
Wage rate per man-day (MYR)	70.63	24.89
Cost of Medicine per chick (MYR)	0.24	0.60
Cost of capital inputs (MYR)	2,962.72	3,887.59
Cost of Utilities (MYR)	3,927.27	5,039.40
Cost of Miscellaneous Input (MYR)	8,072.68	16,236.60
Output level (kilograms of birds produced)	49,259.17	29,930.76
Contract Farming (1=Yes, 0=No)	0.76	0.43
Extension (Num of visited frequency)	3.70	3.58
Housing system (1=Closed house, 0=Open house)	0.40	0.49

Source: Survey data (2023)

The maximum-likelihood estimates presented in Table 2 reveal several significant coefficients in the stochastic cost frontier model in broiler farming within Peninsular Malaysia. The observed positive trends in the coefficients of all variables indicate that elevated input costs or increased output levels correspond to higher production costs, consistent with previous research by Etuah et al. (2020), Dziwornu (2017), and Ogundari et al. (2006). Key coefficients such as Feed (β_1), Day-Old Chick (DOC) (β_2), Capital (β_5), Miscellaneous (β_7), and Output (y_i) demonstrate significance at the 1% level, with Utilities (β_6) being significant at the 5% level. This emphasizes the significant role of these factors as cost drivers in broiler farming. The substantial impact of feed costs aligns with established literature highlighting its substantial contribution to total production costs in poultry farming (Fanatico et al., 2009). For instance, a 1% increase in the cost of feed is associated with approximately a 0.62% rise in total production costs, highlighting the importance of optimizing feed management strategies to enhance cost efficiency. Similarly, the positive coefficient for day-old chicks suggests that investments in chick quality and management practices may influence overall cost efficiency positively.

Furthermore, the positive coefficient for output (y_i) suggests the presence of economies of scale in broiler farming operations, indicating that larger farms enjoy cost advantages over smaller counterparts. Specifically, for each additional kilogram of broilers produced, the total production costs increase by approximately 0.8401 units. This finding is consistent with previous research and implies that factors such as bulk purchasing discounts and better resource utilization contribute to cost efficiencies (Sharma et al., 2017). Conversely, the negligible effects observed for Wage (β_3) and Medicine (β_4) expenses suggest that these inputs may not significantly contribute to cost variations among broiler farms in Peninsular Malaysia. Additionally, the highly significant constant term (β_0) represents the baseline cost when all other variables are zero, while the Sigma squared parameter denotes the estimated variance of the error term, highlighting unexplained variability in costs.

The Gamma parameter, as outlined by Coelli et al. (2005), serves as a metric of cost inefficiency in production, reflecting the degree to which farms deviate from the optimal cost frontier due to factors such as suboptimal resource allocation and managerial shortcomings.



This parameter quantifies the extent of this deviation, with a statistically significant Gamma value (0.5220) indicating a substantial level of unexplained variability in production costs within the industry. A higher Gamma value suggests a greater proportion of unexplained variability attributable to inefficiencies in resource allocation and managerial capabilities. Therefore, stakeholders can leverage their understanding of Gamma to discern the magnitude of inefficiencies and develop targeted interventions aimed at enhancing cost efficiency within the broiler industry.

Moreover, the negative coefficient for extension services (α_1) implies that farms with access to agricultural extension programs tend to exhibit a decrease in cost inefficiency, emphasizing the role of extension services in disseminating best practices and technological innovations to enhance farm productivity and efficiency (Olorunfemi et al., 2020). Similarly, the coefficient for contract farming (α_2), while statistically insignificant, suggests that farms engaged in such arrangements may experience slightly lower inefficiency due to access to technical support, inputs, and markets (Harianto et al., 2019). This could be due to contractual agreements providing structured support that helps in minimizing inefficiencies. Surprisingly, the coefficient for the housing system (α_3) is negative and statistically insignificant, indicating that the type of housing system employed by broiler farms does not significantly influence cost efficiency in the studied context. Further investigation into the specific characteristics and management practices associated with different housing systems may elucidate their differential impacts on cost efficiency in broiler farming.

Moreover, the null hypothesis indicates the absence of cost-inefficiency effects in the models. The assessment of technical inefficiency was conducted through the Likelihood Ratio (LR) test, resulting in a test statistic of 27.9674. This value falls above the critical chi-square threshold of 24.049, as specified by Kodde and Palm (1986). Consequently, the null hypothesis concerning cost inefficiency is rejected. This robust rejection provides compelling evidence for the existence of producer-specific cost inefficiencies within the model, as detailed in Table 2.

Table 2: Maximum Likelihood Estimates for Cobb-Douglas Stochastic Cost Frontier

	Parameter	Coefficient	Standard-Error	T-Ratio
Stochastic Cost Frontier Model				
Constant	β_0	1.3066***	0.3372	3.8749
Feed	β_1	0.6155***	0.2426	2.5375
DOC	β_2	0.2337***	0.0748	3.1239
Wage	β_3	0.0085	0.0449	0.1889
Medicine	β_4	0.0083	0.0175	0.4767
Capital	β_5	0.0250***	0.0114	2.1974
Utilities	β_6	0.0031**	0.0157	0.1981
Miscellaneous	β_7	0.1297***	0.0201	6.4664
Output	y_i	0.8401***	0.0262	32.0659
Inefficiency Model				
Constant	α_0	0.1275	0.0847	1.5052
Contract Farming	α_1	-0.1654	0.1320	-1.2533
Extension	α_2	-0.0261***	0.0129	-2.0291
Housing System	α_3	-0.7724	0.8288	-0.9319
Sigma squared	$\sigma^2 = \sigma^2_v + \sigma^2_\mu$	0.0363***	0.0126	2.8747
Gamma	$\gamma = \sigma^2_\mu / \sigma^2$	0.5220***	0.1781	2.9319



Parameter	Coefficient	Standard-Error	T-Ratio
Log-likelihood function	56.5687		
LR test	27.9674		

Source: Survey data estimates, 2023

*** Estimates are significant at a 1% level of significance, ** 5% level of significance and; * 10% level of significance.

The mean predicted score of 1.0707, as indicated in Table 3, provides valuable insights into the cost efficiency of broiler farms in the surveyed area. This figure suggests that, on average, broiler producers exhibit a 7.1% inefficiency in their cost management practices. In practical terms, this inefficiency implies that approximately 7.1% of the costs incurred by broiler producers exceed what would be considered optimal or necessary given their production output and the technology they utilize.

Furthermore, the frequency distribution of cost inefficiency levels among the surveyed broiler farms highlights the distribution of inefficiencies across different levels within the industry. Notably, around 69.5% of respondents are operating within a relatively narrow range of cost inefficiency (between 1.01 and 1.09), indicating that the majority of farms are relatively close to the optimal cost frontier. However, it's crucial to note that a significant portion of farms, approximately 30.5%, exhibit higher levels of inefficiency, with 25.7% falling within the 1.10-1.19 range, 3.8% within the 1.20-1.29 range, and 1.0% within the 1.40-1.49 range.

These findings suggest both opportunities and challenges for improving cost efficiency within the broiler industry. While the majority of farms are operating near the cost frontier, indicating a degree of efficiency, there remains significant room for improvement, particularly among those farms exhibiting higher levels of inefficiency. Addressing these inefficiencies through targeted interventions, such as optimizing input utilization, improving management practices, and leveraging technological innovations, can help enhance overall cost efficiency and competitiveness within the broiler farming sector. Additionally, providing support and resources to help farms transition closer to the optimal cost frontier can yield benefits not only for individual producers but also for the industry as a whole, contributing to its sustainability and resilience in the face of challenges.

Table 3: Frequency Distribution of Cost Inefficiency Levels of the Broiler Farms

Cost efficiency estimates	Level of cost inefficiency	Relative frequency (%)
1.01-1.09	0.01-0.09	69.5%
1.10-1.19	0.10-0.19	25.7%
1.20-1.29	0.20-0.29	3.8%
1.30-1.39	0.30-0.39	0.0%
1.40-1.49	0.40-0.49	1.0%
Total		100%
Minimum	1.014844	
Maximum	1.414930	
Mean	1.070704	
Standard Deviation	0.063510	

Source: Authors' calculations based on survey data.



Conclusion

In conclusion, this study provides valuable insights into the complexities of cost efficiency and its determinants within the Peninsular Malaysia broiler industry. The observed significant coefficients for variables such as feed costs, day-old chick prices, capital investments, utilities, and miscellaneous inputs underscore their pivotal role in shaping production costs. Additionally, the presence of economies of scale highlights the strategic advantage of larger farming operations, suggesting opportunities for consolidation and expansion within the industry. Of particular significance is the impact of access to extension services on cost inefficiency, emphasizing the critical role of support mechanisms in enhancing overall industry efficiency. The findings of this study reveal a notable inefficiency of approximately 7.1% above optimal costs among surveyed farms, indicating substantial potential for cost reduction through improved management strategies. This underscores the urgency for stakeholders to address inefficiencies and implement measures aimed at enhancing cost efficiency within the broiler industry.

The practical implications derived from these findings can guide policymakers and industry stakeholders in formulating effective strategies to improve cost efficiency and competitiveness within the broiler sector. Recommendations include optimizing feed management practices, promoting economies of scale through farm consolidation, and strengthening extension services. Collaboration with policymakers to implement these measures is essential for navigating the challenges posed by rising production costs and ensuring the long-term sustainability of the broiler industry in Peninsular Malaysia.

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Economic Analysis of Direct Seeded Rice Production in Zeyarthiri Township, Nay Pyi Taw Union Territory

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Abstract

As rice is the most important income crop in Myanmar and the direct seeded rice production method is the most commonly used in Nay Pyi Taw Union Territory. The objectives of the study were to observe economic analysis and factor shares of direct seeded rice production and examine the reasons and constraints of the farmers for using direct seeded rice methods in the study area. The survey was conducted in August 2023. A total of 75 direct-seed farmers from three village tracts in Zeyarthiri Township were selected by using the purposive sampling method, only DSR farmers. Descriptive, economic analysis and factor shares were used to fulfill the objectives of the study. In terms of cost and return analysis, the benefit-cost ratios were 1.79 for wet DSR, 1.74 for dry DSR and 2.21 for DSR with drum seeder indicating that the sampled farmers profit from their DSR methods. Higher input costs were the major constraints faced by the DSR methods of the sampled farmers. The reasons for changing DSR methods are low cost than transplanting, labor scarcity at peak season. The major constraints were loss of seeds in the fields, high price of fertilizers and labor scarcity at peak season. To achieve increased productivity DSR with drum seeder method should be encouraged for getting more profits and farm mechanizations also should be supported in time to farmers who are faced with labor scarcity problem. And the availability of adequate irrigated water sources should be provided for rice production.

Key words: benefit cost ratio, Constraint, Drum seeder, Dry DSR, Wet DSR

JEL code: D24, D33, E23, O12

SDG goals: Zero Hunger; Industry, Innovation and Infrastructure; Responsible Consumption and Production; Partnerships for the Goals

Introduction

Rice is a staple food for over half of the world's 7.7 billion people (Bhandari, 2019). It is an important economic, social, political, and cultural commodity in most Asian countries.

Rice is the 1st most widely consumed, 2nd most largely produced, and 3rd most widely grown food crop in the world. About (90%) of the total rice is produced in Asia. China and India, the two biggest rice producers, account for over half of the world's rice production.

The world's average annual per capita milled rice consumption is 64 kg per year providing (19%) of daily calories. Asia accounted for (84%) of global consumption, followed by Africa (7%), South America (3%), and the Middle East (2%). Asia's per capita rice consumption is 100 kilograms per year, providing (28%) of daily calories. The top five rice exporting countries are India, Thailand, Vietnam, Pakistan, and China, accounting for (74%) of the global rice export. The top five rice-importing countries are China, the Philippines, Nigeria, the European Union, and Saudi Arabia, which account for (26%) of global rice imports.

Rice is known as the grain of life and is synonymous with food for Asians. In addition to being a staple food and an integral part of social rites, rituals, and festivals in almost all Asian



countries, it has a medicinal value too, which was clearly recognized by the medicine systems of the region centuries ago. Rice (*Oryza sativa*, L) is the most important food crop in the developing world. Rice production is central to the economy and food security of Myanmar. In Myanmar, rice is not only known as the main staple food but also as an important national crop. Rice cultivation in Myanmar is crucial for the country's economy, employment, and food security.

Rice is grown throughout the agro-climatic conditions of the country (Oo and Kyu, 2012). Among the regions and states, Ayeyawady, Sagaing, Bago, Mandalay and Yangon are major rice growing areas (MOALI, 2021). The cultivation methods have a great impact on the growth and yield of rice and the choice of planting method may be influenced by the availability of technology and labor, particularly in developed countries where labor is scarce (Birhane, 2013). There are different rice planting methods but the most common ones are transplanting and direct seeding methods. DSR is a major yield declining factor and if managed well can help to increase yields by substantial level. Furthermore, DSR avoids the transplanting shock hence attains the physiological maturity earlier than transplanted rice and reduces the vulnerability to late season drought. Yield in DSR is expected to be often lower than TPR principally due to poor crop stand, high percentage of panicle sterility, higher weed and root-knot nematode infestation. But, higher yield, root dry matter, benefit cost ratio and infiltration rate was recorded in DSR than TPR while comparing productivity and economics of various planting techniques in rice based cropping systems in the Indo-Gangetic Plains (Gangwar et al., 2008). It is reported that productivity of DSR is (5-10%) more than the yield of transplanted rice. Farmers get a higher net economic return under wet or dry DSR than TPR, with (13%) higher for wet DSR (Chakraborty et al., 2017). Sahrawat et al., (2010) also observed under dry DSR input and cost of cultivation, (13-16%) labor saving in DSR as compared to manual puddled transplanted rice. Direct seeded rice (DSR) consumed (12-17%) less water as compared to puddled transplanted rice during 2011, whereas, it consumed (5-9%) more water as compared to puddled transplanted rice during 2012. The BCR was highest in direct seeded rice (DSR) in zero till condition 1.74 as compared to manual puddled transplanted rice 1.62 (Kumar et al., 2015). The drum seeder method, the highest benefit cost ratio of 1.92 were obtained whereas the transplanted rice recorded Benefit cost ratio (BCR) of 1.73 and for the broadcast method it was only 1.13.

Appropriate agricultural practices have positive and sustainable impacts on rural farmers' livelihood and decision making activities. It is necessary to improve the production of rice in order to have sufficient domestic food consumption and foreign income. Rice production and yield are increasing year by year, at the same time input and labor costs are also increasing.

Due to the high cost of production, farmers made little or no profit (Kusrini and Rizieq, 2019). There is different between input prices and output prices for agricultural products. Currently, the system of rice production run by farmers becomes more vulnerable to fluctuations in profit and loss. One way to mitigate the risk that farmers face is through the application of economic analysis of DSR production. Additionally, it is important to examine farmers' perspectives and attitudes on the DSR approach. Although manual transplanting is the common method of rice cultivation but it is too much laborious, slow and inefficient, time consuming and a lot of expenditure on raising, uprooting and transplanting of nursery (Rana et al., 2014). Also, transplanting has added disadvantages such as stress on seedlings and raising nurseries. While the economic situation has stabilized over the past months in Myanmar, the economic climate during the 2022 rice season has reportedly affected rice cultivation. The devaluation of



Myanmar's currency coupled with inflation has increased the costs associated with rice farming inputs, including seeds, fertilizers, and labor. Due to higher input costs rice farming has become more arduous for farmers, diminishing their yields' profitability. In this scenario, farmers around the world have shifted toward water and labor saving direct seeding of rice. Direct seeding also reduces methane emission. DSR saves labor as it avoids nursery raising, uprooting seedlings, transplanting as well as puddling. In Myanmar, different DSR methods were cultivated nationwide area for long period. However, need to analyze the comparison of which DSR methods is the most profitable. In Nay Pyi Taw Union Territory, the rice is one of the main income crops for farmers accounted for (79,334 ha) of total rice sown area. This study mainly focuses on the economic analysis of rice production in Nay Pyi Taw Union Territory using various DSR techniques.

The main objectives of this paper were,

1. To conduct economic analysis and factor shares of direct seeded rice production by selected farmers in Nay Pyi Taw Union Territory
2. To examine the reasons and constraints of the farmers for using direct seeded rice methods in the study area

Methodology

General description of the study area

Nay Pyi Taw Union Territory is located between the Bago Yoma and Shan Yoma mountain ranges. The city covers an area of 7,054 km² (2,724 sq miles) and has a population of 924,608 according to records (GAD, 2022). Zeyarthiri Township is selected as a sample survey area in this study. It is situated in North latitude 19° 24 ' and East longitude 96° 40 ' , estimated to be 400 feet above sea level. The total population was 114 ('000) (2021-2022). The reasons for choosing these areas were that Zeyarthiri Township has a total rice sown area of 4,931 ha and utilizes 4,882 ha as direct seeded area, or about (99%) of the total rice sown area (DOA, 2022).

Yezin Agricultural University and the Department of Agricultural Research are closely located in this area. Major crops grown in Zeyarthiri Township are rice, groundnut, green gram, etc. The most common crop grown is rice. Therefore, this study investigates the factor share contribution to the profit of rice. The total 75 direct seeded farmers from three village tracts in Zeyarthiri Township were selected by using the purposive sampling method, only DSR farmers.

Methods of analysis

Both quantitative and qualitative data were first entered into the Microsoft Excel program. The analytical techniques, which included descriptive statistics such as frequency, percentage, etc., Economic analysis and factor shares with related methods were calculated by using Microsoft excel program to fulfill the research objectives.

Economic analysis

An enterprise budget includes all the costs and returns associated with producing one enterprise in a particular manner. Enterprise budgets are constructed on a per-unit basis, such as per hectare or per head, to facilitate comparisons among alternative enterprises. Enterprise budget analysis was used to calculate the cost and benefit of rice production in the study area. In the analysis, the following variable costs are included material input cost, family labor cost, and hired labor cost.

Both cash and non-cash items were included in the estimation of material and labor costs. Non-cash items for material costs included seeds, family labor, and cow dung. Cash payment for the labor involved; hired labor payment for production. Total gross returns or benefits were calculated by total variable cash costs, excluding opportunity costs. Return above variable costs, or gross margin, and return above variable cash costs were also calculated.

Methods to economic analysis

Factor	Unit	How to calculate
Return above variable cost	MMK/ha	$RAVC = TR - TVC$
Return above variable cash cost	MMK/ha	$RAVCC = TR - TVCC$
Gross margin	MMK/ha	$GM = TR - TVC$
Benefit cost ratio (BCR)		$BCR = TR / TVC$
Break-even yield	Ton/ha	$TVC / \text{Average market price per ton}$
Break-even price	MMK/ton	$TVC / \text{Average yield per hectare}$

Source: Olson, 2003

Where;

TR	= Total revenue
TVC	= Total variable cost
TVCC	= Total variable cash cost

Analysis of factor shares

Factor shares are the ratio of the costs of factor inputs used in a production process to the total value of output, i.e., total revenue. Consider a production process in which a firm uses four inputs: current input (C), capital (K), labor (L), and land (A) to produce a single output, paddy (Q). All variables are defined in terms of flow.

If the firm purchases inputs and sells output at constant unit prices (p, i, w, r, and P, respectively), factor shares of the firm's input are: where C, K, L, and A are the physical quantities of each input factor used in production, and Q is the physical quantity of output produced (IRRI 1991).

Factor share of gross margin (%)	= Gross margin/Total revenue x 100
Factor share of interest cash cost (%)	= Interest cash cost/Total revenue x 100
Factor share of hired labour cost (%)	= Hired labour cost/Total revenue x 100
Factor share of family labour cost (%)	= Family labour cost/Total revenue x 100
Factor share of material cost (%)	= Material cost/Total revenue x 100
Total input share (%)	= Material cost+ Labour cost + Interest cost
Farmers' farm income	= Gross margin + Family labour cost

Results and discussion

This chapter includes a description of households' socio-economic characteristics, economic analysis and factor shares analysis, as well as reasons and constraints of farmers for using DSR methods in the study area.

Description of Households' Socio-economic Characteristics

Age, education levels and farming experience of household heads, farm assets, were principally considered as vital socio-economic characteristics of sampled farmers in this study. The



average age of household heads was 54 years ranging from 30 years to 80 years in Table 1. The finding highlighted that majority of the sampled farmers were about 54 years with 28 years average farming experience.

The education levels of sampled farm household heads were presented in Table 4.2. The sampled household heads education levels were distributed into five categories. Monastery education referred to informal schooling although they could read and write, primary level referred to formal education up to 5 years, middle level referred to formal schooling up to 9 years, high school level referred to formal schooling up to 11 years and graduate level mentioned to those who was attending the university and received a bachelor from university. Majority of sample household heads were middle school level (34%), primary school level (31%), and monastery education level (12%), respectively, while the rest of the farmers had undergone higher level of education. Among the gender status of household heads, there were (75%) of male headed households and (25%) of female headed households respectively (Table).

Farming experience of farmers play a vital role in agricultural production to make correct decision and to adopt DSR and take the risk. It is estimated that the higher the farmers' experience in farming, the better production capacity of the farmers. The sampled household heads operated rice production with the farming experience from 4-64 years in Table 1. As they spend almost half of their lives in farming, they had more productive experiences and potential for decision-making in rice production.

Table 1. Demographic characteristics of farm household heads of sampled farmers (n=75)

Items	Unit	Average	Range
Age	Year	53.81	30-80
Farming experience	Year	27.65	4-64
Experience by using DSR method	Year	11.33	3-51
Experience by using previous transplanted method	Year	12.05	1-57
Household size	No.	4.76	1-10
Farm size (Lowland)	ha	2.05	0.5-12
Farm size (Upland)	ha	0.80	0-8

Source: Own survey, 2023

Table 2. Gender and education level of sampled farm household heads (n=75)

Variables	Number	Percent
1.Education level of household head		
Monastery (only read & write)	9	12.00
Primary (up to 5 years)	23	30.66
Middle (up to 9 years)	26	34.67
High (up to 11 years)	11	14.67
Bachelor	6	8.00
2.Gender status of household heads		
Male	56	75.00
Female	19	25.00

Source: Own survey, 2023

Table 3. Farm assets of sampled farmers (n=75)

Items	Frequency	Percent	Items	Frequency	Percent
Hoe	72	96.00	Bullock cart	35	46.66
Sickle	64	85.33	Inter cultivator	10	13.33
Sprayer (battery)	46	61.33	Threshing machine	7	9.33
Sprayer	43	57.33	Hand tractor	6	8.00
Plough/Harrow	36	48.00	Tractor	2	2.66
Water pump	36	48.00	Combine harvester	1	1.33

Source: Own survey, 2023

Descriptive statistics of output based on each sampled farmers

According to the results presented in Table 4, the average yield of wet DSR farmers was 4.07 ton/ha, with a minimum yield of 2.47 ton/ha and a maximum yield of 5.54 ton/ha. The average yield of dry DSR farmers was 4 ton/ha, with a minimum yield of 2 ton/ha and a maximum of 5 ton/ha. The average yield of DSR by using drum seeder for DSR farmers was 4.49 ton/ha, with a minimum yield of 2.97 ton/ha and a maximum of 5.44 ton/ha. The average market price of rice received by the wet DSR sampled farmers was 637 ('000 MMK/ton), with a minimum of 400 ('000 MMK/ton) and a maximum of 900 ('000 MMK/ton). The average market price of rice received by the dry DSR sampled farmers was 610 ('000 MMK/ton), with a minimum of 425 ('000 MMK/ton) and a maximum of 900 ('000 MMK/ton). The average market price of rice received of DSR by using drum seeder was 832 ('000 MMK/ton), with a minimum of 600 ('000 MMK/ton) to the maximum of 1,750 ('000 MMK/ton).

Table 4. Descriptive statistics of output based on each sampled farmers (n=75)

Variable	Unit	Average			Range		
		Wet DSR	Dry DSR	DSR with drum seeder	Wet DSR	Dry DSR	DSR with drum seeder
Yield	Ton/ha	4.07	4.00	4.49	2.47-5.54	2-5	2.97-5.44
Price	*MMK/ton	637	610	832	400-900	425-900	600-1,750

Source: Own survey, 2023

Note * refers to the ('000 MMK)

Material costs of different DSR methods in the study area

The material costs of different DSR cultivated methods in the study area who applied seed, FYM, urea, T-super, potash, compound, gypsum, lime, compose, herbicide, pesticides, foliar, and diesel in rice production were described in Table 5. All sample farmers used for seeds about 121 ('000 MMK/ha) in wet DSR production, 132 ('000 MMK/ha) in dry DSR production, and 131 ('000 MMK/ha) in DSR with drum seeder production. For crop protection, most farmers applied for urea about 228 ('000M MK/ha) in wet DSR, 216 ('000 MMK/ha) in dry DSR, and 257 ('000 MMK/ha) in DSR with drum seeder, and as compound about 165 ('000 MMK/ha) in wet DSR production, 153 ('000 MMK) in dry DSR and 189 ('000 MMK) in DSR with drum seeder production.



Table 5. Material costs of different DSR methods in the study area (n=75)

Items	Wet DSR	Dry DSR	DSR with drum seeder	Total DSR
('000 MMK)				
Seed	121	132	131	128
FYM	39	29	25	31
Urea	228	216	257	234
T-super	13	18	61	31
Potash	8	9	31	16
Compound	165	153	189	169
Gypsum	0.5	7	7	5
Lime	0.3	0	0.34	0.23
Compose	3	0	1	1
Herbicide	40	52	38	43
Pesticide	34	21	39	31
Foliar	16	12	15	14
Diesel	1	15	11	9
Others	16	4	17	13
Total materials cost/ha	690	673	830	731

Source: Own survey, 2023

Family labour and hired labour costs of different DSR methods of sampled farmers

The total labor costs of sample farm households for the wet DSR method was 713 ('000 MMK/ha), with the family labor costs of 151 ('000 MMK/ha) and the hired labor costs of 562 ('000 MMK/ha). The total labor costs of sampled farmers for the dry DSR method was 690 ('000 MMK/ha), with the family labor costs of 136 ('000 MMK/ha) and the hired labor costs of 554 ('000 MMK/ha). The total labor costs of sampled farmers DSR with drum seeder method was 815 ('000 MMK/ha), with the family labor costs of 208 ('000 MMK/ha) and the hired labor costs of 607 ('000 MMK/ha) in Table 7. The largest amount of hired labor costs of the combine harvester was 196 ('000 MMK/ha) in wet DSR, 186 ('000 MMK/ha) in dry DSR, and 207 ('000 MMK/ha) in DSR with drum seeder. Followed by wet DSR total labor costs for ploughing 114 ('000 MMK/ha), family labor costs of ploughing 26 ('000 MMK/ha), and hired labor costs of 118 ('000 MMK/ha), which are presented in Tables 6 and 7.

Table 6. Family labour costs of different DSR methods in the study area (n=75)

Type of operation	Wet DSR	Dry DSR	DSR with drum seeder	Total DSR
('000 MMK)				
Ploughing	26	19	24	23
Harrowing	19	13	37	23
Leveling	1	1	13	5
Basal fertilizer application	7	5	5	6
Seed broadcasting	5	6	0.69	4
Fertilizer application	11	8	20	13
Weeding	7	14	5	9
Irrigation	25	18	24	23
Roughing	2	2	10	5
Pesticide application	6	5	10	7
Herbicide application	10	10	10	10



Type of operation	Wet DSR	Dry DSR	DSR with drum seeder	Total DSR
	('000 MMK)			
Transportation (home)	2	3	10	5
Drying	22	23	24	23
Storage	1	3	9	4
Total family labor cost/ha	151	136	208	165

Source: Own survey, 2023

Table 7. Hired labour costs of different DSR methods in the study area (n=75)

Items	Wet DSR	Dry DSR	DSR with drum seeder	Total DSR
	('000 MMK)			
Ploughing	118	103	103	109
Harrowing	75	87	88	84
Leveling	11	9	25	15
Basal fertilizer application	5	4	2	4
Seed broadcasting	8	9	42	19
Fertilizer application	10	9	4	7
Weeding	50	79	54	61
Irrigation	5	0.49	0	1
Roughing	7	9	18	12
Pesticide application	10	3	8	7
Herbicide application	10	10	4	8
Combined harvester	196	186	207	196
Threshing	0	0	4	1
Transportation (home)	25	17	13	17
Drying	19	19	13	17
Storage	9	2	13	8
Transportation (sell)	0	2	1	1
Total hired labor cost/ha	562	554	607	576

Source: Own survey, 2023

Economic analysis of DSR production in Zeyarthiri Township

The enterprise budget was calculated to analyze the cost and return of DSR production in Zeyarthiri Township. A detailed calculation of cost and return in DSR production is shown in Table 8, the different costs of DSR production for the sampled farmers in the study area. Total material cost included seed, urea, T-super, compound, foliar, FYM, pesticides, herbicides, and diesel used in different DSR production. The opportunity cost of family labor was also calculated by mentioning the wage rate of hired labor. Interest on paid-hired labor costs and material cash costs were also included. The total variable cost or total production cost of different DSR per hectare was then computed by combining total material costs, family labor and hired labor costs, and total interest on cash costs.

Total variable costs of sampled farmers were 1,442 ('000 MMK/ha) in wet DSR, 1,401 ('000 MMK/ha) in dry DSR and 1,690 ('000 MMK/ha) in DSR with drum seeder, while total variable cash costs were 1,290 ('000 MMK/ha) in wet DSR, 1,264 ('000 MMK/ha) in dry DSR and 1,481 ('000 MMK/ha) in DSR with drum seeder.

Total revenue was computed by multiplying the yield and price received by sampled farmers. Total revenue was 2,593 ('000 MMK/ha) in wet DSR, 2,442 ('000 MMK/ha) in dry DSR and 3,736 ('000 MMK/ha) in drum seeder, while return above variable cost was 1,151 ('000 MMK/ha) in wet DSR, 1,041 ('000 MMK/ha) in dry DSR and 2,045 ('000 MMK) in DSR with drum seeder.

In addition, return above variable cash cost was 1,302 ('000 MMK/ha) in wet DSR, 1,178 ('000 MMK/ha) and 2,254 ('000 MMK/ha) for sampled farmers as presented.

Return per unit of capital invested and return per unit of cash expensed in the study area were presented in Table 8. Benefit cost ratios were 1.79 in wet DSR, 1.72 in dry DSR and 2.21 in DSR with drum seeder. The findings indicated that DSR production in the study area was profitable because farmers get back 0.79 MMK in wet DSR, 0.74 MMK in dry DSR and 1.21 MMK in DSR with drum seeder if they invest a unit cash expense in DSR production. The findings of the study were nearly similar to those obtained by Meena et al., (2013).

The break-even yield was the yield that could cover the total variable cost at the current rice price, and the break-even price was the price that could cover the total variable cost at the current rice production. Actual yield and market price of rice production by sampled farmers were 4.07 ton/ha and 637 ('000 MMK/ton) in wet DSR, 4 ton/ha and 610 ('000 MMK/ton) in dry DSR and 4.49 ton/ha and 832 ('000 MMK/ton) in DSR with drum seeder. The break-even yield and break-even price of rice production by sampled farmers were 2.26 ton/ha and 354 ('000 MMK/ton) in wet DSR, 2.43 ton/ha and 329 ('000 MMK/ton) in dry DSR and 2.03 ton/ha and 376 ('000 MMK) in DSR with drum seeder in the study area, respectively. The finding indicated that even if the sample farmer's actual yield cover the total variable cost at the current rice price. Therefore, the sampled farmers in the study area were in a profitable position.

Table 8. Enterprise budgets by using different DSR methods of sampled farmers (n=75)

Items	Unit	Wet DSR	Dry DSR	DSR with drum seeder	Total DSR
Total revenue		2,593	2,442	3,736	2,924
Total variable cost		1,442	1,401	1,690	1,513
Total variable cash cost		1,290	1,264	1,481	1,347
Return above variable cost	('000 MMK/ha)	1,151	1,041	2,045	1,410
Return above variable cash cost		1,302	1,178	2,254	1,576
Gross Margin		1,151	1,041	2,045	1,410
Benefit cost ratio		1.79	1.74	2.21	1.92
Break-even price	*MMK/ton	354	329	376	352
Break-even yield	Ton/ha	2.26	2.43	2.03	2.21

Source: Own survey, 2023

Note: * refer to ('000 MMK)

Factor share analysis

The revenue received from DSR production was shared among the following: material costs, earnings of the household's own labour and hired labour, interest on cash costs, and gross margin. The factor share was divided based on the gross revenue of rice production. Figure 1 and Table 6 showed the factor share percentage of gross margin (profit), interest on cash costs, hired labour costs, family labour costs, and material costs. The gross margin (profit) factor share was the largest in DSR production (44.39%) in wet DSR, (42.63%) in dry DSR and (54.74%) in DSR with drum seeder.

It was followed by material cost (26.47%) in wet DSR, (27.57%) in dry DSR and (22.24%) in DSR with drum seeder, hired labor cost (21.70%) in wet DSR, (22.69%) in dry DSR and (16.27%) in DSR with drum seeder, family labour cost (5.84%) in wet DSR, (5.60%) in dry DSR and (5.59%) in DSR with drum seeder, and the interest on cash cost (1.45%) in wet DSR, (1.51%) in dry DSR and (1.16%) in DSR with drum seeder, respectively. Therefore, farm income factor shares for DSR were (50.22%) in wet DSR, (48.23%) in dry DSR and (60.33%) in DSR with drum seeder.

Table 9. Factor shares by using different DSR methods of sampled farmers (n=75)

Variables	Factor shares (%)			
	Wet DSR	Dry DSR	DSR with drum seeder	Total DSR
Total revenue	100.00	100.00	100.00	100.00
Factor share (%)				
Gross margin	44.39	42.63	54.74	48.25
Interest on cash cost	1.45	1.51	1.16	1.34
Hired labor cost	21.70	22.69	16.27	19.72
Family labor cost	5.84	5.60	5.59	5.67
Material cost	26.62	27.57	22.24	25.02
Farmers' farm income	50.22	48.23	60.33	53.99

Source: Own survey, 2023

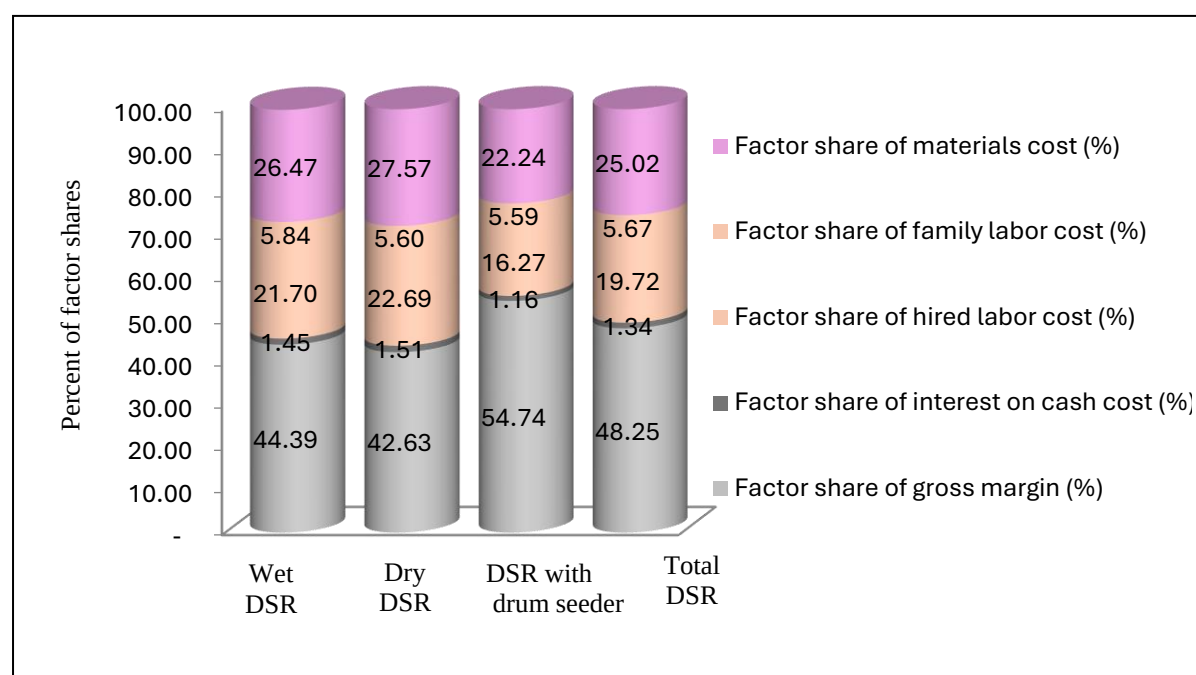


Figure 1. Factor shares by using different DSR methods of sampled farmers

Source: Own survey, 2023

Reasons for changing DSR methods of sampled farmers

The reasons for changing DSR methods of sampled farmers are presented in Table 10. The study area sampled farmers explained about the reasons for changing DSR methods as lower cost than transplanting method (76.00%), labor scarcity at peak season (32.00%), getting higher yield than transplanting method (14.66%), not available irrigation water (12.00%), and adaptation to climate change than transplanting method (12.00%).

Table 10 Reasons for changing DSR methods of sampled farmers (n=75)

No.	Items	Frequency	Percent
1.	Lower cost than transplanting method	57	76.00
2.	Labor scarcity at peak season	24	32.00
3.	Getting higher yield than transplanting method	11	14.66
4.	Not available irrigation water	9	12.00
5.	Resistance to climate change than transplanting method	9	12.00
6.	Time saving than transplanting method	5	6.66
7.	Easy to manage because of a little practices in DSR methods	1	1.33
8.	DSR by using drum seeder is suitable to produce rice seed	1	1.33
9.	DSR by using drum seeder have fertilizer supporting	1	1.33

Source: Own survey, 2023

General constraints in DSR methods faced by selected farmers in Zeyarthiri Township

The farmers' perceptions of constraints on rice production are presented in Table 11. In Zeyarthiri Township, major constraints described by (72.00%) and (66.66%) of sampled farmers were loss of seeds in the field, high price of fertilizers, crop loss of over harvesting time due to limitation of hiring combined harvester (58.66%), labor scarcity at peak season (54.66%), followed by limitations on quality seed availability (53.33%), and poor germination rates of seed (49.33%).

Table 11. General constraints in DSR methods faced by sampled farmers in Zeyarthiri Township (n=75)

No.	Items	Frequency	Percent
1.	Loss of seeds in the field	54	72.00
2.	High price of fertilizers	50	66.66
3.	Crop loss of over harvesting time due to limitation of hiring combined harvester	44	58.66
4.	Labor scarcity at peak season	41	54.66
5.	Limitation of quality seed availability	40	53.33
6.	Poor germination rate of seed	37	49.33
7.	Poor soil fertility	36	48.00
8.	Weak extension service for production technologies	34	45.33
9.	High fuel cost for irrigation	33	44.00
10.	Not available of required agrochemicals in the market	31	41.33
11.	Crop loss in the field due to weeds and pests	30	40.00
12.	Constraint of available price information in time	20	26.66
13.	Limitation for credit availability	20	26.66

Source: Own survey, 2023

Conclusion

In terms of BCR, the sampled farmers could earn a profit of 0.79 from wet DSR, 0.74 from dry DSR and 1.21 from DSR methods with drum seeder production if one kyat was invested. Among these three different methods in the study area, the BCR of DSR cultivation methods with drum seeder is the highest. Therefore, DSR production was economically more attractive for farmers. The main reasons for changing DSR methods of sampled farmers were lower cost than transplanting methods, insufficient labor in peak season, higher yield than transplanting methods, and not available irrigation water, apart from these reasons farmers are trying to adaptable for climate change. On the other hand, they still had constraints in rice production,



particularly loss of seeds in the field, high price of fertilizers, crop loss of over harvesting due to limitation of hiring combined harvester, labor scarcity at peak season, limitation of quality seed availability, and poor germination rates.

Recommendations

In Myanmar, about 70% of country population lives in rural area and their livelihoods mainly rely on agriculture particularly in rice cultivation. Therefore, profitability of rice farming is essential for improving their livelihoods. In order to achieve the purpose of increased rice productivity especially DSR with drum seeder method should be encouraged for getting more profit. The government should encourage not only to use DSR with drum seeder but also to accept new technologies, improved varieties, and extension services. According to the results of labour scarcity in peak season, it was required to reduce the total hired labour cost by using farm machinery in the study area. Therefore, farm mechanization should be supported to farmers who were faced with labour scarcity in rice production. To remedy the constraint of insufficient water for cultivation, the government should provide for the availability of adequate water resources for agriculture. Therefore, adequate water should be supported in time for increased production. According to overcome these constraints, public sector should be aware and formulate the evidence based plan, strategies and policies.

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Track 2

Resilience of food system



Determinants of food waste behavior on Muslim Generation Z in Padang City, Indonesia

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Abstract

Indonesia, which has the largest Muslim population in the world, is the second largest contributor to food waste worldwide. West Sumatra is famous for its strong Islamic cultural tradition, and Padang City, the capital of the province, is the largest contributor to food waste in West Sumatra Province. This study analyzed the factors influencing food waste behavior among Generation Z in Padang City, Indonesia. The research used a survey of 210 respondents, the data collected from February to April 2023 using a web-based questionnaire. The collected data were processed using structural equation modeling with smart-PLS software (SEM-PLS) to determine the effect of exogenous variables on endogenous variables. The results showed that attitude, perceived behavior control (PBC), and religious norms significantly influence the intention to avoid food waste. Habits have a significant influence on food waste behavior. Other variables such as subjective norm, lack of concern, and intention not to waste food did not significantly influence. Religious norms, habits, and PBC can prevent food waste behavior; therefore, it is necessary to increase religious understanding in respecting food, as well as education about the dangers of food waste behavior for the environment, economy, and food security of a country. This research can be a reference in formulating policies to prevent food waste behavior in the younger generation.

Keywords: religious norms, habit, sustainability, Tabdzir

JEL code: D01, D12, E29, Q01

SDG goal: Responsible Consumption and Production

Introduction

A significant quantity of food is wasted annually along the entire supply chain from manufacturing to consumption (Bhatti *et al.*, 2015; Bhatti *et al.*, 2023). In 2019, 931 million tons of food were wasted worldwide (UNEP, 2021). Between harvest and consumption, one-third of the food produced for human consumption is waste (FAO 2011). Food waste is food that can still be consumed by humans but is not consumed and is chosen to be discarded for certain reasons. (FAO 2011) Food waste is defined as food that is still suitable for human consumption but has been discarded for certain reasons (UNEP 2021). Consumers are the main source of the total volume of food waste (Griffin *et al.*, 2009), which exceeds the waste produced during the production, distribution, and processing of food (Bhatti *et al.*, 2023). Indonesia is ranked second in the world, with the amount of food waste reaching 300 kg of food waste per person annually (EIU 2017). The composition of waste by type in Indonesia in 2021 shows that food waste has the largest amount, at 39.57% (SIPSN, 2021).

Food waste in the food supply chain is becoming more widely acknowledged as a problem with detrimental effects on the economy, society, and the environment (Alexander *et al.* 2017; Adel and Roshdy, 2023). Food waste disposal may also result in additional environmental issues such as methane emissions from food decomposition in landfills (Ghani *et al.*, 2013). Food waste is a social issue that is receiving increasing attention at global and local levels (UNEP 2021). This challenge is recognized in Sustainable Development Goal 12.3 to "halve global food waste per capita at the retail and consumer levels and reduce food losses along production and supply chains." Therefore, it is important to reduce food waste. Researchers have investigated several strategies for reducing food waste (Bretter *et al.*, 2023). However, in



reality, it is a challenge to change consumer behavior, especially in the food sector, because habits play a key role (Soma *et al.*, 2020; Piras *et al.*, 2023). Consumer behavior is significantly influenced by culture (Mennell *et al.*, 1992). In particular, religion is a part of culture and can influence emotions, cognition, and actions (Saroglou, 2014; Santovito *et al.*, 2023). A Muslim is prohibited from being excessive, which in the concept of consumption leads to waste (Ghafur, 2016). Intentionally wasting food, including squandering food, causes wasteful behavior (Tabdzir).

Most people in West Sumatra Province are Minangkabau, whose life order has customary Islamic values and norms, and Islam is a complete and strong customary system in their lives (Chaniago, 2020). Padang City, the capital of West Sumatra Province, has a population of 913,450 (Indonesian Statistic 2021), and its 97.5% Muslim population should ideally be able to represent the order of life by Islamic values. However, in reality, some attitudes do not represent the teachings of Islam, one of which is *Tabdzir* behavior. *Tabdzir* refers to waste (Munawwir, 2002).

Padang City has one of the highest waste data in West Sumatra. The amount of annual waste generated in Padang City is very high at 233,385.96 tons. The composition of waste by type was dominated by food waste (62.8 %). These data support the statement that people in Padang City have not fully reflected the behavior taught in Islam, which in this case refers to *tabdzir* behavior.

All groups of society are involved in this wasteful behavior, especially Generation Z and the younger population (Jamaludin *et al.*, 2020). In terms of age, the population of Padang City, the millennial generation, and Generation Z dominate (Bappeda Kota Padang 2016). Generation Z is the population born between 1995-2010 (Bencsik *et al.*, 2016), or in the age range of 13-28 years old. Generation Z is the generation most concerned about the well-being of the planet and inspires others to make purchasing decisions that prioritize sustainability (First Insight.Inc, 2021). Each generation has a different attitude towards food. Currently, Generation Z is the productive generation that will be the successor and will experience various environmental issues (Lemy *et al.*, 2020). Generation Z is environmentally conscious and embraces sustainable food use. However, they pointed out that implementing sustainable consumption practices is not always easy (Orea-Giner & Fusté-Forné, 2023). Therefore, Generation Z needs to be concerned with food behavior. They enjoy dining out and are eager to try new dishes (Lee *et al.*, 2022). A study conducted by Mondéjar Jiménez *et al.* (2016) explains that younger generations in Italy and Spain tend to waste food. A survey conducted by the WWF (2018) found that 11% of young people aged range-18-24 years stated that the habit of throwing food poses no threat to the environment. Often this food-throwing behavior has become a habit and some people do not care about the impact that this behavior will have.

Many adverse effects occur when food is wasted. In terms of the economic impact, potential economic losses will occur, such as in the supply chain stage. This stage causes economic losses of 107-346 trillion rupiah/year. Other impacts arising from social factors include loss of nutritional content, such as energy content of 618-989 kcal/capita/day, protein of 18-32 grams/capita/day, vitamin A of 360-953 Ug RE/capita/day, and iron of 4-7 mg/capita/day. Similarly, environmental impacts cause greenhouse gas emissions. This consumption stage is the stage of the supply chain that has the largest global warming impact (Bappenas, 2021).



In this study, people in Padang City, the majority of whom are Muslims, often waste food, as indicated by the fact that a lot of food is wasted there. Therefore, the purpose of this research is twofold: to describe the characteristics and analyze the factors that influence food waste behavior among Gen Z Muslims in Padang City. What distinguishes this study from previous research is the existence of religiosity variables.

The theory of planned behavior, known as TPB by Ajzen (1991), is the result of an update of the theory of reasoned action proposed by Ajzen and Fishbein (1980). This theory can predict environmentally conscious behavioral intentions, including food-related behaviors (Conner & Armitage, 2002). Because consumers are believed to dislike waste, behavioral intention can be considered a driving force (Bhatti et al., 2023). Ajzen explained that TPB can predict whether someone will do or not do a behavior using three components.

1. Attitudes are derived from beliefs about what is acceptable from a behavior and are reinforced by whether the behavior provides benefits.
2. Subjective norm is the influence of people around, for doing, or not doing this behavior.
3. Behavioral control refers to the feelings of the actor, whether it is easy or difficult to perform a behavior.

Food Waste is determined by several factors in various ways, resulting from several behaviors (Stefan et al., 2013). This study uses the extended TPB (Ajzen, 1991) as a starting point to predict the behavior of Gen Z Muslims in Padang City towards food waste through several factors including attitude, subjective norm, perceived behavior control, lack of concern, religious norm, habit and intention not to food waste.

1.1 Factors affecting intention not to food waste

Attitudes indicate people's general assessment of certain behaviors (Greaves *et al.*, 2013). Attitudes toward behavior are favorable or unfavorable as a good assessment of the behavior performed (Ajzen, 1991). Attitude is a general measure of the liking of certain behaviors by individuals (Russell et al., 2017). Attitudes also sometimes result from previous experiences and refer to an individual's beliefs about the likely outcomes of his or her behavior and evaluations of those outcomes (Hoyt et al., 2009; Jamaludin et al., 2020). The attitudes towards the food waste variable explain consumers' attitudes towards their food waste. Attitudes influence the intention to do or not do food waste behavior (Bhatti et al., 2023). Consumers will look for ways not to throw away food when they have the intention not to throw away food scraps

H1. Attitude toward food waste has a positive effect on the intention to consume food waste.

Ajzen (1991) defined Subjective Norms as the perceived societal force to perform a certain behavior. Subjective norms refer to perceived social pressure to perform or not perform a behavior (Ajzen, 1991). Subjective norm is considered an exogenous construct in TPB and directly affects behavioral intention (Ajzen, 1991). The subjective norm variable refers to whether friends or family influence consumers toward food waste. The better the subjective norm regarding food waste, the stronger the consumer's intention to minimize the amount of food wasted (Ananda et al., 2023). This means that consumers who are influenced not to waste food will desire not to throw away food waste.



H2. Subjective norm has a positive effect on the intention not to food waste

Perceived behavioral control is a factor that shapes behavioral intentions based on past images and the anticipation of barriers. (Ajzen, 1991). Perceived behavioral control defines people's perception of the ease or difficulty of performing a behavior (Ajzen, 1991). Consumers who are confident in their abilities and consider reducing FW under their control are more likely to have positive intentions to reduce food waste. (Mondéjar Jiménez *et al.*, 2016; Stancu *et al.*, 2016). The variable of perceived behavior control in this study makes it difficult for consumers to deal with food waste. This difficulty will influence consumers' desire not to throw away food waste.

H3. Perceived behavior control has a negative effect on the intention not to commit food waste

Concern about food waste determines one's intention to not waste food (Stefan *et al.*, 2013). People who voice environmental concerns have a strong aversion to food waste (Melbye *et al.*, 2016). In reality, there are still significant differences between people's attitudes and behaviors regarding environmental stewardship (Frederiks *et al.*, 2015). Schanes *et al.*, (2018) explained that there are results of studies conducted by researchers in the United States found that the role of concern for the environment is not too large, which is only 40% (Neff *et al.*, 2015) and 58.4% (Qi and Roe 2016). The variable lack of concern for food waste in this study leads to consumer indifference toward food waste.

H4. Lack of concern about food wastage has a negative effect on the intention not to waste food

Obedying the rules that are commanded, and avoiding those that are prohibited in a religious belief, then how a person can commit to these beliefs (Johan *et al.*, 2020). Studies have indicated that religion has a significant influence on consumer behavior (Arli and Pekerti, 2016; Santovito *et al.*, 2023). Religious norms in this study lead to how consumers will stay away from the prohibition of *tabdzir*, namely, wasting food.

H5. Religious norm has a positive effect on the intention not to food waste

1.2 Factors Affecting Food Waste Behavior

Intention is defined as an indication that refers to a person's desire to perform or not perform a behavior (Ajzen, 1991). Intention refers to how a person tries and plans to act on their behavior (Ajzen, 1991). Because individuals generally avoid waste (Bolton and Alba, 2012), it is believed that a deliberate process can trigger their behavior toward food waste (Bhatti *et al.*, 2023). The intention to avoid waste leads to a decrease in food waste behavior (Aktas *et al.*, 2018). The intention not to throw food waste variable in this study refers to consumers' desire not to throw away food waste.

H6. Intention to avoid food waste affected negatively food waste

Habits play an important role in food wastage (Russell *et al.*, 2017). Verplanken and Holland (2002) defined habits as relatively stable patterns of behavior resulting from automatic processes without deliberate consideration, as opposed to controlled processes that have been reinforced in the past (Russell *et al.*, 2017). Food waste disposal is a repetitive and often

habitual behavior (Russell et al., 2017). Food disposal habits greatly influence consumer behavior towards food waste.

H7. Habit has a positive effect on food waste behavior

The initial research model was as follows:

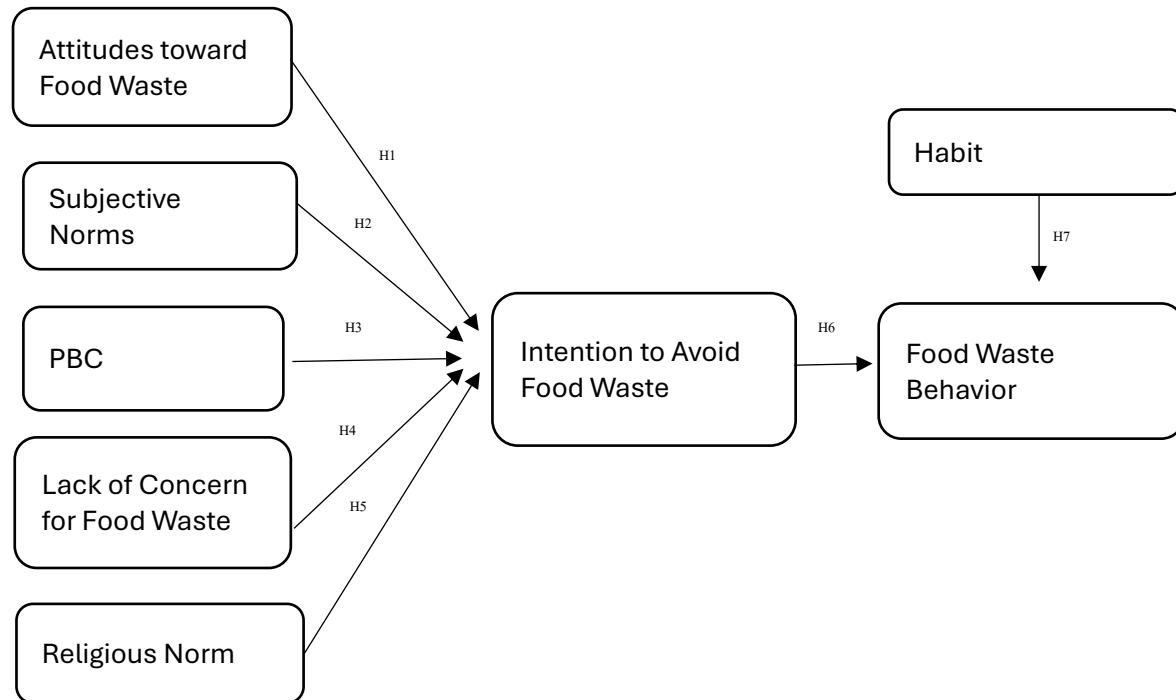


Figure 1 Initial research model using the theory of planned behavior that has been expanded

Methodology

The research was conducted in Padang City, West Sumatra Province, considering that Padang City is one of the cities with a Muslim majority but also has the highest food waste group data in West Sumatra Province. This study was conducted between February and April 2023. Data were collected using non-probability sampling techniques. Purposive sampling was performed using this technique. The criteria for respondents used include domiciling in Padang City, being Muslim, and being in the age of Generation Z in the 1995-2006 birth year range. Based on research from Roscoe (1975), a good sample size is 5-10 times the number of variable indicators in the questionnaire. The questionnaire contained 40 variable indicators; therefore, the minimum sample size for this study was 200 and the maximum sample size was 400. This study included 216 participants; however, only 210 respondents met the criteria of being Muslim and belonging to the Generation Z age group. The following presents the data on demographic characteristics from the results of this study.

Table 1. Characteristics of respondents as a result of the questionnaire distributed

Characteristics	Classification	Total	Percentage
Gender	Male	83	40
	Female	127	60
Year of birth	1995 – 1997	31	15
	1998 – 2000	52	25



Characteristics	Classification	Total	Percentage
Tertiary Education	2001 – 2003	87	41
	2004 – 2006	40	19
	Junior High School	25	12
	Senior High School	94	45
	Diploma/Bachelor	87	41
Occupation	Postgraduate	4	2
	Student	37	18
	College Student	92	44
	Employee	55	26
	Other	26	12
Monthly Income	< Rp1.000.000	87	41
	Rp1.000.000 – Rp2.500.000	59	28
	Rp2.500.000 – Rp4.000.000	31	15
	> Rp4.000.000	33	16
Distance	< 100 m	51	24
	100-300 m	51	24
	300-500 m	29	14
	> 500 m	79	38

Source: primary data (2023)

The majority of respondents were female (127 respondents), while those with male gender were 83 respondents. Based on the year of birth, the results of the questionnaire showed that the majority of respondents were born between 2001-2003 with a total of 87 respondents (41 percent). Based on the last education, the results of the questionnaire explained that the majority of respondents had graduated from high school (94 respondents, 45 percent), followed by the majority of students (92 respondents, 44 percent). The majority of respondents had a monthly income of less than Rp 1,000,000 (87 respondents, 41 percent). Based on the distance from their residence to the shopping center, the majority of respondents have a distance of more than 500 m with a total of 79 respondents (38 percent).

Results and discussion

Convergent validity testing was carried out with outer loading and average variance extracted (AVE), with outer loading testing criteria ≥ 0.5 , as well as AVE testing criteria ≥ 0.5 . In testing the outer loading, five variables had a value of less than 0.5, so they were removed from the model. These variables included A4, PBC1, LC5, RN1, and I3, as shown in Figure 2.

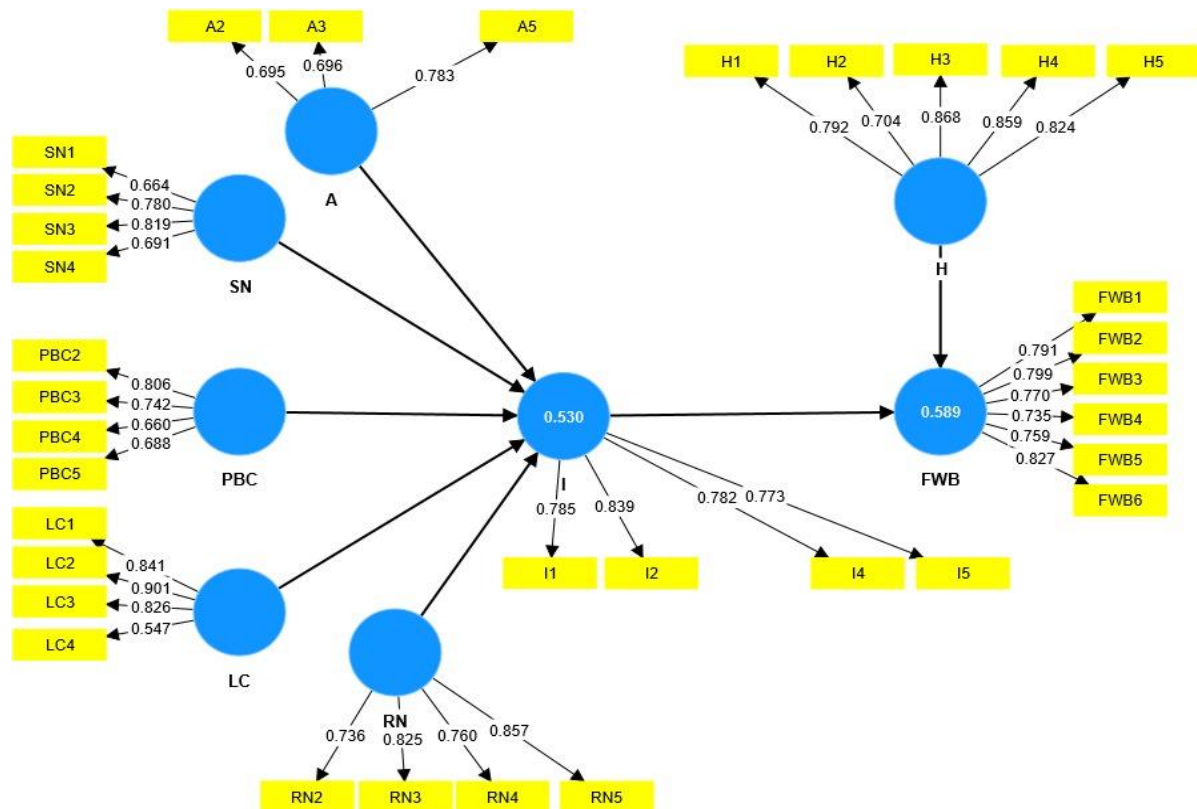


Figure 2 The outer loading after indicators that did not fit the test criteria were removed

To test the reliability, the test was carried out using Composite Reliability (CR) with the test criteria $CR \geq 0.7$. Table 2 presents the results of testing the AVE and CR values. AVE and CA were used to test validity and reliability.

Table 2. The results of testing the AVE and Composite Reliability values seen per variable

Variable	AVE	Composite Reliability
<i>Attitudes Towards Food Waste</i>	0,527	0,769
<i>Subjective Norms</i>	0,549	0,829
<i>Perceived Behavior Control</i>	0,597	0,815
<i>Lack of Concern for Food Waste</i>	0,625	0,866
<i>Religious Norm</i>	0,633	0,873
<i>Habit</i>	0,658	0,906
<i>Intention to Avoid Food Waste</i>	0,632	0,873
<i>Food Waste Behavior</i>	0,610	0,903

Source: primary data (2023)

After testing, the AVE value met the criteria, namely $AVE \geq 0.5$ for all variables. Thus, it can be concluded that in this study, all latent variables have good validity. Likewise, the results of reliability testing using Composite Reliability, have a CR value ≥ 0.7 , for each variable. It can be concluded that all the variables in this study are consistent.

Path Significance Test

Significance testing was carried out using the t-value and p-value with the test criteria of t-value ≥ 1.96 and p-value ≤ 0.05 . The test results are presented in Table 3.

Table 3. Path Coefficient Value to see the variable relationship and its significance value

Hypothesis	Original Sample (O)	Standard Deviation (STDEV)	T Statistics (O/STDEV)	P Values
$H_1. A \rightarrow I$	0,143	0,059	2,407	0,016
$H_2. SN \rightarrow I$	0,054	0,057	0,943	0,346
$H_3. PBC \rightarrow I$	-0,162	0,056	2,911	0,004
$H_4. LC \rightarrow I$	-0,020	0,053	0,389	0,697
$H_5. RN \rightarrow I$	0,594	0,069	8,598	0,000
$H_6. I \rightarrow FWB$	-0,006	0,075	0,082	0,935
$H_7. H \rightarrow FWB$	0,765	0,043	17,733	0,000

Source: primary data (2023)

Because the three variable connections have a p-value of more than 0.5 and a t-statistic value of less than 1.96, they are not significant. Subjective norms of intention to avoid food waste, absence of concern about intention to avoid food waste, and intention to avoid food waste to food waste behavior were the three variables. The test results also show that certain variables, such as perceived behavior control for intention to avoid food waste, absence of concern for intention to avoid food waste, and intention to avoid food waste for food waste behavior, have negative relationships with the original sample value.

Referring to Table 4's significance testing, there is a positive and significant direction in the association between attitude and intention to avoid food waste. It is evident from the original sample value of 0.143, which is positive, and the t-statistic value of 2.407 (>1.96) and p-value of 0.016 (<0.05), all of which indicate significance. Customers are more likely to want to minimize food waste if they feel guilty about throwing it away (Aktas et al. 2018). In conclusion, it can be said that H_1 's aim to prevent food waste is positively and significantly influenced by their attitudes towards it. It can be concluded that attitudes towards food waste positively and significantly affect the intention to avoid food waste. Therefore, hypothesis (H_1) was accepted.

The findings of the significance test indicate that there is no significant association between the subjective norm and the desire to avoid food waste, as indicated by the positive sign of the original sample value of 0.054 and the t-statistic value of 0.943 (<1.96) and p-value of 0.346 (>0.05), respectively. This is consistent with studies by Wajon et al. (2019) and Jiménez et al. (2016), who showed that intentions to reduce food waste are not influenced by social pressure or other people's opinions. Based on the aforementioned rationale, it may be inferred that subjective standards significantly and favorably influence the intention to avoid consuming food waste. Thus, the hypotheses (H_3) were disproved.

There was a substantial negative correlation between the aim of avoiding food waste and perceived behavioral control. The initial sample value of -0.162, which has a negative sign, and the t-statistic value of 2.911 (>1.96) and p-value of 0.004 (<0.05), which indicate significance, both support this. The stronger the consumer's intention to not leave food, the lower the barriers to decreasing food waste (Wajon et al., 2019). This justification leads to the



conclusion that the aim of preventing food waste is significantly negatively affected by perceived behavior control. Thus, the hypothesis (H₃) was accepted.

Based on the results, the relationship between lack of concern and intention to avoid food waste has a t-statistic value of 0.389 (<1.96) and a p-value of 0.697 (>0.05) which means it is not significant, and the original sample value is -0.020 which has a negative sign. This is in contrast with Stefan et al. (2013), who found a significant relationship in the context of the intention to avoid food waste. Therefore, it can be concluded that the hypothesis (H₄) is rejected.

Regarding Table 4's significance test, there was a positive and significant correlation between religious norms and the intention to avoid food waste. The original sample value of 0.594, which has a positive sign, and the significant t-statistic value of 8.598 (>1.96) and p-value of 0.000 (<0.05) both support this. The relationship between religious norms and the intent to avoid food waste concluded that hypothesis (H₅) is accepted.

The initial sample value was -0.006, which is negative. The significance test results for the association between intention to avoid food waste and food waste behavior are t-statistic values of 0.082 (<1.96) and a p-value of 0.935 (>0.05), which is negligible. This is in line with the results of Stefan et al. (2013), but it did not have a significant impact on food waste in the context of the intention to avoid food waste. It can be concluded that the intention not to avoid food waste has a negative and significant effect on food waste behavior in H₆ is rejected.

The significance test results indicate that there is a substantial and positive association between habit and food waste behavior. As can be observed from the original sample value of 0.765, which has a positive sign, the t-statistic value of 17.733 (>1.96) and p-value of 0.000 (<0.05), which indicate significance. This is in line with research by Aydin and Yildirim (2021), which explains that consumers who buy outside of consumer needs will end up in wasteful behavior. From this explanation, it can be concluded that habit has a positive and significant effect on food waste behavior in H₇.

Conclusion

The respondents in this study were Generation Z residents of Padang City. The majority of respondents were female (61%) and were between the birth years 2001-2003 (40%), with student status (44%), whose last education was high school (44%), and had an average respondent income in the range of less than IDR1,000,000 (41%). The distance between the respondent's residence, school/campus, and workplace to shopping centers such as malls, stalls, restaurants, canteens, etc., was more than 500 m (38%). The results of the analysis in this study show that the variables that have a positive effect on the intention to avoid food waste are attitude and religious norms, while food waste behavior is a habit. In addition, perceived behavior negatively affected the intention to avoid food waste. Other variables, such as subjective norm, lack of concern, and intention to avoid food waste, had an insignificant effect. Government and educational institutions must participate in providing education and socialization for food waste prevention.

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Determinants of Using Cold Storage Technology: Insights from Onion Farmers in Bongabon and San Jose City, Nueva Ecija, Philippines

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Abstract

Recent developments in the Philippine onion industry include investments on cold storage facilities to abate postharvest losses and to provide farmers an option to increase their profit. Considering that onion is a highly seasonal crop, farmers may benefit from storing their harvest by selling in another time period when prices are higher. While previous studies showed that adoption of storage technology has resulted into additional net income, farmers are unable to capitalize this opportunity due to several barriers. Thus, this study examined the factors that are associated with the likelihood of using cold storage technology. Binary logit analysis was used to identify the factors that determine cold storage use. A total of 169 farmers are randomly selected using stratified random sampling. Farmers who are reliant on financiers serve as an impediment in practicing onion storage. Farmers who are engaged in trading, have stored onion previously, are members of a cooperative, and have attended training on postharvest management are more likely to use the cold storage facility.

Keywords: postharvest management, choice model, collective action

JEL code: Q13

SDG goals: Industry, Innovation, and Infrastructure

Introduction

There is a recent development in the Philippine onion industry. The government has been ramping up its investments on cold storage facilities to abate postharvest losses and to provide farmers another option for expanding their profit. In 2019, there are 14 cold storage facilities in Nueva Ecija with a capacity of 2.42 million bags or 72,000 metric tons (MT)¹ of onion (Southeast Asian Regional Center for Graduate Study and Research in Agriculture (SEARCA), 2021). Since 2022, however, at least four farmer-based organizations have received cold storage facilities under state funding in the province of Nueva Ecija² (Department of Agriculture Philippine Rural Development Project (DA PRDP), 2023; Philippine News Agency, 2023). An additional 5,100 MT can be stored and thus presents an opportunity for small-scale farmers to augment their profit on top of their net returns on farm production.

Considering that onion is a highly seasonal crop, farmers can take advantage of the high price during the lean season. Based on the seasonal indices, the farmgate price of onion in the

¹ Assuming that one bag is equivalent to 30 kg based on the farm survey conducted by the author in 2024

² Nueva Ecija is a province in Central Luzon and is the major contributor (58.5%) of the domestic supply of onion in the Philippines.



Philippines during March is 39.35% lower than the average monthly price. On the other hand, during the off-season, prices are higher than the average by 46.82% particularly in December. While previous studies showed that adoption of storage technology has resulted into additional net income (Alemu et al., 2021; Nwet et al., 2018), empirical evidence showed that liquidity constraints, transaction costs, and risk aversion serve as roadblock in exploiting intertemporal price arbitrage. However, the recent development on the establishment of cold storage facilities given to producers cooperatives may increase the capacity of farmers to store onion. Thus, this paper examined the factors that are associated with the use of cold storage facility in Nueva Ecija, Philippines.

As previously mentioned, empirical studies provide insights on what factors influence the likelihood of use of cold storage. Cardell and Michelson (2022) considered a model to reflect household's decision to store or sell grains after harvest and found that risk averse farmers tend to opt out of storage because of the possibility of negative returns. Using a multivariate sample selection model of market entry, access to credit and off-farm income reduces the likelihood of market entry as sellers in the harvest period (Stephens and Barrett, 2010). Using bivariate logit and probit regression, longer distance from the farm to a passable road (Gitonga et al., 2013) reduces the likelihood of adopting metal silos (i.e., grain storage) or the distance from a market stall to the cold storage reduces the likelihood of use (Takeshima et al., 2022). On the other hand, wealthier farmers are more likely to store thus capturing the benefits of price premium. The measures of wealth include total land area owned and access to off-farm income (Minten et al., 2014; Gitonga et al., 2013). Moreover, the greater the land area owned and the more quantity sold by the farmer will also lead to greater likelihood of cold storage use. Factors that enhance the capacity of farmers to put their harvest in a storage facility such as cooperative membership or training related to improved storage technology increases their likelihood of adoption (Alemu et al., 2021; Bokusheva et al., 2012). In the Philippines, registered cooperatives engaged in onion production recently received cold storage facilities that are expected to increase the involvement of farmers in the practice of onion storage.

Consistent with the hypotheses, the results show that members of a cooperative are more likely to use cold storage. The collective action and clustering approach which are the key tenets of a cooperative can be a solution to the strict volume requirement being implemented by privately owned cold storage facilities. The conduct of panel data study which considers the farmgate price of onion may provide a clearer picture into the storage behavior of onion farmers.

The rest of the paper is organized as follows. The methodology discusses the data collection procedure, methods of analysis, and the estimation strategy. The results and discussion section provides the data and summary statistics by adoption of cold storage technology and discusses the empirical results. The paper concludes and suggests further research undertaking.

Methodology

Data collection and sampling procedure

The top two onion producing areas in Nueva Ecija and the corresponding top three villages in each area are purposively selected. The sampling frame consist of the total number of onion farmers (i.e., 966) in the six villages considered in the study. Since there is a considerable variation in the population of farmers across the six villages, stratified random sampling with proportional allocation was employed wherein the village is regarded as the stratum.

Since the proportion of farmers who are using the cold storage technology is unknown, a proportion of 50% is assumed which yields the highest possible sample size of approximately

276 farmers. Since the computed sample size exceeds 5% of the population, Cochran's sample size correction formula was used and yielded 215 (Bartlett et al., 2001). Randomly selected farmers are interviewed using a pre-tested questionnaire. Pre-testing was conducted last December 2023 and the face-to-face interviews are currently being conducted. As of January 2024, there are 169 farmers interviewed and descriptive statistics and model estimations are based on the current sample.

Methods of analysis

Descriptive statistics was used to characterize the onion farmers across their socioeconomic, farm, and risk characteristics. For quantitative data, comparison of means using t-test and medians using Mann-Whitney U test were employed as a preliminary step to determine the factors that are associated with cold storage use. For qualitative data, comparison of proportion using Chi-square test of independence was used.

Estimation strategy

To determine the factors affecting the use of cold storage technology, logit model was employed. The model is non-linear and assumed to follow logistic distribution. Mathematically,

$$Y_i^* = \beta'x_i + \varepsilon_i, D_i = \begin{cases} 1, & \text{if } Y_i^* > 0 \\ 0, & \text{otherwise} \end{cases}$$

Y_i^* is the unobserved preference of farmer i representing the latent utility on the use of cold storage technology, β' is the vector of coefficients representing the effect of unit changes in the vector of observable factors, x_i . The selection of covariates is based on the literature review and initial farm survey and are summarized in Table 1. Risk aversion was measured using the hypothetical investment choice model adopted from Fausti and Gillespie (See Appendix Table A). This variable is measured ordinally with increasing level of risk aversion as the number goes from 1 to 5 and is hypothesized to be negatively associated with cold storage use. Transaction cost is represented by the distance from the farm to the nearest cold storage facility. Liquidity measures include: access to production loan provided by formal credit institutions such as banks, cooperatives, and microfinance institutions; and access to off-farm income which are expected to be positively associated with cold storage use. Measures of capacity building such as cooperative membership and trainings related to postharvest management are the key variables that are hypothesized to be associated with use of cold storage technology. Farmers who had a greater farm profit in the last cropping season are more likely to immediately sell their harvest and hence are less likely to store. The same expectation is posited on farmers who relied on traders for financing. On the other hand, farmers who are older, who expected the price to increase after harvest period, and have more years of farming experience and formal education are more likely to use cold storage technology.

Table 1. Description of variables

Variable	Description
Use	Onion farmer used the cold storage technology after the harvest season in 2023 (Use =1)
Total land area	Total land area owned by the farmer in hectares
Total land area for onion	Total land area allocated for onion production in hectares
Total quantity sold	Marketable surplus that was sold in 2023 in kilograms



Variable	Description
Distance	The distance from the farm to the closest cold storage facility in kilometers
Last year's farm profit	The profit of farmer in the 2022 cropping season expressed in Philippine Pesos
Age	Age of the farmer in years
Farming experience	Number of years in farming
Formal education	Number of years spent in formal education
Price expectation	The farmer expected the price of onion to increase after the harvest season
Cooperative membership	The farmer is a member of a cooperative (Member =1)
Training	The farmer attended a training on postharvest management (Training = 1)
Access to formal credit	Farmer loaned from either a bank, cooperative, or a microfinance institution (Access = 1)
Access to off-farm income	Farmer has access to off-farm income (Access = 1)
Farmer under financier	Trader provided inputs to the farmer as loan (Yes = 1)
Risk averse	Risk aversion based on a hypothetical investment choice elicitation method
Stored previously	The farmer stored onion prior to 2023 (Yes = 1)

Results and discussion

Table 2 provides a summary statistics on the characteristics of onion production. It can be observed that the land area allocated for onion production is positively skewed. It must be emphasized that onion production is small-scale with only one-fourth of the sample cultivating more than one hectare. Thus, it is more appropriate to use median as the average value.



Table 2. Summary statistics and test of normality on quantitative explanatory variables, 169 farmer respondents, Bongabon and San Jose City, Nueva Ecija, Philippines, 2023

Variables	Mean	Standard deviation	Median	Skewness	Shapiro-Wilk p-value
Total quantity sold	18,413.20	49,625.60	4,725.00	5.34	0.000
Total land area	1.77	2.97	1.00	5.47	0.000
Total land area for onion	1.20	2.12	0.10	5.19	0.000
Distance	22.65	17.60	19.00	0.36	0.000
Profit last season	97,573.96	342,147.88	41,000.00	1.90	0.000
Age	53.87	11.52	55.00	-0.15	0.233
Farming experience	28.53	13.06	29.00	0.26	0.009
Formal education	9.36	2.92	10.00	-0.08	0.000



On the average, farmers allocated 0.10 ha for onion production with a median total quantity sold of 4,725.00 kg or 157.50 bags. After the onion is harvested in March and April, the land is rested and prepared for planting rice in the wet season (i.e., around June). The distance from the farm to the nearest cold storage facility reported by the farmers is also noteworthy. As of January 2024, there is at least one cold storage facility for the Municipality of Bongabon and San Jose City.

In 2022, the Department of Agriculture provided a cold storage facility to the farmers of Valiant Primary Multipurpose Cooperative with a capacity of 900,000 kg. While the facility is situated in Palayan City, it is only 11 km away from Barangay Vega – a village in Bongabon. In 2023, a cold storage facility with a capacity of 300,000 kg was given to Kalasag Farmers Producers Cooperative. The facility is situated in Barangay San Agustin in San Jose City which is only one to two kilometers away from the farmer-members. Since these two facilities are recently established, the majority of farmers are still not aware of these facilities and are more aware of the privately owned cold storage facilities located in Bongabon, Palayan City, and Cabanatuan City. Hence, a median distance of 19.00 km was recorded.

Comparison of average values by use or non-use of cold storage was employed to check for the difference between the two groups. Shapiro-Wilk test for normality was conducted and it can be stated that the total land area, land area devoted for onion production, distance to the nearest cold storage facility, profit from the last cropping season, farming experiences, and years spent in formal education are not normally distributed. Hence, the Mann-Whitney U test was more appropriate to use than the classical independent sample t-test. Except for years spent in formal education, the aforementioned variables have a statistically significant median difference. Age is the only characteristic that met the assumptions for an independent sample-test and no significant mean difference was observed. At a glance, it seems that socio-economic characteristics are unrelated with participation in cold storage activity.

Table 3. Median and mean comparison between users and non-users of cold storage technology, 169 farmer respondents, Bongabon and San Jose City, Nueva Ecija, Philippines, 2023

Variables	Non-user (n=148)	User (n=21)	p-value
Total quantity sold	4,410.00	27,900.00	0.000
Total land area	0.80	2.00	0.000
Total land area for onion	0.50	1.75	0.000
Distance	25.00	8.00	0.029
Profit from last cropping season	30,000	100,000.00	0.033
Age	55.00	57.00	0.297
Farming experience	29.00	30.00	0.429
Formal education	10.00	10.50	0.035

In Table 4, the test of hypothesis on independence between the categorical independent variables and the dependent variable was employed. At 5% level of significance, it can be concluded that being a member of a cooperative, participating in trainings related to postharvest management, having off-farm income source/s, being a farmer-trader, relying on financier, and storing onion previously are associated with cold storage use.

It is completely certain that farmers who relied on financiers are impossible to store onion. Roughly one-fourth of the sample have relied on financiers. There are two common modes of financing, *samak* and *pabuto* system. *Samak* is an Ilocano term for profit sharing wherein

farmers rely on either a trader or another farmer (collectively called as financiers) for their inputs. All the costs are incurred by the farmer and after deducting the total cost from the gross revenue, the profit is shared between the farmer and financier. On the other hand, in *pabuto* system, the financier typically provides the seed (*buto* is the Tagalog term for seed) and in return, the farmer needs to pay the seed plus the interest and must sell all the harvest to the financier.

Liquidity, as represented by access to off-farm income, is associated with cold storage use. It is observed that off-farm income is also associated with farmers engaging in onion trading since this activity is one of the sources of off-farm income. Specifically, 10 out of 11 traders have stored onion in 2023 (Appendix Table B). In addition, being a member of a cooperative and attending a training is also associated with each other. Ten farmers out of the 22 affiliated farmers also attended the training (Appendix Table C). DA PRDP and the DA Philippine Center for Postharvest Development and Mechanization has been providing trainings to the farmers that are related on proper storage techniques. As an anecdote, a farmer mentioned that the cooperative was advised to put the onion in an anteroom with a temperature of about 17 degree Celsius before subjecting the onion to the cold storage. For Yellow Granex onion, the appropriate temperature ranges between 2 to 5 degrees Celsius while Red Creole onion needs to be stored at 0 degrees Celsius.

Table 4. Comparison of proportion between users and non-users of cold storage technology, 169 farmer respondents, Bongabon and San Jose City, Nueva Ecija, Philippines, 2023

Variables	Non-user (n=148)	User (n=21)	p-value
Price expectation			0.256
Did not expect	76 (51.58%)	8 (38.10%)	
Expect	72 (48.32%)	13 (61.90%)	
Cooperative membership			0.000
Not a member	135 (91.22%)	12 (57.14%)	
Member	13 (8.78%)	9 (42.86%)	
Training			0.000
Not attended	136 (91.89%)	12 (57.14%)	
Attended	12 (8.11%)	9 (42.86%)	
Access to formal credit			0.222
No access	111 (75.00%)	12 (57.14%)	
With access	37 (25.00%)	9 (42.86%)	
Access to off-farm income			0.001
No access	98 (66.22%)	6 (28.57%)	
With access	50 (33.78%)	15 (71.43%)	
Farmer-trader			0.000
Not a trader	146 (98.65%)	12 (57.14%)	
Also a trader	2 (1.35%)	9 (42.86%)	
Farmer under financier			0.006
No financier	107 (72.30%)	21 (100.00%)	
With financier	41 (27.70%)	0 (0.00%)	
Risk aversion			0.372
High risk aversion	79 (53.38%)	9 (42.86%)	
Moderate risk aversion	13 (8.78%)	0 (0.00%)	
Neutral	7 (4.73%)	4 (19.05%)	
Moderate risk taking	6 (4.05%)	1 (4.76%)	
High risk taking	43 (29.05%)	7 (33.33%)	
Stored previously			0.0000
Did not store previously	125 (84.46%)	1 (4.76%)	



Variables	Non-user (n=148)	User (n=21)	p-value
Stored previously	23 (15.54%)	20 (95.24%)	

Column percentages are in parentheses

To model the storage behavior of onion farmers, two regression models are presented in Table 5. The dummy variable indicating the reliance of farmer from a financier is omitted since it perfectly predicts non-use of cold storage. Thus, it can be concluded that farmers who are dependent on financiers are completely certain not to adopt the cold storage technology.

A parsimonious model is first presented with total quantity sold as the explanatory variable. The bivariate regression model already have a decent explanatory power with a pseudo R-squared of 0.3187. An increase in the quantity of onion sold (in logarithm) increases the likelihood of cold storage use by 8.7%. This conforms the typical reason of farmers regarding their non-participation of storage. Privately owned cold storage facilities require at least 30,000 kg or 1,000 bags of onion. This volume requirement serves as a barrier in using the cold storage facility. That is why it is evident that those farmers who engaged in trading have the capability to store since they are able to consolidate the onion bought from several small hold farmers. In the long logit model, being a farmer-trader increases the likelihood of cold storage use by 24.6%. As a response, some farmers attempt to put their onion in cold storage from traders who still need to complete the required volume set by the operator of cold storage facility.

Previous storage behavior also increases the likelihood by 14.5%. The percentage of those who stored prior to 2023 is 25.4% while the adoption rate in 2023 is only 12.4%. It must be noted that 2023 is a unique year in the sense that the farmgate price considerably increased. For Red Creole onion, the farmgate price³ in March 2022 (i.e., peak harvest season) was 0.68 USD/kg (Philippine Statistics Authority, 2022). In the same month of 2023, the typical price was 1.08 USD/kg as reported by farmer-respondents. For Yellow Granex onion, the farmgate price was only 0.26 USD/kg but the average price in March 2023 was 0.90 USD/kg. Price attracted both farmers and traders to sell immediately thus reducing the rate of cold storage use.

Capacity building measures also increases the likelihood of cold storage use. A member of a cooperative is more likely to use cold storage by 6.3% and farmers who attended training are more likely to use by 8.4%. The results are consistent with Alemu et al. (2021) citing that farmers are able to benefit from pooling their resources and hence are more likely to manifest intention to store. Similar to the result of Bokusheva et al. (2012), training increases the likelihood of adopting improved storage technology since farmers acquire knowledge and awareness on new technological solutions.

³ According to the Philippines' Central Bank, 1 USD is approximately 54.48 pesos in 2022 and 55.63 pesos in 2023. <https://www.bsp.gov.ph/statistics/external/Table%2012.pdf>



Table 5. Logit regression showing the average marginal effects of various factors on use of cold storage technology, 169 farmer respondents, Bongabon and San Jose City, Nueva Ecija, Philippines, 2023

Variables	Parsimonious model				Long logit model			
	Coeff.	p-value	dy/dx	p-value	Coeff.	p-value	dy/dx	p-value
Intercept	-13.410	0.000	-	-	-31.69	0.003	-	-
Total quantity sold (in logarithm)	1.219	0.000	0.087	0.000	1.227	0.054	0.033	0.083
Total land area					0.008	0.954	0.000	0.953
Distance					0.102	0.086	0.003	0.024
Profit from last season					0.000	0.584	0.000	0.570
Age					0.098	0.340	0.002	0.268
Farming experience					0.072	0.430	0.001	0.466
Formal education					0.011	0.950	0.000	0.950
Expect					2.057	0.081	0.055	0.054
Risk averse					0.133	0.618	0.004	0.594
Cooperative membership					2.364	0.017	0.063	0.023
Training					3.130	0.023	0.084	0.023
Access to formal credit					-3.360	0.033	-0.090	0.043
Access to off-farm income					2.931	0.076	0.079	0.077
Farmer-trader					9.123	0.001	0.246	0.000
Stored previously					5.402	0.131	0.145	0.029
Wald χ^2	30.40				31.68			
Prob χ^2	0.0000				0.0071			
Pseudo R^2	0.3187				0.7598			



Conclusion

Recent developments in the Philippine onion industry include investments on cold storage facilities to abate postharvest losses and to provide farmers an option to increase their profit. The recent development on the establishment of cold storage facilities given to producers cooperatives may increase the capacity of farmers to store onion. However, there are still barriers to adoption such as liquidity constraints, transaction costs, and risk aversion. Thus, the paper examined the factors that are associated with use of cold storage technology in Bongabon and San Jose City, Nueva Ecija, Philippines.

Consistent with the hypotheses, the results show that members of a cooperative are more likely to use cold storage. The collective action and clustering approach which are the key tenets of a cooperative can be a solution to the strict volume requirement being implemented by privately owned cold storage facilities. Previous storage behavior is also positively associated with use of cold storage. Given that farmgate prices in 2023 are relatively high as compared to the previous year, some of the farmers who stored previously decided to sell onion immediately. Consequently, panel studies which considers the farmgate price of onion may be explored to enhance external validity further leading to a better understanding of storage behavior.

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Appendix Tables

Appendix Table A. Risk assessment using a hypothetical investment choice adopted from Fausti and Gillespie (2000)

	Lowest possible return	Average possible return	Highest possible return	Coefficient of Absolute Risk Aversion	Level of risk aversion
Probability	0.33	0.33	0.33		
Crop # 1	10,000	10,000	10,000	[0.000317, +∞]	High risk aversion
Crop # 2	8,170	10,600	13,030	[0.000109, 0.000317]	Moderate risk aversion
Crop # 3	6,420	11,200	15,980	[0, 0.000109]	Neutral
Crop # 4	5,420	11,200	16,980	[-0.000109, 0]	Moderate risk taking
Crop # 5	3,440	10,600	17,760	[-∞, -0.000109]	High risk taking



Appendix Table B. Test of association between access to off-farm income and engagement in onion trading

Variables	Not a farmer-trader (n=158)	Attended a training (n=11)	p-value
Access to off-farm income			0.000
No access	103 (65.19%)	1 (9.09%)	
With access	55 (34.81%)	10 (90.91%)	

Appendix Table C. Test of association between cooperative membership and participation in training related to postharvest management

Variables	Did not attend training (n=148)	Attended a training (n=21)	p-value
Cooperative membership			0.000
Not a member	76 (91.89%)	11 (52.38%)	
Member	72 (8.11%)	10 (47.62%)	



The Potential of Vertical Farming in Brunei Darussalam

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Abstract

The issue of food security in Brunei justifies the need to increase the local agricultural production effectively due to the constraint of land scares for farming where the soil acidity in Brunei is high which affect the crop production. Furthermore, climate change has affected the way people do farming. Vertical Farming (VF) plays an important role in modern agricultural practices today. VF has the potential to produce crops all year round and using less land. Therefore, the aim of this paper is to highlight the challenges and solution of vegetables VF in Brunei. In depth interviews were conducted with respondents consist 12 modern farmers in Brunei, 1 officer in Department of Agriculture and Agrifood, 1 academics, and 1 services provider. The research findings reveal challenges encountered by farmers in Brunei practicing modern farming methods VF such as high investment cost; unpredictable weather condition; market dynamics and competition; Nutrient distribution, pest and disease; light distribution and the need of skilled labour. However, VF has the potential to attract youth to participate in the agriculture. The significant of the study provides valuable insight regarding the potential of VF as a solution for food security and may benefit farmers, youth and policy makers regarding modern application of VF in Brunei

Keywords: vertical farming, potential, challenges, Brunei

JEL code: Q10, Q13

SDG goals: Zero Hunger; Quality Education; Decent Work and Economic Growth

Introduction

Agriculture has always been and continues to be extremely important globally and contributes significantly to economic growth and development (Blandford, 2011; Manescu et al., 2016). According to the World Bank (2021), agriculture accounted for 4% of global gross domestic product (GDP) in 2018, and in some developing countries, it accounted for more than 25% of GDP. With the rapid growth of the global population, it is expected to rise to 10 billion people by the year 2050 and the world's food production needs to increase 70 per cent by the year 2050 (UN, 2018; FAO, 2021). Furthermore, around 7 billion people worldwide are expected to live in urban cities (UN, 2018). According to D'Amour et al. (2017), urban expansion is projected in a 1.8-2.4% loss of global farmlands by the year 2030, and the Asia region would be the most likely to experience urban expansion; highest loss in farmlands, whereas Africa with highest percentage loss of farmlands (D'Amour et al., 2017). Therefore, food security has become a critical issue for countries with different levels of economic development, and the agricultural sector plays a vital role in improving food availability and with the rapid urbanisation, urban agriculture is in high demand (Chatterjee et al., 2020; Pawlak et al., 2020). In the context of Brunei Darussalam, the economy is still heavily relying on its hydrocarbon resources, such as oil and gas upstream and downstream industries and has been known for its exports and revenue for the past 90 years (International Trade Administration, 2022a). While, the low price of oil in 2013 has affected the budget deficit and weakened economic growth (The Commonwealth, 2021). Moreover, according to the Department of Statistic (2020), the labour force survey 2020 revealed the unemployment rate in Brunei has increased from 6.8%



in 2019 to 7.4% in 2020. Therefore, Brunei Darussalam would be vulnerable to economic shocks, posing challenges to Bruneian's lives.

According to the Department of Agriculture and Agrifood (DoAA) (2021), agriculture is one of Brunei Darussalam's primary and most essential contributor sectors to the country's economic diversification. Therefore, the growth and development of agriculture industries will support the country's vision of 'Wawasan 2035', which is to achieve a dynamic and sustainable economy. During the United Nations Food System Summit (UN FSS), It was stressed that Brunei Darussalam's commitment to strengthen the food system by accelerating the production growth of the agriculture and fisheries sector; promoting both domestic and foreign direct investment (FDI), and increasing productivity through technology to meet domestic demands and for export (Prime Minister's Office Brunei Darussalam, 2021). In 2019, Brunei's sources of food were obtained through imports from over ninety countries (Ministry of Finance Economy, 2020). Between 2015 and 2020, Brunei's overall trend of importation of food has been increasing while the exportation of food has been stagnant, resulting in the trade balance in the food sector being increasingly deficit (Department Economic Planning and Statistics, 2021a,2021b). The overall trend of Brunei's agriculture GDP is increasing. The highest Brunei's agriculture GDP was recorded at B\$91.36 million in 2018 and the lowest at B\$89.07 million in 2015. However, the contribution of agriculture's GDP towards Brunei's GDP has been very low. The data for the year of 2015-2020, shown the contribution of agriculture sector was averaging 0.53 percent (Department of Agriculture and Agrifood, 2021).

According to the Grealish et al. (2008) on the project 'Soil Fertility Evaluation/Advisory Service in Negara Brunei Darussalam'. Under the Soils and Land Suitability of the Agricultural Development of Area concludes that the soil acidity is high in Brunei, with pH between 4.2 and 4.9. Thus, it affects crop production due to toxic chemicals and deficiencies in micronutrients. Moreover, Brunei's climate, landscape, and soils predisposed much of the country to waterlog due to high rainfall, shallow groundwater (typically less than 0.5m from the surface), perched water table (overlying unsaturated soil), poor surface drainage and convergent runoff.

It is proven that Brunei is facing land limitations for agricultural purposes and most of the soil in Brunei is not suitable for farming due to high soil acidity that affects crop production, climate, landscape and soil predisposition.

Therefore, the aim of this paper is to study the potential of VF as solution for food security by examining the challenges and solutions of VF practice in Brunei Darussalam. VF is one of the modern agricultural solutions for urban agriculture to tackle these problems. It uses a content analysis and in-depth interviews methods.

In the context of Brunei Darussalam, VF is relatively new industry in the Brunei's agricultural sector. According to Wardi Wasil (2018), during the year 2018, Brunei started the first initiative to encourage the participation of youth to venture in VF. As stated by Hirman Hj Abu, the Head of International Affairs and Public Relations at the department, the initiative titled "Kursus Pendedahan Teknologi Mudah dan Murah" aims to provide young individuals with knowledge on cost-effective approaches to initiating agricultural enterprises. The initiative encourages youth to establish vertical gardens utilizing minimal spaces and affordable materials like recycled plastic bottles and wooden planks, thereby addressing the challenge of needing land to start a farm. "The objectives of the initiative provide the youth a head starts in the world of agriculture and we will help them to overcome common problems faced by other agriculture



startups like pests” he said. Furthermore, “Upon the completion of the first course, participants who are interested in pursuing this venture will be encouraged to register for a second and more intensive course. We will give them more in-depth information on the technicalities and economics of running their vertical farms”.

Some examples of the present VF in Brunei are RZ Prisma Enterprise, located at the Brunei Agricultural Research Centre, Kg Kilanas. Initially the farm was one of the pilot projects under the Department of Agriculture and Agrifood back in the late of 2017. During that year, the farm has the capacity to cultivate more than 7000 of lettuces using hydroponic vertical system. The business made their first ever harvest on the 23rd February 2018. The following years the farm expanded their agriculture land plot to 3 hectares. In the year 2023, the business has already expanded where it has the capacity to cultivate 20,000 of lettuces at one time.

Natural Healing Enterprise is a 1 hectare commercial hydroponic farm situated in Agrotechnology in Kg Tungku. Initially established in 2018 as a health business, it transitioned to agribusiness in 2020 amidst the COVID-19 pandemic, prompted by the scarcity of fresh vegetables in local supermarkets in Brunei. The company's mission is to achieve self-sustainability in technology-based agriculture, producing healthy food while nurturing the local community. Its vision is to ensure environmental sustainability in food security. Operating two greenhouses, each measuring 8.8 meters by 39 meters, the company employs two distinct cultivation methods. In one greenhouse, they utilize 980 Dutch buckets for cherry tomato cultivation, while the other houses 49 VF racks capable of accommodating 12,740 plants simultaneously. With an ambitious annual production target of 15,600 kilograms, valued at BND\$200,000 (approximately USD 148,000), the company aims to meet the demand for fresh produce while maintaining a focus on sustainability.

Springhill Farm is a 4-hectare farm located in the agrotechnology park in Kg Tungku, Brunei dan Muara, registered in 2022. The company is committed to preserving the natural health and beauty of the land through sustainable and natural farming practices, utilizing the award-winning Agrivoltaics & Aquaponics system (HAVVA technology) and natural soil enriched with healthy organic inputs. Their goal is to produce the highest quality natural local vegetables and fruits in Brunei. The company's mission includes promoting environmentally sustainable green practices and technologies, serving as a conduit for best practices, awareness, and knowledge in agro-tech farming in Brunei, and growing and marketing safe, natural, and nutrient-dense products for the market. Springhill Farm's aquaponic VF system has the capacity to cultivate 4,100 plants, including lettuce, kale, pak choy, and amaranth, within a month. The estimated monthly yield is 1000 kilograms, valued at BND\$2,820.51 (USD9,486.32).

I AM Food, a 2-hectare agritech farm utilizing technological innovation to improve the efficiency & output of agricultural processes with three farming systems - Aquaponics, Fertigation & Outdoor Natural Farming. The company aims to produce quality hygienic & safe crops & currently harvesting Melon Royale, leafy vegetables, chilis, capsicums & herbs. Other produce includes freshwater fish, Kelulut Honey, jams & sauces. It is estimated that the farm's crop yield can generate 30,000kg per month and 2400kg of fish per cycle.

According to Biz Brunei (2023), Brunei's first indoor vertical strawberry farm, situated at the Agrotechnology Park in Kg Tungku, occupies a compact space smaller than an average household in Brunei. This pioneering venture comprises four vertical racks, each with five layers, accommodating a total of 2,000 plants. Lee Wei Sheng, co-founder and Chief



Technology Officer of Superfish Growers, initiated experimentation with this pilot setup in 2019, with two primary commercial objectives: exporting their proprietary strawberry farming system and establishing a commercial farm capable of hosting 10,000 to 15,000 plants by the following year. Such an establishment could yield between 40 to 60 tonnes of strawberries every eight months. The pilot setup has successfully cultivated seedlings of four strawberry varieties: Ozark Beauty (US), Sweet Sensation (Netherlands), Seolhyang (Korea), and Benihoppe (Japan). Plants from the pilot project have demonstrated impressive productivity, yielding between 1.5kg to 2kg of strawberries each over a five-month season—four times the output of traditional field farms and double that of existing indoor farms. The company offers their vertical strawberry farming setup and consultancy services for 4,000 to 7,000 plants at BND\$500,000 to BND\$1 million, with larger productions for 10,000 to 15,000 plants priced at BND\$1.5 million to BND\$2 million. The required space varies depending on building height, with 10,000 plants fitting within 2,000 square feet using a five-story system. This paper will continue with discussing the literature review on VF, methodology, findings and discussion.

Literature Review

Despite global increases in food production over recent decades, more than 750 million people still suffer from undernourishment, primarily in developing countries (FAO, 2021). Food security in these regions is particularly vulnerable due to factors such as population growth and the increasing frequency of environmental disasters such as floods, droughts, and extreme weather events (Ahmed et al., 2017). Climate change is expected to exacerbate these challenges further, leading to shifts in ideal crop varieties, seasonal conditions, and increased occurrences of extreme weather events like high temperatures and heavy rainfall (Lin et al., 2022).

Furthermore, the issue of food insecurity is not only caused by the shortage of food supply but also a lack of purchasing power and access at national and household levels (Ahmed et al., 2017). As a result of the decrease in food supply brought on by climate change, consumers have to bear additional costs for obtaining food, thus reducing their access to it (Liu et al., 2022).

Traditional food production systems, which have been relied upon throughout human history, have faced challenges and criticisms in recent times. The intensification of traditional farming practices has led to a decline in organic matter content in agricultural soils in many countries, (ITPS, 2015). Farmers practicing traditional farming encounter various challenges, including exposure to weather catastrophes, long working hours, inconsistent yields, vulnerability of crops to pests and diseases, and low returns on investment (Sreedhar & Kumar, 2020). Moreover, traditional farming globally consumes a significant amount of freshwater, accounting for 70% of total usage (FAO, 2017). Coyle & Ellison (2017) highlight that traditional farming, especially for lettuce production, uses 91% more water compared to VF and greenhouses. Additionally, traditional farming has been implicated in contributing to biodiversity loss, soil erosion, water and atmospheric pollution, and groundwater contamination (ITPS, 2015). The annual usage of pesticides has increased globally by approximately 3.5 million tonnes per year (Sharma et al., 2019), with overuse in Southeast Asia resulting in agricultural soil degradation and adverse effects on health and the environment (Aisyah et al., 2019; Laili & Aisyah, 2020).

With a projected global population projected to exceed 10 billion and a further 70% in food production in 30 years, as well as compounded competition for land and water resources and the impact of climate change, the current and future food security hinges on our ability to

increase yields and good quality using the soils that are already under production (Spanner, 2015).

One of the ways to deal with the issues of local vegetables production is to introduce VF. Banerjee & Adenauer (2014) described VF as a system of commercial farming whereby plants, animals, fungi and other life forms are cultivated for food, fuel, fibre or other products or services by artificially stacking them vertically above each other. Al-Chalabi (2015) and Lu & Grundy (2017) talked about the same on VF as the urban farming of fruits, vegetables, and grains, inside a building or in door, in a city or urban centre. de Oliveira et al. (2020) defined VF as a method of food production that uses vertical dimension to grow crops hydroponically'. There are three types of VF; (i) hydroponics, the primary cultivation method utilized in vertical farms, wherein plants are grown in nutrient solutions, free of soil. (Birkby, 2016; Al-Kodmany, 2018; Birkby, 2016). (ii) aeroponic is the practice of growing plants with their root systems floating in the air and a nutrient solution sprayed at the roots to keep a constant film of nutrients and moisture (He & Lee, 2013), (iii) aquaponic is the method of cultivating plants and fish in the same system that relies on the biotic relationship between fish and bacteria (Santos et al., 2021).

Beacham et al. (2019) mentioned that the VF system can be categorised into two; multiple of levels of traditional horizontal growing platform and the crops are grown in a vertical surface.

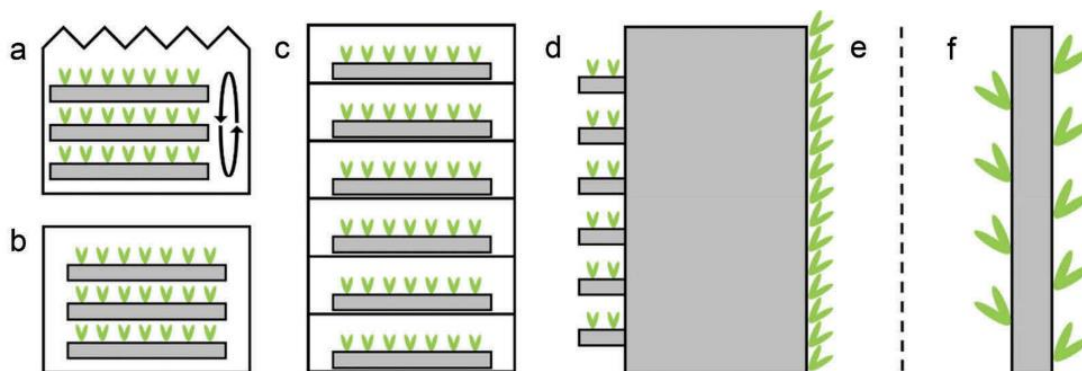


Figure 1 shows representation types of VF, where (a) multiple layers of horizontal growing surfaces in a stacked horizontal system, (b) the use of controlled-environment facilities, (c) multifloor towers in which each level is separated from the surrounding (e) a stacked horizontal VF system, balconies (d) Green walls, on the sides of the buildings, other vertical surfaces and (f) cylindrical growth units along with the vertical arrangement of the plant (Beacham et al., 2019).

Practically, vertical farms can be built almost anywhere, and with the global warming where extreme temperature or adverse weather conditions, farmers can be guaranteed of cultivating crops at ease (Miller, 2020). Kalantari et al. (2018) presented a successful vertical city farm worldwide such as the US, Canada, Singapore, South Korea, Japan, Holland, Sweden, and China (See Kalantari et al., 2018).

VF has the potential to produce crop all year round in a controlled environment, eliminating the cost of transportation, improving food safety and biosecurity, and reducing reduced inputs such as water supply, pesticides, herbicides, and fertilisers (Benke & Tomkins, 2017). Furthermore, it also alleviates pressure on agricultural lands by farming vertically rather than



horizontally, thus incorporating soil-free growing systems can appeal to urban environments (Beacham et al., 2019). In 2020, the market size of VF was valued at \$3.24 billion and is projected to reach \$24.11 billion by the year 2030 (Allied Market Research, 2021). Therefore, these agricultural technologies will be redefining the food industry in the years to come.

Vertical farms integrated with modern technologies will enable the cultivation of crops within urban areas (Januszkiewicz & Jarmusz., 2017). It is a revolutionary plant production system which allows high-quality fruits and vegetables to be produced locally for rapidly expanding cities (Rameshkumar et al., 2020). Furthermore, that VF could achieve 13.8 times more as a yield ratio to occupied growing floor area. (Touliatos et al., 2016). It also uses 18 times less water using a semi-closed loop water system, has lower freshwater pollution rates (eutrophication is reduced by 70–90% due to minor use of excessive fertilisers), and significantly reduces transport distance, which reduces CO₂ (Wildeman, 2020).

The literature highlights various challenges and considerations associated with VF systems.

Firstly, He (2015) argues that small-scale vegetable production methods, including soil-based, hydroponic, and aquaponic systems implemented in rooftop and vertical farms, may struggle to meet the food requirements in densely populated and land-scarce cities like Singapore, especially considering the additional challenges posed by climate change. O'Sullivan et al. (2019) emphasizes that urban farming, particularly VF, necessitates extensive research and innovation to address food security, human nutrition, and environmental sustainability issues. Benke & Tomkins (2017) point out that the significant challenge for VF systems lies in their high initial investment costs, with careful site selection being crucial. Moghimi & Asiabanpour (2021) highlight the potential high costs of VF due to energy consumption and labor-intensive operations. Banerjee & Adenaeuer (2014) discuss the cost analysis of a designed vertical aquaponic farm, indicating high expenses for construction, equipment, water, and electricity. Despite the costs, the study suggests that a vertical farm with a 0.25 ha area could significantly increase crop production yields. The proposed structure of the vertical farm includes multiple levels for crop production, aquaculture, environment management, waste management, plant germination, processing, and sales. The dimensions of the designed vertical farm include a height of 167.5 meters, a length and width of 44 meters each, resulting in an aspect ratio of 3.81. Additionally, the vertical farm requires a large space elevator for harvesting and waste transportation. It utilizes over 200,000 liters of water for daily operations, with a water-recycling system implemented to manage waste water efficiently.

However, the big challenges may face in introducing it in Brunei is the need for skilled labour and capital intensive.

Literature by Lubna et al. (2022) mentioned that VF is a heavy labour intensive compared to traditional farming. Thus, the reliance on human labour is crucial. Domestic labour is desirable compared to traditional farms that hire seasonal labour where vertical farm does operate all year round. Furthermore, most vertical farms are located in urban areas; therefore, a more significant domestic labour force is needed (Lubna et al., 2022). While, Wood et al. (2020) argues domestic labours from urban areas lack experience and training in managing a vertical farm. Due to the necessity of extensive labour, training programmes such as farming techniques, integrated pest management, food safety and handling, and data collection are required (Lubna et al., 2020). In the absence of skilled labour, depending on untrained and inexperienced workers could present considerable risks to a newly established vertical farm



(Lubna et al., 2020). Hence, it is imperative for supervisors to foster an environment of open communication within the workplace, enabling new employees to share concerns regarding farm-related issues, potential inefficiencies, and matters requiring expert insight (Lubna et al., 2020).

Therefore, developing human capital is a vital step to promote the practice of VF. It must be started from school education and trainings. Up skilling training for the existing farmers and workers will also help this idea and initiative.

Methodology

Despite a reported total of 3,187 farmers and entrepreneurs in the fruits and vegetables industry in Brunei Darussalam, statistical data specifically on VF operations in the country is lacking. This study utilizes qualitative methods, employing in-depth interviews to a total 15 respondents. 9 Bruneian farmers were selected from the list provided by the Department of Agriculture and Agrifood (DoAA) that uses modern farming methods, 1 officer from the DoAA and 1 instructor from the School of Agrotechnology and Applied Science at the Institute of Brunei Technical Education (IBTE). Although more respondents could have been selected from the list provided by the DoAA, those chosen were particularly notable for their responsiveness and willingness to share opinions and experiences. Therefore, this study also applied snowball sampling method, where an additional 3 locally own modern business farm were identified and selected. The researcher conducted semi-structured, in-depth interviews over a period of 3 months, focusing on open-ended questions to address the research objective. Interviews lasted between 30 to 60 minutes and were recorded for accuracy and focus. Content analysis is employed to analyze and organize the data gathered from these interviews. Krippendorff (2004) defines content analysis as ‘research technique for making replicable and valid inferences from texts (or other meaningful matter) to the contexts of their use’. Furthermore, it includes ‘any of several research techniques used to describe and systematically analyse the content of written, spoken or pictorial communication—such as books, newspapers, television programs, or interview transcripts’

Overall, the study gathered insights from a diverse range of respondents involved in modern farming techniques in Brunei Darussalam's fruits and vegetables industry, providing valuable perspectives on VF.

Table 1. List of respondents

Respondent No.	Company name	Hectare	Type of Farming	Current produce	Technology
1.	I Am Food Agritech	2	Aquaponics, Fertigation and Outdoor Natural Farming.	Melon Royale, leafy vegetables, chilis, capsicums & herbs. freshwater fish, Kelulut Honey, jams & sauces.	- Greenhouse -Aquaponic system (HAVVA technology) -Natural and LED grow light -Automated weather control system



Respondent No.	Company name	Hectare	Type of Farming	Current produce	Technology
					-Automated fertilising system -Rainwater harvesting
2.	Rz Prisma Enterprise	3	Hydroponic greenhouse system using vertical and horizontal system.	Lettuce, asparagus, rock melon	- Greenhouse - Hydroponic system -Natural light -'A' frame vertical system -Horizontal hydroponic system
3.	Springhill	4	Agrivoltaic, Aquaponic and Natural Organic Based Farming	Dwarf Pak Choy, Choy Sum, Basil, Cherry Tomato, Strawberries, Pandan Leaf, Papaya, Moringa Leaves	-Aquaponic system -cylindrical vertical -Solar power system -Natural and LED growlight -Rainwater harvesting system -Automated weather control system -Automated fertilising system
4.	Natural Healing Enterprise	1	Hydroponic using vertical rack system and Fertigation system.	Lettuce, Cherry Tomato, basil and mint.	- Hydroponic system - VF rack -Natural and LED grow light -Automated weather control system -Automated dosing system



Respondent No.	Company name	Hectare	Type of Farming	Current produce	Technology
5.	Hua Ho Agricultural Farm	42	Mixed farming – Poultry , Fruits and Vegetables using hydroponics system and greenhouse system and protected cultivation	Varieties of tropical fruits and vegetables	- Hydroponic - Greenhouse -Organic compost
6.	S&R Aquafarm	0.01	Aquaponic using greenhouse system	Lettuce, cherry tomato, chilli, basil and mint.	-Aquaponic system - Greenhouse -1 floor stacked bed -stacking vertical towers -Rainwater harvesting
7.	UZ Farm	0.01	Hydroponic farm using greenhouse system	Lettuce	-hydroponic system (horizontal and vertical system)
8.	Kabunku Aquaponic	0.1	Aquaponic and hydroponic in a greenhouse system	Leafy vegetables such as lettuce, pak choy, basil, aloe vera	-aquaponic and hydroponics system -rainwater harvesting -Insect farming (for fish food)
9.	Perusahaan Teratak Jaya	4	Fertigation and hydroponic in greenhouse system	lettuce and chilli	-vertical
10.	Ibnu Anwari	1.2	Fertigation System	Various Fruits and leafy vegetables	- Greenhouse
11.	FR Agro Farm	2.5	Fertigation and hydroponic	Chilli and Lettuce	- Greenhouse - ‘A’ frame vertical system
12.	Cahaya Agro		Fertigation system using drip irrigation system	Chilli	-Drip irrigation
13.	Agrowmetro	-	Local hydroponic Supplier		-
14.	IBTEInstructor in the School of Agro	-	-	-	-



Respondent No.	Company name	Hectare	Type of Farming	Current produce	Technology
	Technology and Applied Science				
15.	DoAA officer	-	-	-	-

Results and discussion

The findings below show several challenges mentioned by the respondents in Table 2. The challenges are as follows:

Table 2. Summary of the challenges in VF in Brunei Darussalam

Challenges of VF in Brunei	Farmer's Opinion	Frequency
High Investment Cost	“Large-scale modern farming involves a slow rate of return on investment, for eg. 2 hectare of land requires BND\$1.9 million (USD1,430,843.45)”	100%
Weather related condition	“The adverse weather condition in Brunei such as strong winds, storms that can damage the greenhouse and water shortage during the hot seasons” “Due to heavy rain, our greenhouse was affected by flash flood”	40%
Market dynamics and Competition	- “To sell it profitable enough that it justifies the investment cost, because right now in Brunei, we import a lot from Malaysia and locally grown using the cheapest and fastest method.” - “trying to stay sustainable with imported crops from neighbouring countries. For example, cost of planting chillis is BND8 per kilo but imported chillis is only BND3.90 per kilo” - “Limited market size in Brunei leading to competition among local farmers growing similar crops.”	46.67%
Limited crop variety	“limited range of crops that can be economically produced in VF systems”.	46.67%
Pest and Diseases	- “VF is susceptible to water-borne disease and pest” - “the crops have bacterial spot”	46.67%
Light Distribution	“the inconsistent distribution of light sources affects the development of plants” “When I used to sell VF system, I received a lot of feedbacks from the customers that some plants are not exposed to sunlight”	20%
Nutrient Deficiency	"When I first started my journey in aquaponics, experience nutrient deficiency in the crops that I grow" “The challenge is to maintaining optimal nutrient levels for plant growth” “nutrient delivery and distribution to all plants can be challenging especially in VF	20%
Advance technical knowledge	"managing VF operations must possess proper knowledge to ensure successful implementation and operation” "Farmers need to be equipped knowledge before starting VF business”	46.67%



High investment cost

The opinions shared by respondents shed light on the significant financial barriers associated with modern farming practices in Brunei. Majority agree that modern farming, whether large-scale operation or specialized systems like VF and, hydroponics, aquaponics and fertigation, demands substantial capital, posing a major challenge for aspiring Bruneian farmers with limited financial resources. Furthermore, beyond initial setup costs, modern farming incurs ongoing operational expenses such as maintenance, utilities, and labour, contributing to the overall financial burden. Furthermore, it evident that modern farming methods are considerably more expensive than traditional soil-based practices, highlighting the economic challenges faced by farmers opting for innovative techniques. The slow rate of return on investment in large-scale modern farming further compounds the financial strain, potentially deterring investors and hindering sector growth. Therefore, implementing large scale VF, presents a significant challenge in Brunei due high capital intensive, potentially rendering it commercially unviable (Al-Kodmany, 2018).

Weather related condition

The opinions expressed by respondents highlight the weather-related conditions in Brunei, including strong winds, heavy rain, and hot temperature that could lead to dried water storage. Additionally, the hot weather poses a significant concern, often necessitating modifications to greenhouses to mitigate heat exposure. Flash floods caused by heavy rain can also impact greenhouse structures and crops, leading to potential damage. Furthermore, the combination of hot days and rainy nights can create ideal conditions for pests like caterpillars, further complicating crop management. Overall, these weather-related challenges highlight the need for adaptive strategies and resilient agricultural practices in Brunei.

Market dynamic and competitiveness

The issue of market competitiveness emerges prominently, with local farmers struggling to compete with cheaper imports from neighbouring countries. This disparity in pricing poses a significant barrier to the profitability of locally grown crops, particularly when compared to the lower-priced imported alternatives. As a result, farmers face difficulties in marketing their produce to both supermarkets and local stores, where pricing decisions often favour cheaper imported options. Moreover, due to limited market size in Brunei, these challenges intensify the competition among local farmers who grow similar crops. Moreover, local supermarkets pricing for vegetables based on weight, posing a challenge for modern farmers to sell their produce at a justified cost.

Limited crop variety

The opinions provided by respondents highlights the limited variety of crops that are economically viable for production within VF systems. While some respondents acknowledge the prevalence of leafy greens and microgreens in VF, there is a consensus among several respondents regarding the restricted range of crops suitable for this farming method. This limitation contrasts with traditional farming practices, which offer the flexibility to cultivate a broader spectrum of crops, including tropical fruits and various vegetables. However, it is noteworthy that opinions vary concerning the potential for diversification within VF systems. While some respondents suggest that the vertical arrangement of farms may favour the cultivation of specific crops like leafy greens and microgreens, others indicate the possibility of growing fruits such as tomatoes and strawberries, particularly in horizontally oriented vertical systems.



Pest and disease

The opinions provided by respondents highlight the susceptibility of VF systems to water-borne diseases and pests, posing challenges to crop health and overall productivity. Several respondents' express concerns about issues such as bacterial spots and pest infestations, which can negatively impact crop quality and yield. Despite efforts to mitigate these challenges through greenhouse technology and pest control measures, such as integrated pest management strategies, instances of crop damage and loss still occur. However, it is notable that some respondents indicate that the impact of pest issues on overall operations is relatively low, accounting for less than 5% per crop cycle. Nonetheless, specific incidents, such as the death of cherry tomatoes due to water overflow, underscore the need for continuous monitoring and management of environmental conditions in VF systems. These challenges highlight the importance of implementing robust disease and pest management protocols, along with efficient water management practices, to safeguard crop health and optimize production outcomes in VF setup

Distribution of light source

The opinions provided by the respondents shed light on the challenges associated with the inconsistent distribution of light sources in VF systems. Respondent's express concerns about the impact of this inconsistency on the development of plants, noting that some plants may not receive adequate sunlight due to issues with the implementation of LED lighting. Particularly, during cloudy or rainy days, while sunlight may not be as critical, the effectiveness of artificial lighting becomes crucial. Moreover, respondents highlight the additional cost incurred by implementing LED systems, which adds to the financial burden of VF operations. Feedback from customers further emphasizes the importance of addressing these issues to ensure optimal growth conditions for all plants within the VF system. These challenges underscore the need for innovative solutions and careful planning to optimize light distribution and minimize associated costs in VF setups.

Advanced technical knowledge

The opinions respondents collectively highlight the paramount importance of knowledge in the realm of VF. It's widely acknowledged that VF demands advanced technical knowledge for successful implementation and operation. This sentiment is echoed by the recognition that farmers embarking on VF ventures must be well-equipped with the necessary knowledge beforehand. Moreover, there's an emphasis on the need for proper knowledge management within VF operations to ensure efficiency and effectiveness. However, there's also a cautious note regarding the applicability of knowledge obtained that are not from tropical climate countries, suggesting the importance of contextual understanding in Brunei's agricultural landscape. Overall, it is noted that in Brunei, there is a lack of awareness and understanding regarding VF, indicating a potential need for educational initiatives to increase knowledge and awareness in the region.



Table 3. Respondent's perspective on skilled labour in VF

Respondent	Perspective on skilled labour in VF	Percentage of respondents indicating skilled labour is necessary	Percentage of respondents indicating skilled labour may not be necessary
R1	"it does not require skilled labour; however, they must follow the standard operating procedure, exercise a strict discipline and passion."		
R2	"Yes, VF do need skilled labour but not highly skilled labour. One needs to resolve problem when arise."		
R3	Yes		
R4	"Yes, VF do required skill such as knowing how much nutrients to put in and size and colour of vegetables etc."	66.67%	33.33%
R5	Yes		
R6	No		
R7	Yes		
R8	"Yes, at first, we did on the job training for new employee, but now we realized that we need more skilled labour to do job properly"		
R9	No		
R10	No		
R11	"No, skilled labour may not be necessary as we can provide training to our workers. Hiring skilled labour would result in higher labour costs."		
R12	you don't need a lot of labour; however, you need skilled labour. So yes.		
R13	'Having skilled labour is essential'.		
R14	"Yes, that's why I believe in the importance of acquiring skills myself before imparting knowledge to others."		
R15	Yes		

The need for skilled labour arises from the specialized tasks and technologies involved in maintaining optimal growing conditions and maximizing crop yields. Lubna et al. (2020) argues having no skilled labour, relying on untrained and inexperienced employees might pose a significant danger to a new large scale vertical farm. The specialized tasks and technologies involve in maintaining optimal growing conditions in VF require technical knowledge and skill sets. Table 3. shows the opinion of respondents regarding on the perspective of skill labour in VF, where 66.7% of respondents agree that skilled labour is necessary in vertical farm while 33.33% of respondents agree that it is not necessary to hire skilled labour.

In regards to the perspectives of respondents regarding youth participation in agriculture highlight several key insights into the evolving landscape of farming practices and the role of technology in engaging younger generations. One significant observation is that traditional farming methods, which often involve manual labour and exposure to harsh weather conditions, may deter many individuals, especially youth, from pursuing careers in agriculture.



However, VF presents a more appealing option for young people, offering a conducive working environment and requiring less manual labour. Furthermore, the shift towards modern farming aligns with the technological inclinations of today's youth. As modern farming methods, including hydroponics, gain popularity, educational programs such as the HnTEC programme initiative play a crucial role in cultivating interest among students. Exposing students to various types of farming, particularly horizontal hydroponics, helps bridge the gap between traditional and modern agricultural practices. However, despite the growing interest in modern farming, challenges such as the need for intensive capital investment remain significant barriers, particularly for young farmers. Passion and access to capital are essential factors influencing youth participation in agriculture. Nevertheless, the potential for modern farming to create job opportunities for future generations underscores its importance in sustaining the agricultural sector.

In conclusion, the perspectives of farmers highlight the need to leverage technology and educational initiatives to engage youth in agriculture effectively. By addressing barriers such as capital requirements and providing opportunities for hands-on experience and learning, the agricultural sector can attract and retain the next generation of farmers, ensuring its sustainability and resilience in the long run.

The Potential of VF in Brunei Darussalam

The potential of VF in Brunei lies in its ability to address several key challenges faced by the agricultural sector in the region. Implementing VF in Brunei offers a promising solution by maximizing limited land resources and reducing the dependency on traditional soil-based agriculture. With its ability to produce high yields in a controlled environment or greenhouse technology, VF can contribute to food security and promote self-sufficiency in Brunei.

Moreover, VF presents an opportunity to diversify crop production beyond the limited range traditionally grown in Brunei. While leafy greens and microgreens are commonly cultivated in VF systems, there is potential for expanding to other crops such as fruits and vegetables, especially with the current advancements in technology and infrastructure. This diversification can help meet the demand for a wider variety of fresh produce in the local market, reducing reliance on imported goods and enhancing food sovereignty. Furthermore, VF offers economics benefits, including reduced water usage, pesticide, and fertilizer inputs compared to traditional farming methods. Given Brunei's susceptibility to weather-related challenges such as high temperature, heavy rainfall, storms and strong winds, the controlled environment or greenhouse vertical farms provides resilience against unpredictable weather conditions, safeguarding crop health and productivity. Additionally, VF has the potential to create job opportunities, reduce the unemployment rate and stimulate economic growth in Brunei. By requiring skilled labour for VF operations, it can contribute to the development of a skilled workforce and support the growth of a sustainable agricultural industry in Brunei. Moreover, VF has the potential to enhance food safety and quality by minimizing exposure to contaminants and pollutants commonly found in soil-based agriculture. VF can ensure that consumers have access to healthy, safe and nutritious food options, thereby promoting public health and well-being.

Overall, the potential of VF in Brunei lies in its capacity to address various challenges while leveraging technology and innovation to promote sustainable agriculture and economic development in the country.



Conclusion

In conclusion, the insights gathered from farmers in Brunei highlights the significant challenges faced by modern farming practices, including high investment costs, weather-related constraints, market competitiveness, limited crop variety, pest and disease management issues, inconsistent light distribution, and the need for advanced technical knowledge. Despite these challenges, VF presents a promising avenue for addressing some of these limitations, offering opportunities for increased productivity, resource efficiency, crop diversification and job opportunity. However, past literature review mentioned that VF requires high investment cost, (Banerjee & Adenaeuer, 2014; Benke & Tomkins, 2017; Moghimi & Asiabanpour, 2021). In this study, it is noted that modern farming method including VF in Brunei requires capital intensive. Furthermore, the study suggests that Brunei is not yet in a critical position to implement VF due to having a lot of agricultural land.

Limitation of study

It is important to acknowledge the limitations of this study. The findings are based on a relatively small sample size and may not be generalizable to all farmers in Brunei. It is noted that more respondents would be selected that are practicing modern farming methods from the DoAA but these farmers were willingly to be interviewed their experience in modern farming. A snowballing was initiated to enhance the sample size of the study.

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Assessment of the Economic Effect of Value-Adding Activities in the Production and Marketing System of Salt in Ilocos Norte, Philippines: The Case of Pagnasahan Norte Agas Asin Association

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Abstract

The study is an attempt to determine whether the adoption of iodization and proper packaging of salt will improve not only the production and marketing system but also the income of the salt producers in Ilocos Norte. It used the unprocessed secondary data of the DAAE-UPLB CHED-funded project entitled “Value Chain Upgrading and Capacity Building for Salt Supply Chain Actors and Business Model Development for Village-Level Processors in the Philippines” to assess the economic effect of iodization and packaging in the production and marketing system of salt among the 16 active producer-members of the Pagnasahan Norte Agas Asin Association in Badoc, Ilocos Norte. They were grouped into Non-Adopters and Adopters to determine the difference in their contribution income statement from performing the two value-adding practices. The contribution income statements of the two groups were also subjected to cost volume profit and partial budget analyses and Fisher’s Exact Test to verify the socio-economic impact of their value-adding practices. Results revealed that the Adopters have higher net operating income and operating profit margin than Non-adopters. It was also found that if Non-adopters were to perform iodization and packaging practices, the increase in their net income would be more than enough to cover the corresponding increase in their expenses. This was further strengthened by Fisher’s exact test result which verified that the adoption of iodization and packaging indeed increased the income of the salt producers. These results can be used to encourage non-practicing salt producers to adopt iodization and packaging.

Keywords: value-adding, cost volume profit, partial budget, Fisher’s Exact test

JEL code: M54

SDG goal: Industry, Innovation, and Infrastructure

Introduction

Salt, scientifically known as sodium chloride (NaCl), serves as a widely used food seasoning present in various culinary applications across different cultures. (Sánchez-Castillo & James, 2013). It serves multiple functions in food beyond enhancing flavor, including preserving freshness by inhibiting microbial growth and extending shelf life. Salt production in the Philippines remains rooted in the traditional practice of solar drying. This poses constraints as salt producers largely depend on the dry season for production, compounded by the unpredictability of dry seasons due to climate change, as well as concerns regarding seawater quality, directly impacting the quality of salt produced (Delos Reyes et al., 2021). In addition, the documentation of the value chain in the Philippine salt industry remains largely undocumented, despite salt’s economic significance for all participants in the supply chain,



from farmers to retailers (Tan et al., 2022). Therefore, it is imperative that the marketing system and value-adding specifications of salt production to meet market demands be explored.

The “ASIN Law” or the Republic Act 8172 (An Act Promoting Salt Iodization Nationwide and for Related Purposes) is one of the responses of the government to provide quality and iodine-fortified salt in the market and prevent the increasing cases of Iodine Deficiency Disorder (IDD) and chronic salt deprivation (Mannar as cited by Calixtro, 2019). This form of salt value-addition caters not just to consumers but also to producers as there is price premium for iodized salt. Value-addition is the process of improving or enhancing products or services that raise their value before they are offered to the market for sale to increase the income of those who perform them. It also helps in differentiating a product or service of a certain company or business from its competitors, especially in a perfectly competitive market like the salt market.

In the case of the Philippine salt industry, the prices of salt vary depending on whether it is iodized or non-iodized (Delos Reyes et al, 2021). Iodized salt is more expensive than non-iodized salt primarily because of the former’s iodine fortification and proper packaging. While iodized salt is expected to eliminate the health complications associated with IDD, non-iodized salt still proliferates in the market as consumers tend to buy sea salt in public markets and retail stores because it is cheaper. Additionally, the proper labeling and packaging of iodized salt is also crucial as iodine tends to evaporate if left unsealed hence defeating the purpose of iodization. According to Deresa, Befkadu, & Hamda (2023), it is essential to package and store iodized salt correctly to prevent iodine evaporation, necessitating storage in a dark and cool environment to minimize iodine loss. Added to this is the fact that locally-produced salt is hard to differentiate mainly because of its natural white color. There are however, efforts to properly distinguish them through assignment into different classes, namely: (1) Class A which has the highest quality, has the whitest crystals, and is sold at premium prices; (2) Class B that are commonly used for food processing with color that is not as white as the Class A; and finally, Class C or “mud salt” with visible impurities such as sand and stones and brownish color. Fine salts are produced via the method of cooking and are priced higher than the rock salts that are produced via solar evaporation.

In Ilocos Norte, one of the existing salt-producing provinces in the Philippines, salt farmers are using the cooking method to produce the more expensive refined salts. However, salt farmers are foregoing this practice and tend to pass iodization and product packaging to intermediaries as they are leaning toward producing non-iodized and unpackaged salts which are less costly to produce. This behavior and mindset of salt farmers tend to contradict the primary objective of the ASIN Law as they unconsciously promote and prioritize the supply of non-iodized salt in the market. Nevertheless, this practice limits the salt farmers’ potential for a greater market outside of their locality as checkpoints are designated at municipal borders, as mandated by the ASIN Law, to control the proliferation of trade of non-iodized salts.

The research question therefore banks on whether salt farmers could economically gain significant benefits from salt iodization and packaging to encourage them to adopt the practice and finally follow what the ASIN law prescribes them to do. This also becomes a pertinent research agenda for possible salt value chain upgrading. The general objective of this study, therefore, is to assess the economic benefits of the adoption of iodization and proper packaging practices of salt production in Ilocos Norte. The results of positive benefits seek to encourage salt producers to adopt salt iodization for increased income and be compliant with the ASIN Law. Otherwise, this study can be a basis for revisiting the said law.



Specifically, this study aimed to:

- 1) characterize the salt producer-members of the Pagnasahan Norte Agas Asin Association (PNAAA);
- 2) determine the production and marketing practices done by the salt producer-members;
- 3) assess the changes in revenues and costs, and net gains associated with salt iodization and packaging; and
- 4) provide appropriate recommendations based on the results of the study.

Methodology

Study Area, Types of Data, and Methods of Data Collection

Ilocos Norte was chosen as the study area since it is one of the major salt-producing areas in Luzon. The unprocessed data from the DAAE-UPLB CHED-funded project entitled “Value Chain Upgrading and Capacity Building for Salt Supply Chain Actors and Business Model Development for Village-Level Processors in the Philippines” covering the production period of 2019 was utilized for this study. The project collected primary data through face-to-face interviews and key informant interviews using pre-tested questionnaires. Data collected covered the harvest season of salt from March to April. In addition, a complete enumeration of target salt producers was employed for the study.

Analytical Tools

Descriptive analysis and action research designs were implemented in the study to present the current situation of the salt producer-members of the PNAAA. They were grouped based on their current production and marketing practices. Reasons for the adoption and non-adoption of value-adding practices specifically, iodization and packaging practices were also obtained. In determining the effect of iodization and packaging on the net income of the salt producers, the Cost Volume Profit Analysis (CVP) was performed. Adopters and Non-adopters were assigned to two separate groups. Their contribution income statements were compared and changes in price and variable and fixed costs were determined. The contribution income statements covered the production period of 2019 counting all the costs incurred by the salt producers. To verify the results of the CVP Analysis, a Partial Budget Analysis was also performed. This tool highlights the positive and negative effects of adopting salt iodization and packaging on the income of salt producers.

The Breakeven Point was determined for the number of units or pesos of sales that will be needed to cover both the fixed and variable costs. In the break-even analysis two equations were used: (1) dividing the total fixed expenses by the unit of contribution margin; and (2) dividing the total fixed costs by the contribution margin ratio. For a better understanding, both of these equations were used in case the salt producers are adopting iodization and packaging. Another financial measure employed in the study was the business investing principle of Margin of Safety. It is the amount of sales that are more than the total sales over the break-even sales. which shows a safety pad that ensures the safety of a business against misfortune like loss. A high margin of safety is good as it implies a lower risk of making a loss while a low margin of safety indicates a greater risk in doing the business.

The degree of Operating Leverage is an effective measure used to predict the changes in the net operating income that results from the change in sales. The higher the degree of operating leverage the more sensitive is a business income to the changes in sales as it exhibits a large



portion of fixed cost to the company's cost. In contrast, a lower degree of operating leverage is less sensitive to the changes in sales as it exhibits a large portion of variable cost to the company's cost.

Quantitatively, a comparative study of the contribution statements between the identified groups was done to determine which of the groups earned the higher profit based on their current operations. Partial budget analysis was also performed to further analyze the change in the net income of the salt producers if they were to adopt value-adding practices. Partial budget analysis is a decision-making tool that compares the cost and benefits of a business's current practice vis-a-vis alternative practices whether the latter is economically beneficial or not (Cornelisse, 2023). Additionally, the Fisher's Exact Probability Test was used to determine whether there is a significant association between the net income of salt producers and their value-adding practices. It is employed when examining the association between two categorical variables with nominal data, aiming to assess whether the distribution of one variable differs based on the levels of the other variable. This test is particularly suitable for situations with limited sample sizes (McDonald, 2024).

Limitations of the Study

The research is limited to evaluating and analyzing the processes of salt iodization and packaging. Due to the scope of the study, recommendations regarding additional value-adding activities beyond those covered here cannot be provided. Similarly, the study area was limited to Badoc, Ilocos Norte such that caution on relating the results to other areas should be practiced.

Results and Discussion

Profile of the Salt Producer-Members of the Pagnasahan Norte Agas Asin Association (PNAAA)

PNAAA is a livelihood organization formed in 2017 by the salt producers in Badoc, Ilocos Norte. Initially, the association had 30 members but due to the relatively old age of its members and the laborious processes in salt making, some of them decided to stop and shift to less cumbersome sources of income. Currently, the association is composed of 16 active members who employ the cooking method as their mode of salt production.

The majority (62.5%) of the salt producer-members are women as salt production in the area is viewed as an alternative source of income that is commonly practiced by the married respondents (75%). Their average age was 47 years with the highest proportion (37.5%) observed to belong to the age range of 41-50 years, indicating that the salt producers are still in their productive years. Viviani, et. al (2021) claimed that those within this age bracket tend to have better work performance. For educational attainment, it was discovered that half (50%) of the members were elementary graduates which explains their lack of technical knowledge about value-adding practices. This is quite ironic as their average number of years in the salt industry was 14 years. According to them, salt iodization is unnecessary as their produce is still being patronized in their area, as supported by their average monthly income of ₱16,780.22, which is quite stable.



Table 1. Distribution by socio-economic characteristics, 16 PNAAA salt producer-members, 2019

Socio-economic Characteristics	Frequency	Percentage
Sex		
Male	6	37.5
Female	10	62.5
Age (years)		
30-40	3	18.75
41-50	6	37.5
51-60	5	31.25
≥61	2	12.5
AVERAGE	47	
Civil Status		
Single	3	18.75
Married	12	75
Widowed	1	6.25
Separated	-	-
Educational Attainment		
Elementary Undergraduate	3	18.75
Elementary Graduate	8	50
High School Undergraduate	4	25
High School Graduate	1	6.25
College Undergraduate	-	-
College Graduate	-	-
Number of years in the salt industry		
1-20	14	87.5
21-40	1	6.25
≥41	1	6.25
AVERAGE	14	
Monthly Income (₱)		
Less than 5,000	3	18.75
5,001-10,000	2	12.5
10,001-20,000	9	56.25
≥20,001	2	12.5
AVERAGE	16,780.22	

Note: US dollar rate ₱1.00 = \$53.4385 by US Dollar to Philippine Peso Spot Exchange Rates for 2019, (n.d.).

Production and Marketing Practices

Salt production involves seawater collection, storage of seawater, watering of sand, filtration of seawater, transfer of seawater to cooking vessel, cooking, and finally harvesting. Except for the watering of sand and filtration of seawater, the rest of the activities are being performed by the respondents. According to the 81 percent who performed watering of sand, this practice helps in improving the salinity of seawater. Watering saturates the sand, which they put in a makeshift device, where they pour in newly collected seawater for filtration. The filtered water is the one cooked for salt making. The members mentioned that this practice was passed on to them by their ancestors. Aside from increasing salinity, salt producer-members who practiced filtration (75%) did so to remove impurities in the collected seawater. The other three salt-producing members who did not do sand watering and filtration claimed that such practices are tedious and time-consuming.

In addition, there were four post-harvest practices performed by the farmer- respondents: iodization, packaging, storage, and transporting. Only half (50%) of them practiced iodization, packaging, and transportation (Table 2). The main reason is that they view this as an additional cost only and not necessary. Those who did not do transportation reported that they do not own a vehicle and are not capable of renting one. They also indicated the advantage of having the trader pick up their salt as they can also avoid paying for the cost of hauling. According to them, iodization and packaging are done by the traders in their area. While the salt producers-members claimed that they are content with their current practices, they are also open to performing such practices if proven to be profitable.

Table 2. Distribution by marketing practice, 16 PNAAA salt producer-members, Badoc, Ilocos Norte, Philippines, 2019

Post-Harvest Practices	Frequency	Percentage
Iodization	8	50
Packaging	8	50
Storing	16	100
Transporting	8	50

Cost Volume Profit Analysis

An average of 248 sacks of salt were produced by the eight non-adopters as opposed to 325 sacks of the adopters but for comparability, standardization (248 sacks) was performed.

Comparatively, the adopters were able to sell salt at a much higher price (₱1,637.41/sack) than the non-adopters (₱1,092.07/kg. The total variable expenses of the adopters were higher by 18.16 percent (₱12,142.63 vs. ₱10,276.00) for the adopters. The contribution margin was higher for the adopters by ₱130,379.97 (50.04%), resulting in operating profit income of ₱259,576 and ₱388,883.29 for the non-adopters and adopters, respectively. However, the difference in operating profit margin between the two groups was small at only 0.64 percent favoring the adopters (Table 3).

Table 3. Comparative Contribution Income Statements (standardized to 248 sacks), 16 PNAAA salt producer-respondents, Badoc, Ilocos Norte, Philippines, 2019

Particulars	Non-Adopters	Adopters	Change
Sales (₱)	270,832.00	403,078.60	132,246.60
Price Per Sack (₱)	1,092.06	1,637.41	545.35
Less: Variable Expenses			
Wooden handled strainer	60.00	68.68	8.68
Sack	0	1,373.54	1,373.54
Firewood/combustibles	3,250.00	2,533.42	-716.58
Rake/Improvised Rake	150.00	152.62	2.62
Labor (non-cash)	4,953.00	4,067.20	-885.80
Selling	1,100.00	1,019.47	-80.53
Potassium Iodate	0	839.38	839.38
Transportation fee	0	1,401.01	1,401.01
Utilities	763.00	687.32	-75.68
Total Variable Expenses (₱)	10,276.00	12,142.63	1866.63
Change (%)			18.16



Particulars	Non-Adopters	Adopters	Change
Contribution Margin (₱)	260,556.00	390,935.97	130,379.97
Change (%)			50.04
Less: Fixed Expense (Depreciation)			
Sprayer	0	7.63	7.63
Pail	30.00	22.89	-7.11
Baskets	150.00	114.46	-35.54
Salt iodization machine	0	1,144.62	1,144.62
Water pump	350.00	267.08	-82.92
Cooking vessel	300.00	381.54	81.54
Clay jars	150.00	114.46	35.54
Total Fixed Expenses	980.00	2,052.68	1,072.68
Change (%)			109.46
Net Operating Income	259,576.00	388,883.29	129,307.29
			49.81
Operating Profit Margin (%)	95.84	96.48	0.64

Looking at the details, the highest change is likely to be experienced in total fixed expenses which can soar up to about 109 percent more for the adopters. This is due mainly to the investment in salt iodization machines. Similarly, total variable expenses are likely to rise by 18.16 percent for the adopters which are accounted for by the cost of potassium iodate and the cost of transportation (Table 3). It should be noted that iodized salt is allowed to be transported outside of the municipality thus they can sell to farther markets and incur more transportation costs.

Though the difference in the operating profit margin was small at 0.64 percent, increasing the production volume up to the full capacity of the fixed investments and vehicle can further increase the operating profit margin.

Break-Even Point

Results revealed that a total of two sacks of iodized salt must be sold or ₱10.78 must be earned by the salt producer-members to cover both of their variable and fixed expenses. The low break-even point can be explained by the fact that salt production in Badoc, Ilocos Norte required relatively low fixed costs compared to that of variable costs. The main contributor to the fixed cost was only the cost of the salt iodization machine.

Table 4. Other financial indicators, 16 PNAAA salt producer-respondents, Badoc, Ilocos Norte, Philippines, 2019

Indicator	Computed Value
Unit sales to break-even (sacks)	2
Peso sales to break even (₱)	10.78
Margin of safety (₱)	403,067.82
Margin of safety in percentage	99.99
Margin of safety in units (sacks)	305
Degree of operating leverage	0.97



Margin of Safety

The margin of safety of salt producer-members of the association for the season is ₱403, 067.82 or 99.99 percent which implies that sales of salt producers can drop by ₱403,067.82 (305 sacks of iodized salt) or 99.99 percent and still would not lose money.

Operating Leverage

The operating leverage of 0.97 signifies that for every one percent change in the sales of the members of the PNAAA will change its operating income by 0.97 percent. Since a large proportion of the costs of producers were identified as variable costs then they exhibit a low operating leverage. Hence, does not need to generate much sales volume to cover its fixed costs. This also means that the salt producers who will be adopting value-adding practices (iodization and packaging) will still earn profit at low levels of sales.

Partial Budget Analysis

The items and values listed in each column of positive and negative impacts were based on the comparative contribution income statement by the salt producer-members of PNAAA as presented in Table 5.

As shown in Table 6, it can be observed that for the positive impact of adopting iodization alone, a pack of salt can be sold at ₱943.33 having an additional revenue of ₱110.00 per sack and added costs equivalent to ₱48.53 per sack resulting to a net income of ₱61.47.

Table 5. Partial budget for the adoption of iodization practice per sack of salt, 8 PNAAA salt producers, Badoc, Ilocos Norte, Philippines, 2019

Positive impacts		Negative impacts	
A. Added Returns		C. Added Costs	
Additional revenue	110	Materials	45.87
		Labor	0.32
		Depreciation	1.75
		Selling	0.59
B. Reduced Costs		D. Reduced Returns	
Total	110	Total	48.53
Net income			61.47

On the other hand, as shown in Table 6, the adoption of packaging alone would give the salt producer-members an additional revenue of ₱19.18 with an added cost of ₱9.80, increasing the net income to ₱9.38 per sack of salt suggesting that packaging salt can be beneficial to them.

Likewise, Table 7 revealed that if non-adopters were to adopt both iodization and packaging, an additional revenue of ₱343.39 per sack can be generated. Given this, although they will incur an additional costs equal to ₱46.75 per sack, they can still gain a net income of ₱296.74 per sack of salt. On the whole, the partial budgets revealed that higher net income can be earned if the non-adopters were to adopt both iodization and packaging practices.

Table 6. Partial budget for the adoption of packaging practice per sack of salt, 8 PNAAA salt producers, Badoc, Ilocos Norte, Philippines, 2019

Positive impacts		Negative impacts	
A. Added Returns		D. Added Costs	
Addition in revenue	19.18	Materials	4.50
		Labor	0.62
		Transportation fee	4.59
C. Reduced Costs	0.00	E. Reduced Returns	0.00
Total	19.18	Total	9.80
Net income			9.38

Table 7. Partial budget for the simultaneous adoption of iodization and packaging practice per sack of salt, 8 PNAAA salt producers, Badoc, Ilocos Norte, 2019

Positive impacts		Negative impacts	
A. Added Returns		E. Added Costs	
Addition in revenue	343.49	Materials	33.22
		Labor	2.94
		Transportation fee	10.59
D. Reduced Costs	0.00	F. Reduced Returns	0.00
Total	343.49	Total	46.75
Net income			296.74

Association between Income and Value-Adding Practices

The Fisher's Exact value of 0.009 verified the significant association between the net income generated and adoption of iodization and packaging, implying that the relatively high monthly income of salt producers was due to their adoption of these value-adding practices.

Table 9. Fisher's Exact Test Result for the association between income and the adoption of Value-Adding Practices, 16 PNAAA salt producers, Badoc, Ilocos Norte, Philippines, 2019

Monthly Income	Adopters	Non-Adopters	Total
Less than 5,000	-	5	5
5,001-10,000	3	1	4
10,001-20,000	4	2	6
≥20,001	1	-	1
Total	8	8	16
Fisher's Exact: 0.009			

Conclusion and Recommendations

Results of the analyses point to the conclusion that performance of salt iodization and packaging is profitable and would increase the net income of salt farmers even if they will incur extra costs in the form of added investment. It is therefore recommended that non-adopter members of the PNAAA be encouraged to perform these two value-adding practices. This will be a win-win strategy for them as they would adhere to the government's call to promote salt



iodization in the country and help reduce IDD at the same time that they are also increasing their net income. Also, given that the two value-adding practices would require additional investments primarily for salt iodization machine, it is also recommended that PNAAA as an association should engage with the local unit for the possibility of provision of iodizing machine if not free of charge should be in the form of interest-free loans. Repayment period could also be negotiated and maybe through the PNAAA to reduce transaction costs on the part of the government. Coursing the loan transactions through the PNAAA increases the bankability of the farmers from the point of view of the lender. Similarly, through PNAAA, market linkage/tie-up can be forged such that payment for the loaned additional investment can be assured. Market linkage will be easier if PNAAA, instead of individual farmers, can assure the buyers of quality and volume requirements.

It is also recommended that a similar study be done for other value-adding activities (e.g., incorporating different flavors, etc.) and in other salt producing areas in the country to gain a comprehensive understanding of value addition in the Philippine Salt Industry. Continuous research and exploration will contribute to a more nuanced understanding of the dynamics within the Philippine Salt Industry, which at present is demanding so much attention for improved and sustained business operations.

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Track 3

Coping with vulnerability and risk



Structural Price Fluctuation Caused by Oil Price Variation in China's Mutton and Beef Market

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Abstract

Beef and mutton to be as the essential daily consumption, their prices have been given much attention by the government, researchers, and households. And some of researchers thinks that the instability of their prices is the result of the market gaming. However, the aim of my study is to employ and develop the VAR model of order p (price) and relative impulse response functions to account for the role that endogenous variables and oil price effect to the price fluctuation. We ask to how analyze and in what methods endogenous variable and oil price play a role for price transmission, movement and formation. We do so to enable agricultural policy makers, producer, and academics to understand the nuances of what factors and how they can have an obvious impact on price changes. Collecting 20 year monthly relevant data, we show that price changes are mutually affected by endogenous variables (retail price, producer price, international price and corn price) and oil price under VAR system analysis. The significance of this study is that it informs our theoretical understanding of forecasting the trend of prices by demonstrating the movement of prices of beef and mutton under introducing econometric VAR model, and informs our empirical understanding of stabilizing prices and guiding production.

Keywords: Price Fluctuation, Agricultural Supply Chain.

JEL code: C10

SDG goal: Good Health and Well-being

Introduction

The health of the nation as a whole is highly dependent on how well the agricultural economy works. Above all, it is essential to ensure sustainable food security, employment and livelihoods for almost one-third of the world's population (FAO, 2013). For this reason, agriculture is highly valued in each country, and efforts are being made to expand and secure the industry. Agricultural economic performance plays an important role in the general well-being of the population. Agriculture in China has a long history and has played many progressive roles historically. Its origins lie in the social, political and economic spheres of China and other Asian countries in general.

Variations in agricultural prices have a detrimental effect on the stability and growth of the economy of nations. The negative consequences of agricultural price instability on nations are amplified by inadequate storage facilities, disjointed agricultural supply chains, and restricted access to risk-sharing markets farmers. As a result, farmers in these nations experience significant price risk and struggle to production planning results in social unrest and food insecurity (Barrett et al., 2010). Such an instance, for the past ten years, has occurred in China's mutton supply chain, where continuous Price swings have deterred investments in the goat meat production and prompted thousands of farmers facing bankruptcy (Khan et al., 2014). To demonstrate the endogenous nature of price volatility in the Chinese mutton supply chain and bridge the gap between theory and practice, this study uses data from the endogenous literature



on agricultural prices to conduct fieldwork, model-driven We present hypothesis testing, and evidence from numerical simulations. change.

Two competing hypotheses about price volatility are at the centre of the literature discussion of the main reasons for the price volatility of agricultural commodities (Gouel, 2012). The idea of exogenous price volatility (Williams & Wright, 2005), based on the rational expectations model of storage and livestock, is often acknowledged as the dominant paradigm for understanding agricultural price volatility (Rosen et al. al., 1994). These rational expectations models link current and future supply through inter temporal arbitrage conditions, and exogenous shocks cause quasi-cyclical price swings. The idea of endogenous price fluctuations is based on cobweb-type models, in which boundedly rational farmers depend on expectations of future prices that are backward-looking and increase production during periods of high prices or vice versa. Some aspects of agricultural production, such as farmer heterogeneity, market linkages, and convex costs, cause cobweb-type models to exhibit nonlinearities, which cause quasi-cyclical price variations that are unaffected by external shocks (Onozaki, 2018). The price volatility of agricultural products, the subject of my research, has been changed by a series of events. Research on nonlinear dynamics has largely addressed well-known criticisms of spider web-like models. First of all, price cycles in nonlinear spiderweb models are characterized by a sensitive dependence on initial conditions and irregular frequencies, so extrapolative expectations do not always exhibit systematic forecast errors. Second, in contrast to the constrained price dynamics of linear spider web models, nonlinear spider web models exhibit a variety of complex price dynamics (Hommes, 2018).

Finally, laboratory studies show that people behave in a rationally constrained manner and rely on simple heuristics to predict prices in complex situations (Arango & Moxnes , 2012; Sonnemans et al., 2004). Fourth, his efforts to curb agricultural price volatility in LDCs through policies predicated on external price volatility have not yielded the expected results (Galtier, 2013). These results have revived interest in the spider web-like model as a whole. Both ideas have the potential to explain agricultural price instability in different institutional contexts. By incorporating empirically significant elements of agricultural markets, theoretical research has advanced models of exogenous and endogenous price changes in significant ways. For instance, heterogeneous expectations in nonlinear cobweb models (Hommes, 2018), capacity constraints in the competitive storage model (Oglend & Kleppe, 2017), and cobweb-type models with speculators and market inter linkages (Chaudhry & Miranda, 2018; Lundberg et al., 2015; Westerhoff & Wieland, 2010) are examples. Further improvements, such as competitive storage models with naive expectations (Mitra & Boussard, 2012) and supply shocks in nonlinear cobweb-type models, have investigated the implications of merging the key components of the theory of exogenous and endogenous price variations (Dieci & Westerhoff, 2010).

The mutton industry is crucial to the animal husbandry sector of the economy. It is also a crucial component of determining the competitiveness of local animal husbandry and a significant animal husbandry indicator. China further built the grassland ecological preservation subsidy and incentive mechanism in 2011 to further protect the ecological environment. Several regulations have been put into effect, including those that forbid grazing, balance cattle and grass, and bring back grazing to grasslands (Sheng Y et al., 2019). The execution of the policy will certainly result in a change in how animal husbandry is produced (Yang C et al., 2016) As a result, the traditional mutton industry has faced certain difficulties as a result of the reduction

in the natural grazing area, which has resulted in significant changes to the production process and the factors affecting industrial competitiveness.

China is skilled at producing and eating mutton, according to Ding CZ et al. (2016). China's mutton industry has grown quickly since the country's reform and opening up, and its output have significantly increased. For years, China has ranked first in the world for mutton production (Liu Y et al., 2019). The amount of mutton produced nationally in 2019 was 4.8752 million tons. The growth of the China mutton business has been steady, and it has now established itself as a key pillar of animal husbandry, driven by the country's economic development and improvements in the tourism sector. Nonetheless, the business still faces some issues that limit its ability to compete. This study initially creates an indicator system for the competitiveness of the mutton business based on Michael Porter's diamond model. After that, a thorough examination of the competitive landscape is used to explain the current state of the Chinese mutton sector. Lastly, this report makes some recommendations for boosting the China's mutton industry's industrial competitiveness.

Methodology

In this research, the corn price is the average price in the Chinese market. The international price of beef and mutton is the import price of beef and mutton. All the price data comes from WIND. The oil price data comes from OPEC, and oil price refers to the price of crude oil. The above are monthly data from January 2003 to December 2022. Endogenous Variables are involved in retail beef price, retail mutton price, beef producer price, mutton producer price, corn price, international beef price, international mutton price, and exogenous variable is focus on oil price.

Then, with the help of STATA 16.0 and EViews 12.0 software, we first conduct analyses such as descriptive statistics stationary test to glance at the raw data and check whether there is a price transmission among the beef and mutton industrial chain. Subsequently, the VAR model of order p , denoted as $VAR(p)$, can be expressed (Wooldridge 2015):

$$y_t = \alpha + A_1 y_{t-1} + A_2 y_{t-2} + \dots + A_p y_{t-p} + B X_t + \mu_t \quad (1)$$

We will introduce the meaning of the parameters, in equation (22) y_t is a $k \times 1$ matrix and stands for a set of endogenous variables; α is a $k \times 1$ matrix and serves as the intercept of the equation; A_1, A_2, A_p are the $k \times k$ matrix parameters needed to be estimated; and p denotes the lag order, that is a number of earlier time periods the model should include (for example, if $p = 1$, the above equation can be simply re-written as $y_t = \alpha + A_1 y_{t-1} + B X_t + \mu_t$). Moreover, X_t means the exogenous variables and B is the corresponding coefficients, and μ_t is the error term, which satisfies three conditions:

$$\begin{aligned} E(\mu_t) &= 0 \\ E(\mu_t \mu_t') &= \Omega \\ E(\mu_t \mu_{t-k}') &= 0 \end{aligned} \quad (2)$$

Furthermore, the lag order (p) can be determined according to some standard criteria, e.g., Schwarz Criterion (SC), Hannan Quinn (HQ), and Akaike Information Criterion (AIC) selection methods, which help to check the most fitted lag order (Sakamoto, Ishiguro, and Kitagawa 1986; Ludden, Beal, and Sheiner 1994). Lag order (p) is a necessary step since if the chosen lag order is not very large, the forecast precision of the corresponding VAR(p) model



can be reduced by specific procedures or criteria for selecting the adequate lag order p . In other words, with an optimal lag order (p), the conditions of Equation (2) can be precisely satisfied. With available lag order p , we, thus, are able to perform Johansen co-integration test exploring the long-run equilibrium within the beef and mutton market (Johansen 1995). We assume that there is a statistically significant long-term equilibrium between beef and mutton products in such a way that they are alternatives to each other. We also assume that the rise of upstream costs and transpiration costs can significantly increase the price of beef and mutton, and so does the international market in the long run.

The next step is to analyze its short-term shock effect by the adoption of the impulse response function. The impulse response function presents the evolution of the endogenous variables of interest along a specified time horizon (usually short-term) after a shock in a given moment from a specific endogenous variable (Hamilton 2020). For example, it displays the short-term impact of changes in the corn market on beef and mutton prices or the short-term impact of changes in the demand market on the total market. Because impulse response analysis traces the dynamic influence on a set of shocks from the demand side or supply side, it is valuable to be used to predict the trend of beef and mutton prices under certain circumstances under our theoretical framework. It is expected that the shocks are not persistent. Over time, variables can converge, but they might not converge to their original state, depending on the restrictions imposed on our VAR(p) model (Wooldridge 2015; Hamilton 2020). Apart from the impulse response functions, we also conduct variance decomposition analysis, decomposing the forecast error variance and showing the impact's contribution to variables due to various shocks. Intuitively, variance decomposition analysis indicates the importance a shock is in explaining the fluctuations of the variables. Besides, variance decomposition analysis can demonstrate how that contribution changes over a more extended time period. Possibly, some shocks might not be responsible in the short run but might lead to fluctuations in the long run, vice versa. Like the impulse response function, variance decomposition analysis is generally displayed graphically, e.g., a bar graph or an area graph, and at each time point, the composition of variance from shocks is plotted to all the variables (Eric 2021). In our study, both impulse response functions and variance decomposition analysis can be adopted to find the rationale among the corn market, the international market, and the beef and mutton market, as well as any shocks from the demand side and supply side, which prompts us to make a reasonable prediction analysis.

Results and discussion

In this article, we focus on that an increase in transportation costs cause a significant increase in the price of beef and mutton.

The smoothness of the examined model is first verified:

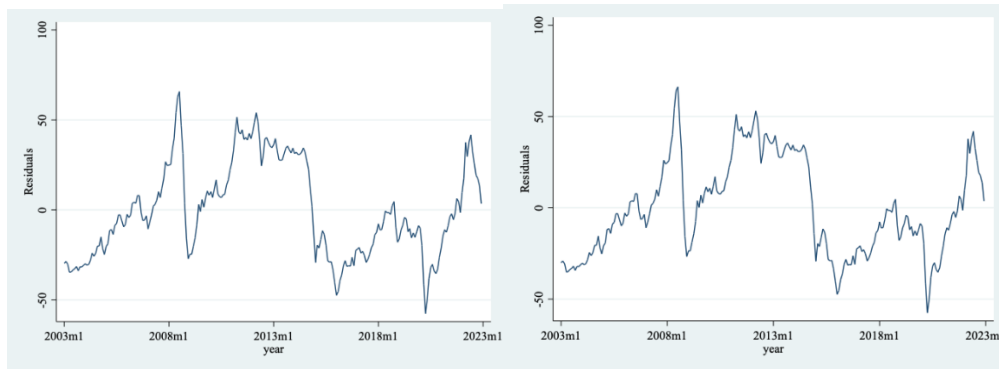


Figure 1 Smoothness test

According to Figure1, the model is smooth, so the optimal lag order can be examined using the information criterion, and the results are shown in Table 1, Table 2.

Table 1 Oil Prices and Beef

Lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	-1959.33					189942	17.8302	17.8427
1	-913.604	2091.4	4	0		14.6478	8.36004	8.39741
2	-871.254	84.7	4	0		10.3363*	8.0114*	8.07369*
3	-869.325	3.8578	4	0.426		10.533	8.03023	8.11744
4	-866.875	4.8997	4	0.298		10.683	8.04432	8.15645
5	-864.836	4.0779	4	0.396		10.876	8.06215	8.19919
6	-863.91	1.8531	4	0.763		11.1854	8.09009	8.25205
7	-861.917	3.9848	4	0.408		11.3931	8.10834	8.29522
8	-861.521	0.79205	4	0.94		11.7748	8.1411	8.3529
9	-858.202	6.6386	4	0.156		11.8508	8.14729	8.384
10	-856.201	4.0029	4	0.406		12.0718	8.16546	8.42709
11	-854.857	2.6867	4	0.612		12.3714	8.18961	8.47616
12	-850.451	8.8124	4	0.066		12.3312	8.18592	8.49738
13	-849.488	1.9254	4	0.749		12.683	8.21353	8.54991
14	-846.674	5.629	4	0.229		12.8281	8.22431	8.5856
15	-845.535	2.2768	4	0.685		13.1753	8.25032	8.63654
16	-838.482	14.108*	4	0.007		12.8246	8.22256	8.63369
17	-836.943	3.0769	4	0.545		13.1265	8.24494	8.68099
18	-836.567	0.75286	4	0.945		13.5797	8.27788	8.73884
19	-832.141	8.8509	4	0.065		13.5424	8.27401	8.75989
20	-829.757	4.7687	4	0.312		13.7599	8.2887	8.7995



Table 2 Oil Prices and Lamb

Lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	-1975.84				220718	17.9804	17.9929	18.0112
1	-946.05	2059.6	4	0	19.673	8.655	8.69237	8.74755
2	-915.989	60.121	4	0	15.5233	8.41808	8.48038*	8.57234*
3	-910.824	10.331	4	0.035	15.3602	8.40749	8.4947	8.62345
4	-909.287	3.0729	4	0.546	15.7088	8.42989	8.54201	8.70755
5	-901.09	16.395	4	0.003	15.1218*	8.39173*	8.52877	8.73109
6	-899.553	3.0745	4	0.545	15.4659	8.41412	8.57608	8.81518
7	-898.035	3.0359	4	0.552	15.8212	8.43668	8.62356	8.89945
8	-894.239	7.5919	4	0.108	15.8536	8.43853	8.65033	8.963
9	-893.443	1.5914	4	0.81	16.3262	8.46766	8.70438	9.05384
10	-891.672	3.5415	4	0.472	16.6655	8.48793	8.74956	9.1358
11	-889.883	3.5776	4	0.466	17.0102	8.50803	8.79458	9.21761
12	-885.686	8.3949	4	0.078	16.9871	8.50624	8.8177	9.27752
13	-880.399	10.574*	4	0.032	16.7982	8.49454	8.83092	9.32752
14	-876.931	6.9374	4	0.139	16.8896	8.49937	8.86067	9.39405
15	-875.652	2.5562	4	0.635	17.3247	8.52411	8.91033	9.4805
16	-872.255	6.795	4	0.147	17.4336	8.52959	8.94072	9.54768
17	-869.707	5.0966	4	0.278	17.6809	8.54279	8.97884	9.62258
18	-869.051	1.3116	4	0.859	18.2449	8.57319	9.03415	9.71468
19	-867.26	3.5826	4	0.465	18.6358	8.59327	9.07915	9.79646
20	-864.618	5.2831	4	0.259	18.8909	8.60562	9.11642	9.87

The tables provided are an in-depth statistical analysis, showcasing the relationship between oil prices and meat products, specifically beef and lamb. The two tables reflect the impact of oil prices on these two meat commodities, revealing potential vulnerabilities and opportunities in the global meat market due to fluctuating oil prices.

The first table, titled "Oil Prices and Beef", employs several statistical techniques, including Lag, Log-Likelihood (LL), Likelihood Ratio (LR), degrees of freedom (df), p-value (p), Final Prediction Error (FPE), Akaike's Information Criterion (AIC), Hannan-Quinn Information Criterion (HQIC), and Schwarz Bayesian Information Criterion (SBIC), to map out the dynamics of oil prices and beef.

At a lag of zero, the LL is -1959.33, indicating a high level of volatility. As the lag increases, the LL displays a substantial decrease, reflecting an improvement in the model's fit. This downward trend continues until the lag reaches 16, where the model seems to reach an optimal point, with LL at -838.482 and the LR at 14.108. The use of the asterisk (*) signifies the best parameters for the model.

In terms of information criteria, the FPE, AIC, HQIC, and SBIC values all decrease as the lag order increases, signifying a better model fit. At a lag order of 16, the FPE reaches its lowest

value of 12.8246, and the AIC achieves its optimal value of 8.22256. Both the HQIC and SBIC also attain their best values at this point, signalling the ideal model fit.

The second table, titled "Oil Prices and Lamb", presents a similar pattern. The LL value at a lag of zero is -1975.84, which again signifies considerable volatility. The LL value decreases with an increase in the lag, reflecting the improved model fit. The optimal point for this model is at a lag of 13, where the LL is -880.399 and the LR is 10.574.

The information criteria values in this model also decrease with the increase in the lag order. The FPE value drops to its lowest at a lag order of 13, reaching 16.7982. The AIC is also optimal at this lag order, value being 8.49454. The HQIC and SBIC reach their best values at this point too, indicating the best fit of the model.

Based on the information criterion, the model of oil price and beef should be chosen to lag up to order 16, and the model of oil price and lamb should be chosen to lag up to order 13. These optimal lag orders provide the best fit for the models, allowing for a more accurate prediction of the effects of oil prices on beef and lamb prices. Understanding these relationships can be vital for stakeholders in the meat industry, as it can guide strategic decision-making, particularly in times of oil price fluctuations.

In conclusion, these statistical models offer valuable insights into the complex dynamics between oil prices and meat commodities. By identifying the optimal lag orders, they provide the basis for more reliable and accurate predictions, thereby supporting informed and strategic decision-making in the global meat industry.

Next, Table 3 reports the results of a regression of transportation costs on beef and mutton.

Table 3 Transportation Costs and Beef and Lamb Prices

	(4)	(5)
Rbeef		
Oil	0.0793*** [8.6216]	
_cons	2.3748*** [2.7550]	
Rmutton		
Oil		0.0652*** [8.4826]
_cons		1.5011** [2.1225]
N	224	227
R2	0.9572	0.9747

t statistics in brackets

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

According to model (1), when beef as the explanatory variable and oil price as the explanatory variable, the regression coefficient is 0.0793, and the result is significantly positive at 1% level, that is to say, when the oil price increases, the price of beef will also increase; according to model (2), when mutton as the explanatory variable and oil price as the explanatory variable, the regression coefficient is 0.0652, and the result is significantly positive at 1% level. The

regression coefficient is 0.0652, and the result is significant at 1% level, which means that when the oil price increases, the price of mutton will also increase. To sum up, the increase of transportation cost will increase the price of beef and mutton significantly. Therefore, the second half of hypothesis 2 is valid.

Figure 2 reports the results of the robustness test and from the figure it is clear that the results are robust. Therefore, hypothesis 2 is valid.

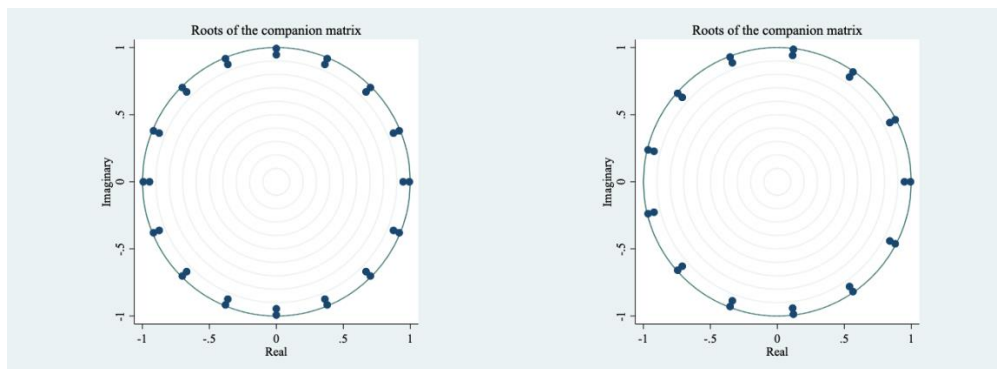


Figure 2 Smoothness test

The validation of hypothesis is more than an academic study; it has practical implications for the meat industry. Understanding the factors that contribute to the pricing of meat products is critical for stakeholders, including farmers, distributors and retailers. This enables them to make informed decisions about production, distribution and marketing strategies. For example, producers may hedge against rising corn prices by exploring alternative feed ingredients or investing in futures contracts to lock in prices. Similarly, distributors and retailers may seek more efficient transportation methods or adjust inventory levels in response to changes in oil prices. In addition, the results of the study are an important reference for cost management in the meat industry. By identifying the key drivers of costs, companies can develop strategies to mitigate the impact of price volatility on their operations. This may involve diversifying sources of supply, optimizing the supply chain, or passing on cost increases to consumers in a way that maintains competitiveness. The significance of this study goes beyond the immediate scope of beef and lamb pricing; it highlights the interconnections between different sectors of the economy, highlighting how changes in commodity markets can affect consumer prices through a chain reaction. This interplay between upstream costs and final product pricing is a phenomenon that exists across all sectors, making the insights of this study broadly relevant.

Future research in this area could build on the foundation laid in this study and examine the impact of additional factors on meat prices. Potential areas of investigation might include the role of technological advances in feed production, the impact of alternative energy sources on transportation costs, or the impact of international trade agreements on commodity prices. In addition, researchers could explore the complex interactions between these factors and how they work together to shape pricing mechanisms in the meat industry.

In summary, the rigorous testing and validation of hypothesis in this study has significantly contributed to our understanding of price formation in the meat industry. The insights gained provide a framework for managing costs and developing pricing strategies that are critical to the sustainability and profitability of firms in the industry. As the industry continues to evolve,



ongoing research is critical to adapting to the new challenges and opportunities presented by the dynamic interplay of upstream costs and transportation expenses. However, the volatility of beef and mutton prices is influenced by a complex interplay of exogenous and endogenous factors. A detailed study that considers these variables can shed light on the intricacies of price transmission and the gaps in information flow. Such research is crucial for informing a part of policy decisions and market interventions that aim to protect the interests of both producers and consumers. By leveraging this knowledge, governments and industry committees can work towards creating a more stable and predictable market for beef and mutton, thereby ensuring the well-being of all stakeholders involved.

Conclusion

Our study tries to investigate the price trend of China's beef and mutton product market by constructing a theoretical model including the impact of transportation costs (oil price). Moreover, employing VAR(p) model enables us to understand the responses of beef and mutton to different shocks and make reasonable projections. On this ground, we are able to comprehend the current situation and prospects in China as well as the price responses to various scenarios with different endogenous variables in a short time. In practice, we believe this study can deliver a valuable reference for the sustainable development of China's beef and mutton product market and present empirical evidence for the government to guide production and stabilize prices by forwarding market regulation in advance.

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Spatial Price Transmission in the Retail Rice Markets of the Philippines

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Abstract

Rice markets in the Philippines recently experienced various policy shocks, including the implementation of the Rice Tariffication Law (RTL) in March 2019, and the imposition of price freeze during the COVID-19 pandemic in 2020, and mandated ceiling prices on milled rice in September 2023. This study aims to examine the spatial price transmission of regular milled rice across 17 regional retail markets. By analyzing monthly price data from January 2012 to December 2023, the study seeks to describe structural breaks in price series, assess the speed and magnitude of price adjustments, determine the nature and direction of price transmissions, and identify factors influencing spatial price transmissions. Various analytical techniques, such as descriptive analysis, unit root and structural break tests, Toda-Yamamoto causality tests, and the autoregressive distributed lag technique, are employed to analyze the price series. The findings reveal significant positive and negative structural breaks. Both Central Luzon, the top producer of paddy rice, and Eastern Visayas, the main consumer of regular milled rice, serve as reference markets. The National Capital Region also functions as a central market. The speed of price adjustments ranges from 1.18 to 3.60 months, while asymmetric price transmission is observed in two out of four spatially integrated regional markets. Cagayan Valley exhibits almost one-to-one price transmission, whereas the other reference markets have an elasticity of price transmission of less than 0.80. The study recommends monitoring prices, disseminating market information, investigating unfair trade practices, improving NFA inventory management, and developing targeted price and market policy measures.

Keywords: Autoregressive distributed, asymmetric cointegration, spatial market integration, structural break

JEL code: C22, D40, and Q11

SDG goals: End hunger, achieve food security and improved nutrition and promote sustainable agriculture

Introduction

Food price inflation exacerbates food insecurity by limiting economic access to food. According to the Philippine Statistics Authority (PSA), the year-on-year changes in the Consumer Price Index (CPI) for food in the Philippines were 3.57 and 4.59 percent between 2012-2021 and 2018-2023 (PSA 2024). In the National Capital Region (NCR), the primary consumer hub in the country, food price inflation rates were 4.16 and 4.63 percent, while areas outside the NCR recorded rates of 3.46 and 4.58 percent during the same periods (PSA 2024). Additionally, the CPI for rice in the Philippines (1.72% and 0.32%), the NCR (2.06% and 0.52%), and areas outside the NCR (1.69% and 0.30%) has generally increased despite the decline in 2019 and 2020 (PSA 2024). Rice, as a staple food for 109.04 million Filipinos, accounts for over a third of the average calorie intake, 13.1 percent of total household expenditure, and a third of total food consumption (Valera et al. 2022). This makes it a priority crop for policy interventions aimed at achieving food security goals.



As an archipelago composed of three main island groups (Luzon, Visayas, and Mindanao), food security in the Philippines is best assessed by examining smaller geographic levels such as regions, provinces, and municipalities/cities, which have varying levels of local production, imports (as a net rice importer), and local consumption. Table 1 shows that while all regions, except for the NCR, produce paddy rice, the majority is concentrated in Central Luzon, Cagayan Valley, and Western Visayas. However, the per capita consumption of regular milled rice is higher in Eastern Visayas, Western Visayas, and the Bicol Region.

Table 1. Paddy rice production and per capita consumption of regular milled rice, by region, Philippines

Regions	Production (mt) (2010=2023)	Share (%)	Per Capita Consumption (kg) (FIES, 2018)
REGION III (Central Luzon)	3,444,894	18.56	70.76
REGION II (Cagayan Valley)	2,519,135	13.57	76.25
REGION VI (Western Visayas)	2,157,250	11.62	102.03
REGION I (Ilocos Region)	1,802,246	9.71	75.20
REGION XII (SOCCSKSARGEN -South Cotabato, Cotabato, Sultan Kudarat, Sarangani, and General Santos)	1,271,280	6.85	81.66
REGION V (Bicol Region)	1,251,332	6.74	98.13
MIMAROPA - Mindoro Occidental, Mindoro Oriental, Marinduque, Romblon, and Palawan	1,113,179	6.00	97.00
REGION VIII (Eastern Visayas)	935,354	5.04	104.03
REGION X (Northern Mindanao)	724,469	3.90	64.47
BARMM - Bangsamoro Autonomous Region in Muslim Mindanao	651,967	3.51	77.82
REGION IX (Zamboanga Peninsula)	650,534	3.50	73.08
REGION XIII (Caraga)	490,765	2.64	81.30
REGION XI (Davao Region)	451,318	2.43	58.57
CAR - Cordillera Administrative Region	404,067	2.18	47.12
CALABARZON - Cavite, Laguna, Batangas, Rizal, and Quezon	402,431	2.17	42.03
REGION VII (Central Visayas)	294,170	1.58	34.39
National Capital Region (NCR)	0.00	0.00	46.72
Philippines	18,564,392	100.00	66.52

Source of basic data: PSA (2024) and Family Income and Expenditure Survey (FIES) (2018)

Additionally, Table 2 reveals that some regions, such as Eastern Visayas and BARMM, face deficits in their own rice production and are located far from ports where imported rice is unloaded. These regional differences require specific interventions and strategies to ensure the achievement of food security goals.



Table 2. Classification of provinces by rice self-sufficiency status, and proximity to port where imported rice is disembarked

Rice self-sufficiency	Proximity to port where imported rice is disembarked			
	Near	Region	Far	Region
Surplus	Zamboanga del Sur	Zamboanga Peninsula	Nueva Ecija	Central Luzon
	Occidental Mindoro	MIMAROPA	Cagayan	Cagayan Valley
	Oriental Mindoro	MIMAROPA	Isabela	Cagayan Valley
	Sultant Kudarat	SOCCKSARGEN	Apayao	CAR
	Tarlac	Central Luzon	Kalinga	CAR
	Bukidnon	Northern Mindanao	Nueva Viscaya	Cagayan Valley
	Iloilo	Western Visayas	Ilocos Norte	Ilocos Region
	Capiz	Western Visayas	Quirino	Cagayan Valley
	Antique	Western Visayas	Aurora	Central Luzon
	Zamboanga Sibugay	Zamboanga Peninsula	North Cotabato	SOCCKSARGEN
	South Cotabato	SOCCKSARGEN	Agusan del Sur	Caraga
	Pangasinan	Ilocos Region	Biliran	Eastern Visayas
	Zamboanga del Norte	Zamboanga Peninsula	Palawan	MIMAROPA
	Camarines Sur	Bicol Region	Abra	CAR
	Ilocos Sur	Ilocos Region	Leyte	Eastern Visayas
	Guimaras	Western Visayas	Maguindanao	BARMM
	Lanao del Norte	Northern Mindanao	Ifugao	CAR
	Davao del Sur	Davao Region		
	Compostella Valley	Davao Region		
Marginally Sufficient	Agusan del Norte	Caraga	Camarines Norte	Bicol Region
	La Union	Ilocos Region		
	Pampanga	Central Luzon		
	Bataan	Central Luzon		
	Aklan	Western Visayas		
	Zambales	Central Luzon		
	Negros Occidental	Western Visayas		
	Sorsogon	Bicol Region		
Deficit	Bohol	Central Visayas		
	Davao Oriental	Davao Region	Western Samar	Eastern Visayas
	Masbate	Bicol Region	Northern Samar	Eastern Visayas
	Catanduanes	Bicol Region	Southern Leyte	Eastern Visayas
	Albay	Bicol Region	Eastern Samar	Eastern Visayas
	Zamboanga City	Zamboanga Peninsula	Misamis Occidental	Northern Mindanao



Rice self-sufficiency	Proximity to port where imported rice is disembarked			
	Near	Region	Far	Region
	Surigao del Sur	Caraga	Lanao del Sur	BARMM
	Bulacan	Central Luzon	Romblon	MIMAROPA
	Davao del Norte	Davao Region	Marinduque	MIMAROPA
	Surigao del Norte	Caraga	Mountain Province	CAR
	Quezon	CALABARZON	Benguet	CAR
	Sarangani	SOCCKSARGEN	Batanes	Cagayan Valley
	Negros Oriental	Central Visayas	Sulu	BARMM
	Dinagat Islands	Caraga	Tawi-Tawi	BARMM
	Laguna	CALABARZON	Basilan	BARMM
	Siquijor	Central Visayas		
	Misamis Oriental	Northern Mindanao		
	Camiguin	Northern Mindanao		
	Batangas	CALABARZON		
	Rizal	CALABARZON		
	Cavite	CALABARZON		
	Davao City	Davao Region		
	Cebu	Central Visayas		

Source: Department of Agriculture (2018)

Rice, a highly sensitive and political crop, has been a topic of concern in Philippine politics since the 1950s (Intal & Garcia 2005) and has been a focal point for policy interventions under every administration. During the 2022 presidential elections in the Philippines, President Ferdinand R. Marcos, Jr. campaigned on the promise of reducing the retail prices of milled rice to PhP 20 per kilogram (Presidential Communications Office 2023). Since assuming office on June 30, 2022, the lowest prices were recorded in July 2022 (PhP 39.32/kg) and January 2023 (PhP 39.50/kg), while a record high of PhP 48.48 per kilogram was reached in December 2023 (PSA 2024). Various administrations have implemented production policies such as providing subsidies for seeds and fertilizers, farm and post-harvest machinery and equipment, constructing irrigation facilities and farm-to-market roads, and offering support services and training programs. They have also implemented price and market policies, such as support prices for paddy rice, ceiling prices for milled rice, and subsidized rice from the National Food Authority (NFA), a government-owned and controlled corporation. In terms of trade policies, the country has transitioned from long-standing protectionism through import quotas and the NFA's control of imports to the liberalization of its rice market through the Rice Tariffication Law (RTL), which came into effect on March 5, 2019.

The RTL eliminated restrictions on rice imports and exports and replaced them with tariff systems (RA 11203, 2019). In-quota tariffs based on the 2012-level minimum access volume of 350,000 metric tons were set at 35% and 40% for ASEAN and non-ASEAN countries, and out-quota tariffs of 50% for most favored nations and 180% for others (Estadilla 2022 & RA 11203 2019). Another provision of the RTL involves the reduction of regulatory functions and downsizing of the trading operations of the NFA (RA 11203 2019). Other provisions include



the imposition of a special duty on rice in cases of sudden and extreme price fluctuations and the establishment of the Rice Competitiveness Enhancement Fund (RA 11203, 2019).

On March 8, 2020, President Rodrigo R. Duterte declared a state of public health emergency due to the COVID-19 pandemic (Official Gazette 2020). Proclamation 922 initiates the implementation of a price freeze on basic necessities for a maximum of 60 days in accordance with the Price Act.

On August 31, 2023, the national government issued Executive Order (EO) 39, imposing mandated ceiling prices on regular and well milled rice at PhP 41 and 45 per kilogram (Official Gazette 2023). The justifications for this policy are the alleged illegal price manipulation by traders, the Russia-Ukraine conflict, India's ban on rice exports, and the unpredictability of oil prices in the world market. Through EO 42, this policy was lifted on October 4, 2023 (Official Gazette 2023).

These policy shocks may have affected the price behavior of regular milled rice differently in regional markets of the Philippines. The study uses the Global Bai-Perron L breaks method to identify multiple break dates corresponding to structural changes in price series, and dummy variables in the cointegration models to test the significance of these structural breaks.

If the Law of One Price holds in spatially related markets, a long-run price relationship can be established between reference and peripheral markets. This means that a shock occurring in one market is transmitted to another. Figure 1 illustrates that retail price movements in selected regional markets mirror those in the NCR. However, their price differentials with the NCR vary the most in the case of Caraga, followed by Western Visayas and the Bicol Region. In an efficient market, the price differential should equal the transaction cost between two spatially integrated markets. Consequently, any shock in a reference market (e.g. NCR) should be fully (i.e., magnitude of elasticity of price transmission) and rapidly (i.e., speed of price adjustments) transmitted to a peripheral market (e.g. Bicol Region, Western Visayas, or Caraga) (Meyer & von Cramon-Taubadel 2002, Briones 2019, & Rose and Paparas 2023). If the peripheral market responds similarly to a positive or a negative shock in the reference market, the nature of price transmission is said to be symmetric. However, if the peripheral market reacts differently to a positive or a negative shock, there is asymmetric price transmission (APT). According to Meyer and von Cramon-Taubadel (2002), spatial APT may occur due to asymmetric adjustment costs, asymmetric information, market power, and asymmetric price reporting. These factors, along with the impacts of policy and external shocks, provide crucial information for determining policy measures aimed at improving market efficiency.

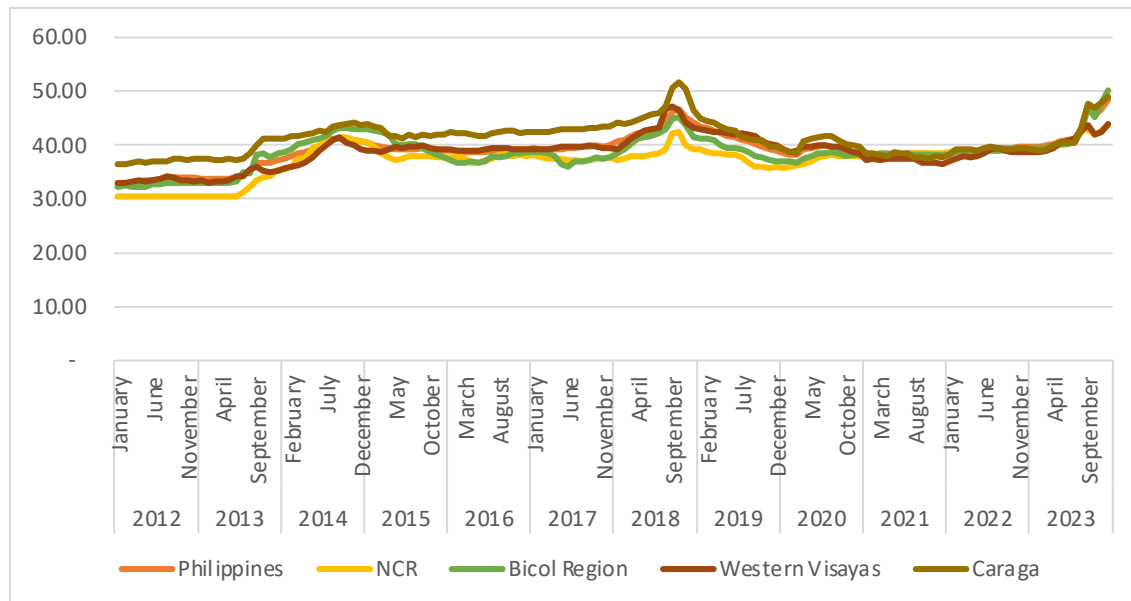


Figure 1. Nominal retail price of regular milled rice in selected regions of the Philippines
Source of data: Philippine Statistics Authority (2024)

To date, only the study of Briones (2019) which used regional price data on well milled rice from 1990 to 2016 addressed spatial price transmission for rice at the retail level. His study found long-run integration in the regional markets. This study contributes to the limited literature on rice price transmission in the Philippines by using retail price series of regular milled rice after the Rice Tariffication Law, conducting unit root tests that account for seasonality and one unknown structural break, including structural breaks in the cointegration models, and testing for asymmetry in price transmission. This study aims to determine structural breaks in price series, assess the speed and magnitude of price adjustments, determine the nature and direction of price transmissions, and identify factors influencing spatial price transmissions.

This paper is structured as follows. The second section describes the secondary data used, their sources, and methods of data analysis. Section 3 presents the main results and discusses these results. The final section concludes and proposes policy recommendations.

Methodology

Secondary data on retail prices of regular milled rice and Consumer Price Index (CPI) from 17 regions between January 2012 and December 2023 were obtained from the OpenSTAT website of the Philippine Statistics Authority (PSA). Descriptive analysis, unit root and structural break tests, Toda-Yamamoto causality tests, and the autoregressive distributed lag (ARDL) cointegration technique performed through Eviews 12 were used for the analysis.

The PSA reported two sets of retail price series with base years 2012 and 2018. To merge these two sets and create a longer series, the prices were adjusted to a common base year. Monthly CPIs for the periods of 2012-2021 and 2018-2023 were rebased by setting 100 as the CPI for January 2018. The ratio between the current and previous month's CPI (index relative) was computed, and then multiplied by the previous month's rebased CPI to obtain the current month's new CPI (BLS 2023). To determine deflated prices, the nominal prices were divided by the new CPI multiplied by 100.



Descriptive statistics, including mean, maximum, minimum, standard deviation, and coefficient of variation (CV) were used to describe the price series. The normality of data was assessed using the Jarque-Bera (JB) test.

Various unit root tests were conducted in the study. The Augmented Dickey-Fuller (ADF) test based on the Schwarz Information Criterion (SIC) and the Phillips-Perron (PP) test based on the Newey-West using the Bartlett kernel (NW-Bk) were used to evaluate the null hypothesis of series containing a unit root (i.e., non-stationary). The Kwiatkowski-Phillips-Schmidt-Shin (KPSS) LM test based on the NW-Bk was used to assess the null hypothesis of series being stationary.

To account for seasonality or structural breaks, the study also utilized the Hylleberg-Engle-Granger-Yoo (HEGY) test for seasonal unit roots and a breakpoint unit root test that allows for one unknown structural break. The HEGY test based on the Akaike Information Criterion (AIC) considers a deterministic (seasonal dummies) and a stochastic seasonal process. If at least one unit root is present in its autoregressive representation, then the stochastic seasonal process is non-stationary (Darne & Diebolt 2002). The breakpoint unit root test determined a break date based on the lag selection criterion of SIC with a maximum lag of 13. A break type of innovation outlier and breakpoint selection based on the Dickey-Fuller minimum t-statistic were used in the analysis. The endogenously determined date corresponds to a structural change occurring in a specific regional rice market. The HEGY and breakpoint unit root tests were performed using both constant and constant and trend models. The results of all the unit root tests show that the log-transformed price series are either stationary at level (I(0)) or integrated of order one (I(1)). This is a necessary condition for estimating an ARDL model, in addition to the dependent variable being I(1).

To test for multiple structural breaks in the individual price series and for each ARDL model, the study employed the Global Bai-Perron L Breaks method with a trimming percentage of 15 percent and a maximum break of five. This test compares information criteria for 0 to M globally determined breaks. The test statistic employed heteroscedasticity and autocorrelation consistent (HAC) covariances, pre-whitening with lags equal to one, a Quadratic-Spectral kernel, and an Andrews bandwidth, assuming common data distribution. Structural breaks, selected based on a modified Schwarz criterion (LWC), may correspond to shocks in regional retail markets for regular milled rice.

The Toda-Yamamoto (TY) causality test was conducted before and after the ARDL estimation (Toda & Yamamoto 1995). Its main advantage over the Granger causality test is that it does not require all variables in the vector autoregressive (VAR) model to have the same order of integration. The initial optimal lag length is determined using the LR – sequential modified LR test statistic, FPE – Final prediction error, AIC – Akaike information criterion, SIC – Schwarz information criterion, and HQ – Hannan-Quinn information criterion. Diagnostic tests such as Inverse Roots of the Characteristic AR Polynomial (all roots have modulus less than one and lie inside the unit circle), Autocorrelation LM test (no serial correlation), Normality test (residuals are multivariate normal), and White Heteroskedasticity test (homoscedastic) are also conducted to determine the final optimal lag length (p). The maximum order of integration ($d_{\max}$) was set at 1.0 and VAR models were estimated at VAR($p+d_{\max}$).

The TY test is conducted before the ARDL estimation to identify the dependent and independent variables that should be included in each ARDL model. The dependent variable

represents the price of a peripheral market, while the independent variable(s) represent the price(s) of one or more reference market(s). It is then conducted after the ARDL estimation to determine the direction of causality. For Central Luzon, Davao Region, Northern Mindanao, and Zamboanga Peninsula with seasonal unit root at π frequency (Appendix Table 1), seasonal dummy variables were included in the VAR models. To avoid ARDL models that may be affected by simultaneous causality bias, only models showing a unidirectional relationship were considered. This means that the regional rice markets in a specific ARDL model are assigned distinct roles as either peripheral or reference markets.

The study utilized the ARDL technique due to its several advantages (Nkoro and Uko 2016). It is particularly effective in distinguishing between dependent and independent variables when there is only one long-run relationship. It can also detect cointegrating vectors even in cases with multiple cointegrating vectors. Additionally, the ARDL model can be transformed into an Error Correction Model (ECM) through a simple linear transformation that combines short-run and long-run adjustments. The ECM model includes optimal lags to adequately capture the data generating process within the general-to-specific modeling frameworks. From the ECM, the speed of price adjustments, in months, is computed as $-1/ECT$ where ECT refers to the error correction term, indicating the rate at which the system adjusts towards long-run equilibrium following short-run shocks.

The presence of cointegration between dependent and independent variables in the ARDL models was determined using the F-bounds test to establish a long-run relationship and the t-bounds test to determine whether the equilibrating relationship is non-generate, generate, or nonsensical, as proposed by Pesaran and Shin (1999), Pesaran, Shin, and Smith (2001), and Shin, Yu, and Greenwood-Ninmo (2014). The linear ARDL (p,q) cointegration model, with the peripheral market's price (Y) and the n-reference market's price (X_n , $n=1,2,3$) time series, is presented as follows:

$$\Delta Y_t = \beta_0 + \rho Y_{t-1} + \sigma Z_t + \varphi X_{1,t-1} + \varphi X_{2,t-1} + \varphi X_{3,t-1} + \sum_{i=1}^p \lambda_i \Delta Y_{t-i} + \sum_{i=0}^q \delta_i \Delta X_{1,t-i} + \sum_{i=0}^q \delta_i \Delta X_{2,t-i} + \sum_{i=0}^q \delta_i \Delta X_{3,t-i} + v_t$$

where p and q refer to the lengths of lags for Y and X; Z_t is a vector of regressors containing trend and/or endogenously determined structural breaks; and v_t is a stochastic error term, that is independently and identically distributed.

To test the non-linear relationship between the dependent and independent variables, the asymmetric cointegrating equation is expressed as follows:

$$\Delta Y_t = \beta_0 + \rho Y_{t-1} + \sigma Z_t + \varphi^+ X_{1,t-1}^+ + \varphi^- X_{1,t-1}^- + \varphi^+ X_{2,t-1}^+ + \varphi^- X_{2,t-1}^- + \varphi^+ X_{3,t-1}^+ + \varphi^- X_{3,t-1}^- + \sum_{i=1}^{p-1} \lambda_i \Delta Y_{t-i} + \sum_{i=0}^q \delta_i^+ \Delta X_{1,t-i}^+ + \sum_{i=0}^q \delta_i^- \Delta X_{1,t-i}^- + \sum_{i=0}^q \delta_i^+ \Delta X_{2,t-i}^+ + \sum_{i=0}^q \delta_i^- \Delta X_{2,t-i}^- + \sum_{i=0}^q \delta_i^+ \Delta X_{3,t-i}^+ + \sum_{i=0}^q \delta_i^- \Delta X_{3,t-i}^- + v_t$$

where + and – represent positive and negative shocks in the n-reference market's price (X_n) as they affect the peripheral market's price (Y). Wald tests were also performed to assess the presence of long-run and short-run asymmetry.

To establish model stability, the following diagnostics were conducted: Jarque-Bera normality test, Breusch-Godfrey serial correlation LM test, Breusch-Pagan-Godfrey heteroscedasticity

test, Autoregressive Conditional Heteroskedasticity (ARCH) test, Ramsey Regression Equation Specification Error Test (RESET), Cumulative Sum of Recursive Residuals test, and Cumulative Square Sum of Recursive Residuals test.

Results and Discussion

Description of the Retail Price Series

After adjusting for regional inflation, Table 3 shows that 82 percent of regional markets have retail prices for regular milled rice that are below the average. Most provinces in Caraga and Central Visayas do not produce enough paddy rice to meet their own needs. On the other hand, although the majority of provinces in Zamboanga Peninsula have a surplus, the region has the second highest average price after Central Visayas. This indicates that having a surplus at the farm level does not always result in lower retail prices.

When it comes to price volatility, the CV shows that the highest and lowest dispersions are observed in BARMM (0.11) and CAR (0.06) (Table 3). Only five regions exhibit a normal distribution of deflated retail price series, as determined by the Jarque-Bera test (Table 3). In the subsequent analysis, log-transformed deflated retail price series are utilized.

Table 3. Descriptive statistics of deflated retail price (January 2018=100) of regular milled rice, by region, January 2012-December 2023 (n=144)

Regions	Production (mt) (2010=2023)	Share (%)	Per Capita Consumption (kg) (FIES, 2018)
REGION III (Central Luzon)	3,444,894	18.56	70.76
REGION II (Cagayan Valley)	2,519,135	13.57	76.25
REGION VI (Western Visayas)	2,157,250	11.62	102.03
REGION I (Ilocos Region)	1,802,246	9.71	75.20
REGION XII (SOCCSKSARGEN -South Cotabato, Cotabato, Sultan Kudarat, Sarangani, and General Santos)	1,271,280	6.85	81.66
REGION V (Bicol Region)	1,251,332	6.74	98.13
MIMAROPA - Mindoro Occidental, Mindoro Oriental, Marinduque, Romblon, and Palawan	1,113,179	6.00	97.00
REGION VIII (Eastern Visayas)	935,354	5.04	104.03
REGION X (Northern Mindanao)	724,469	3.90	64.47
BARMM - Bangsamoro Autonomous Region in Muslim Mindanao	651,967	3.51	77.82
REGION IX (Zamboanga Peninsula)	650,534	3.50	73.08
REGION XIII (Caraga)	490,765	2.64	81.30
REGION XI (Davao Region)	451,318	2.43	58.57
CAR - Cordillera Administrative Region	404,067	2.18	47.12
CALABARZON - Cavite, Laguna, Batangas, Rizal, and Quezon	402,431	2.17	42.03
REGION VII (Central Visayas)	294,170	1.58	34.39
National Capital Region (NCR)	0.00	0.00	46.72
Philippines	18,564,392	100.00	66.52

Source of basic data: PSA (2024)

Results of the Unit Root and Structural Break Tests

Appendix Table 1 provides the conclusions for various unit root tests, including ADF, PP, KPSS, HEGY, and breakpoint tests. Four regions, using the constant model, and nine regions, using the constant and trend model, were found to be integrated of order one. Regions with inconclusive order of integration are classified as either I(0) or I(1) but not I(2). This allows for the estimation of ARDL models.

The results of the breakpoint unit root test, considering one endogenously determined structural break in both constant and constant and trend models, identified January 2019, August 2023, and September 2023 as the break dates with positive coefficients. Normally, paddy and rice prices in January are lower due to the harvest months running from October to December in the Ilocos Region and Central Luzon, and from January to March in Cagayan Valley, Central Luzon, and Western Visayas. However, a positive structural break occurred most frequently in January 2019, which can be attributed to the deficit in domestic rice stocks. The NFA appeared to have not purchased enough from local paddy rice farmers and delayed rice imports in 2018 (Tolentino & dela Pena 2020). Another possible explanation is the suspicion of hoarding and price manipulation by rice traders. In anticipation of the passage of the Rice Tariffication Law, wholesalers and/or retailers may have postponed the sales of their rice stocks in January 2019, leading to a decrease in supply and an increase in price in the retail market.

The positive structural breaks in August and September 2023 confirm the “current surge in retail prices of rice (EO 39),” which led to the imposition of mandated ceiling prices on regular and well-milled rice. Based on month-on-month changes in real retail prices of regular milled rice using PSA (2024) data, the growth rates between August-September and September-October substantially declined. For regions whose structural break is either August or September 2023, the growth rates changed from 1.52 to -4.87 percent in the Ilocos Region, 11.75 to -8.62 percent in Central Luzon, and 10.39 to -3.59 percent in the Davao Region. As the policy ended on October 4, 2023, prices between October and November for the three regions rise again by 2.07, 5.08, and 4.17 percent.

Based on the multiple breakpoints determined using the Global Bai-Perron L Breaks method, positive structural breaks are observed in October and December 2013, January-March and September 2014, July 2015, March and July-September 2018, and January 2019, and negative structural breaks in October-December 2015, March and April 2016, October-December 2020, and January 2021 (Table 4). The break dates November and December 2013 and the first quarter of 2014 correspond to the negative effects of Typhoon Haiyan on paddy rice production, which occurred in November 2013 (GMA News 2013). As discussed earlier, the structural breaks in 2018 can be attributed to the inability of NFA to stabilize the domestic rice supply, while the structural break in January 2019 can be explained by suspected uncompetitive practices among rice traders.

Table 4. Results of the Global Bai-Perron L breaks method in determining multiple structural breaks

Regions	Break Dates	
	Model: Intercept	Model: Intercept and Trend
NCR	4: 2013M12 [+], 2017M02 ^{ns} , 2019M01 [+], 2022M04 ^{ns}	2: 2014M03 ^{ns} , 2018M09 ^{ns}
CAR	3: 2014M09 [+], 2019M01 ^{ns} , 2020M11 ^{ns}	3: 2013M10 ^{ns} , 2019M01 ^{ns} , 2022M04 ^{ns}



Regions	Break Dates	
	Model: Intercept	Model: Intercept and Trend
Ilocos Region	4: 2014M03 [+], 2015M12 [-], 2018M09 [+], 2020M11 ^{ns}	3: 2014M04 ^{ns} , 2018M09 ^{ns} , 2022M04 ^{ns}
Cagayan Valley	4: 2013M10 [+], 2015M07 [+], 2018M10 ^{ns} , 2020M11 ^{ns}	3: 2015M04 ^{ns} , 2018M10 ^{ns} , 2022M04 ^{ns}
Central Luzon	None with seasonal dummies	None with seasonal dummies
CALABARZON	3: 2013M10 [+], 2018M09 [+], 2020M11 [-]	4: 2014M03 [+], 2017M04 ^{ns} , 2019M01 ^{ns} , 2022M04 ^{ns}
MIMAROPA	4: 2014M02 [+], 2015M11 [-], 2018M08 [+], 2021M01 [-]	3: 2014M03 ^{ns} , 2017M10 ^{ns} , 2019M07 ^{ns}
Bicol Region	4: 2013M10 [+], 2015M10 [-], 2018M07 [+], 2020M11 ^{ns}	4: 2013M10 [+], 2015M10 ^{ns} , 2019M01 ^{ns} , 2022M04 ^{ns}
Western Visayas	3: 2014M05 [+], 2018M08 [+], 2020M12 [-]	3: 2014M05 ^{ns} , 2019M01 ^{ns} , 2022M02 ^{ns}
Central Visayas	3: 2013M10 [+], 2019M01 [+], 2021M03 ^{ns}	2: 2019M01 ^{ns} , 2022M04 ^{ns}
Eastern Visayas	4: 2013M10 [+], 2016M03 [-], 2019M01 [+], 2020M12 ^{ns}	3: 2013M10 [+], 2019M01 [+], 2022M04 ^{ns}
Zamboanga Peninsula	4: 2014M01 [+], 2016M04 [-], 2018M09 [+], 2020M10 [-]	None with seasonal dummies
Northern Mindanao	2: 2019M01 [+], 2020M10 [-]	4: 2013M10 ^{ns} , 2017M04 ^{ns} , 2019M01 [+], 2022M04 ^{ns}
Davao Region	None with seasonal dummies	None with seasonal dummies
SOCCKSARGEN	2: 2018M03 [+], 2020M11 ^{ns}	2: 2018M05 ^{ns} , 2020M12 [-] with seasonal dummies
CARAGA	1: 2021M01 ^{ns}	2: 2018M09 ^{ns} , 2022M04 ^{ns}
BARMM	2: 2019M01 [+], 2020M10 ^{ns}	2: 2019M01 ^{ns} , 2022M04 ^{ns}

ns = not significant at 5% level of probability based on OLS estimation that includes the break dates

Results of the causality and cointegration tests

The results of the Toda-Yamamoto causality test confirm that the final ARDL models include the Bicol Region, Western Visayas, Caraga, and CALABARZON as peripheral markets, and NCR, CAR, Cagayan Valley, Eastern Visayas, SOCCKSARGEN, Central Luzon, and Ilocos Region as the reference markets (Table 5). NCR remains as a central market with at least one regional market from Luzon, Visayas, and Mindanao that is spatially integrated with it. There is no simultaneous causality bias, as indicated by the unidirectional relationship between peripheral and reference market prices.

Table 5. Results of the Toda-Yamamoto causality test

Dependent Variable	Independent Variables	Pre-ARDL Estimation	Post-ARDL Estimation		Direction of Causality
			Optimal Lag Length	Optimal Lag Length	
Model: Intercept					
Bicol Region	NCR, CAR, and Cagayan Valley	6	6	2: 2015M11, 2018M02	Bicol Region <- NCR, CAR, and Cagayan Valley

Dependent Variable	Independent Variables	Pre-ARDL Estimation	Post-ARDL Estimation		Direction of Causality
		Optimal Lag Length	Optimal Lag Length	Break Dates	
Western Visayas	NCR, Eastern Visayas, and SOCCKSARGEN	2 ^a	3	3: 2014M08, 2018M05, 2020M04	Western Visayas <- NCR, Eastern Visayas, and SOCCKSARGEN
Caraga	NCR and Central Luzon	14	13	3: 2014M08, 2018M05, 2020M04	CARAGA <- NCR and Central Luzon
Model: Intercept and Trend					
CALABARZON	Ilocos Region and Cagayan Valley	2	6	1: 2018M01	CALABARZON <- Ilocos Region and Cagayan Valley

^aSimultaneous causality bias is present in the VAR model. However, the inclusion of break dates results in unidirectional relationship between Western Visayas and the three regional markets.

Appendix Table 2 provides a summary of the diagnostic and stability tests conducted on the ARDL models. The Bicol Region and Western Visayas models followed a linear ARDL model, while the Caraga and CALABARZON models utilized a non-linear ARDL (NARDL) model.

In terms of price adjustments, Bicol Region exhibited the fastest speed at 1.18 months, whereas CALABARZON had the slowest at 3.60 months (Appendix Table 2). On the other hand, it took Caraga 2.51 months and Western Visayas 2.90 months for retail prices to return to their long-run equilibrium path after a shock (Appendix Table 2). Notably, both Bicol Region and CALABARZON are classified as deficit areas, located near ports where imported rice is unloaded. Despite this similarity, their speed of adjustments differs. Given speculation regarding unfair rice trade practices in CALABARZON, further investigation and enhanced price monitoring are necessary. In the case of Western Visayas and Caraga, which are situated in Visayas and Mindanao, respectively, asymmetric price information is more persistent in these areas than in Luzon.

Table 6 presents the results of the ARDL/NARDL estimation. Bicol Region and CALABARZON show a high level of spatial market integration with Cagayan Valley, as indicated by their close to one long-run elasticity of price transmission. This suggests that changes in the retail price in Cagayan Valley have a proportional impact on the retail prices in Bicol Region and CALABARZON, reflecting efficient price transmission between the reference and peripheral markets.

In the long run, the spatial market integration between Western Visayas and SOCCKSARGEN is stronger (0.58) to that with NCR (0.40), suggesting a more efficient trade flow between Visayas and Mindanao than between Luzon and Visayas. On the other hand, a one percent change in the retail price in Eastern Visayas leads to a 0.36 percent change in the retail price in Western Visayas in the opposite direction. Given the higher per capita consumption but lower share in paddy production in Eastern Visayas (104.03 kg and 5.04%) compared to Western Visayas (102.03 kg and 11.62%), traders exploit the spatial arbitrage opportunity by

purchasing rice at a lower price in Western Visayas and selling it in Eastern Visayas at a higher price. Consequently, this leads to an increased demand and higher prices in Western Visayas, while Eastern Visayas experiences a decrease in price due to increased supply.

There is negative long-run asymmetric price transmission from Central Luzon to Caraga. A one percent increase in the retail price in Central Luzon results in a 0.66 percent increase in the retail price in Caraga. However, Caraga reacts more strongly to a decrease in price where a one percent decrease in the retail price in Central Luzon results in a 0.79 percent decrease in the retail price in Caraga. In the short run, however, the asymmetry is positive, with a positive effect of contemporaneous price and a negative effect of the lagged one-month price.

There is also positive short-run asymmetric price transmission from the Ilocos Region to CALABARZON. The effect of contemporaneous price is positive, while the effects of lagged prices up to two periods are negative suggesting a dampening effect of past prices on the current retail price in the short run.

Regarding the notable dates when significant structural breaks occurred in Western Visayas, the coefficient was positive in May 2018 and negative in April 2020. These coefficients can be attributed to the deficit in domestic rice stocks caused by the policy failures of the NFA in 2018, and the mandatory price freeze of basic necessities, including rice, which lasted for a maximum of 60 days following the proclamation of the State of Public Health Emergency on March 8, 2020 (Official Gazette 2020). On the other hand, additional research is needed to clarify the reasons behind the positive structural break that occurred in Western Visayas in August 2014 and in Caraga in April 2017, as well as the negative structural break in Caraga in January 2021.

Table 6. Results of the ARDL/NARDL estimation

Dependent Variable / Lag Structure	Independent Variables	Coeff.	Standard Error	t-Statistic	Probability
LDBICOL_REGION (9,8,5,12)	Constant	0.36	0.32	1.13	0.26
	LDBICOL_REGION(-1)	0.61	0.11	5.44	0.00
	LDNCR	0.27	0.11	2.57	0.01
	LDNCR(-1)	-0.13	0.15	-0.89	0.38
	LDNCR(-3)	-0.34	0.14	-2.40	0.02
	LDNCR(-5)	0.24	0.12	2.01	0.05
	LDNCR(-7)	-0.30	0.13	-2.40	0.02
	LDNCR(-8)	0.22	0.08	2.63	0.01
	LDCAR	0.13	0.13	1.03	0.30
	LDCAR(-1)	-0.19	0.22	-0.88	0.38
	LDCAR(-3)	0.34	0.19	1.79	0.08
	LDCAGAYAN_VALLEY	0.61	0.12	5.20	0.00
	LDCAGAYAN_VALLEY(-1)	-0.32	0.14	-2.19	0.03
	LDCAGAYAN_VALLEY(-12)	0.12	0.05	2.58	0.01
	November 2015	-0.02	0.01	-1.83	0.07



Dependent Variable / Lag Structure	Independent Variables	Coeff.	Standard Error	t-Statistic	Probability
LDWESTERN_VISAYAS (1,0,1,1)	February 2018	0.00	0.00	1.43	0.16
	R ²	0.98			
	Adjusted R ²	0.97			
	Long Run Effect				
	LDNCR	0.11	0.08	1.29	0.20
	LDCAR	-0.31	0.18	-1.78	0.08
	LDCAGAYAN_VALLEY	1.11	0.16	6.92	0.00
	Constant	0.48	0.11	4.24	0.00
	LDWESTERN_VISAYAS(-1)	0.66	0.05	12.27	0.00
	LEASTERJ_VISAYAS	-0.12	0.03	-4.41	0.00
	LDNCR	0.45	0.07	6.83	0.00
	LDNCR(-1)	-0.31	0.07	-4.33	0.00
	LDSOCCKSARGEN	0.43	0.05	9.08	0.00
	LDSOCCKSARGEN(-1)	-0.23	0.05	-4.34	0.00
	August 2014	0.02	0.00	4.22	0.00
LDCARAGA (3,2,1,1)	May 2018	0.02	0.00	3.67	0.00
	April 2020	-0.03	0.01	-5.68	0.00
	R ²	0.97			
	Adjusted R ²	0.97			
	Long Run Effect				
	LEASTERJ_VISAYAS	-0.36	0.06	-6.27	0.00
	LDNCR	0.40	0.08	5.27	0.00
	LDSOCCKSARGEN	0.58	0.07	8.48	0.00
	Constant	1.54	0.23	6.60	0.00
	LDCARAGA(-1)	0.64	0.08	8.14	0.00
	LDCARAGA(-2)	0.18	0.08	2.19	0.03
	LDCARAGA(-3)	-0.22	0.05	-4.60	0.00
	LDNCR	0.31	0.06	5.03	0.00
	LDNCR(-1)	-0.11	0.09	-1.17	0.25
	LDNCR(-2)	-0.21	0.07	-2.86	0.01
LDCEN_LUZON_POS	LDCEN_LUZON_POS	0.72	0.07	10.45	0.00
	LDCEN_LUZON_POS(-1)	-0.46	0.09	-4.85	0.00
	LDCEN_LUZON_NEG	0.17	0.11	1.53	0.13
	LDCEN_LUZON_NEG(-1)	0.14	0.11	1.32	0.19
	May 2014	-0.01	0.01	-0.69	0.49
	April 2017	0.01	0.00	2.76	0.01



Dependent Variable / Lag Structure	Independent Variables	Coeff.	Standard Error	t-Statistic	Probability
	January 2019	0.00	0.01	-0.27	0.79
	January 2021	-0.03	0.01	-4.42	0.00
	R ²	0.98			
	Adjusted R ²	0.98			
	Long Run Effect				
	LDNCR	-0.03	0.10	-0.28	0.78
	LDCENTRAL_LUZON_POS	0.66	0.11	5.77	0.00
	LDCENTRAL_LUZON_NEG	0.79	0.10	7.88	0.00
	Wald Test	F-statistic	df	Probability	Remark
	Long Run	5.38	(1, 128)	0.02	Asymmetric
	Short Run	111.51	(1, 128)	0.00	Asymmetric
LDCALABARZON (1,5,9,2)	Constant	0.03	0.20	0.16	0.87
	Trend	0.00	0.00	2.10	0.04
	LDCALABARZON(-1)	0.72	0.06	11.93	0.00
	LDILOCOS_REGION_POS	0.28	0.07	4.15	0.00
	LDILOCOS_REGION_POS(-1)	-0.27	0.09	-3.10	0.00
	LDILOCOS_REGION_POS(-2)	-0.22	0.09	-2.55	0.01
	LDILOCOS_REGION_NEG	-0.06	0.12	-0.46	0.64
	LDILOCOS_REGION_NEG(-1)	0.19	0.15	1.26	0.21
	LDILOCOS_REGION_NEG(-3)	-0.34	0.15	-2.28	0.02
	LDCAGAYAN_VALLEY	0.52	0.06	8.84	0.00
	LDCAGAYAN_VALLEY(-1)	-0.34	0.07	-4.76	0.00
	January 2018	0.00	0.00	0.82	0.41
	R ²	0.97			
	Adjusted R ²	0.98			
	Long Run Effect				
	LDCAGAYAN_VALLEY	0.95	0.20	4.79	0.00
	LDILOCOS_REGION_POS	-0.04	0.19	-0.20	0.85
	LDILOCOS_REGION_NEG	0.42	0.32	1.28	0.20



Dependent Variable / Lag Structure	Independent Variables	Coeff.	Standard Error	t-Statistic	Probability
	Wald Test	F-statistic	df	Probability	Remark
	Long Run	3.50	(1, 126)	0.06	Symmetric
	Short Run	14.16	(1, 126)	0.00	Asymmetric

For brevity, short run estimates that are not significant at 5 percent level of probability were removed from the table

Conclusion

The study identifies only four out of 17 regional markets that are spatially integrated. This is done through a rather strict approach that includes conducting unit root tests accounting for seasonality and structural breaks, establishing market pairs and groups based on the Toda-Yamamoto causality test, and ensuring that the ARDL models do not suffer from simultaneous causality bias.

Spatial price transmission from NCR, CAR, Eastern Visayas, and Ilocos Region to Bicol Region, Western Visayas, Caraga, and CALABARZON, is not complete and rapid. In addition, there is asymmetric price transmission from Central Luzon and Ilocos Region to Caraga and CALABARZON. These can be explained by suspicion of rice hoarding and price manipulation, policy failures of the NFA, and the presence of asymmetric price information.

The Department of Trade and Industry (DTI), Department of Agriculture (DA) – Agribusiness and Marketing Assistance (AMAS), and local government unit's price coordinating councils should enhance their price monitoring efforts, especially in regions with slow speed of price adjustments like CALABARZON. To address asymmetric price information, the dissemination of price and market information should also be improved.

The Philippine Competition Commission (PCC) should continue its efforts to investigate smuggling, hoarding, and price manipulation in the rice markets, prioritizing the regions with low levels of spatial market integration. On the other hand, the NFA with its new mandate under the Rice Tariffication Law, should ensure sufficient buffer stocks to stabilize prices in case of a sudden shock in the rice market.

As regions in the Philippines exhibit varying levels of spatial market integration, targeted price and market policies should be considered. A general policy, such as mandated price ceilings on rice throughout the entire country, may lead to different outcomes—either effective or ineffective, with larger or smaller impacts.

To gain provide further insights into the results of this study, it is important to correlate them with spatial price transmission at the farm and wholesale levels, as well as with other types of rice (i.e., well milled, special, and premium rice). Examining vertical price transmission in the rice supply chain can also provide clarity regarding the behavior of retail markets. It is suggested to employ mixed methods research to capture the qualitative aspects of this empirical work.



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Appendix Table 1. Results of the unit root tests

Unit Root Test	NCR	CAR	Ilocos Region	Cagayan Valley	Central Luzon	CALA BARZON	MIMARO PA	Bicol Region	Western Visayas	Central Visayas	Eastern Visayas	Zamboanga Peninsula	North Mindanao	Davao Region	SOCC KARSAR GEN	CARAGA	ARMM
Model: Intercept																	
ADF	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)
PP	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)
KPSS	I(0)	I(0)	I(0)	I(0)	I(0)	I(0)	I(0)	I(0)	I(0)	I(1)	I(0)	I(0)	I(0)	I(1)	I(0)	I(1)	I(1)
HEGY	None	0	None	0	0	0	0	None	0	0	None	0 and π	0 and π	0	0	0	0
One Unknown Breakpoint																	
I(0)	2013 M06 ns	2019 M01 ns	2019 M01ns	2019 M01ns	2013 M07ns	2013M07ns	2019 M01ns	2019 M01 ns	2019M01ns	2019 M01ns	2013 M07ns	2019M01 ns	2019M01 ns	2019 M01ns	2019M01ns	2019 M01 ns	2018 M12 ns
I(1)	2019 M01	2019 M01	2023 M08	2019 M01	2023 M08	2019M01	2019 M01	2023 M07	2019M01	2019 M01	2019 M01	2019M01	2019M01	2023 M09	2019M01	2023 M07	2019 M01
Order of Integration	Inclusive	Inclusive	Inclusive	Inclusive	Inclusive	Inclusive	Inclusive	Inclusive	Inclusive	I(1)	Inclusive	Inclusive	Inclusive	I(1)	Inclusive	I(1)	I(1)
Model: Intercept and Trend																	
ADF	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)
PP	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)
KPSS	I(1)	I(1)	I(1)	I(0)	I(1)	I(1)	I(1)	I(0)	I(1)	I(1)	I(0)	I(0)	I(0)	I(0)	I(1)	I(1)	I(0)
HEGY	0	0	0	0	0 and π	0	0	0	0	0	0	0 and π	0	0 and π	0	0	0
One Unknown Breakpoint																	
I(0)	2013 M06 ns	2013 M07 ns	2018 M06ns	2013 M03ns	2013 M07ns	2013M07ns	2018 M02ns	2013 M06 ns	2018M12ns	2018 M12ns	2013 M07ns	2018M06 ns	2018M12ns	2022 M07ns	2020M08ns	2013 M07 ns	2018 M12 ns
I(1)	2019 M01	2019 M01	2019 M01	2019 M01	2023 M09	2019M01	2019 M01	2019 M01	2019M01	2019 M01	2019 M01	2019M01	2019M01	2019 M01	2019M01	2023 M07	2019 M01
Order of Integration	I(1)	I(1)	I(1)	Inclusive	Inclusive	I(1)	I(1)	Inclusive	I(1)	I(1)	Inclusive	Inclusive	Inclusive	Inclusive	I(1)	I(1)	Inclusive



Appendix Table 2. Results of diagnostic and stability tests

Dependent Variable	Independent Variables	Model [a]	Case [b]	Break Dates [c]	Lag Selection Criterion	Lag Structure
[1] Bicol Region	NCR, CAR, and Cagayan Valley	Linear	Unrestricted constant and no trend	2: 2015M11 ^{ns} , 2018M02 ^{ns}	Adjusted R2	(9,8,5,12)
[2] Western Visayas	NCR, Eastern Visayas, and SOCKSARGEN	Linear	Unrestricted constant and no trend	3: 2014M08 [+], 2018M05 [+], 2020M04 [-]	SIC	(1,0,1,1)
[3] CARAGA	NCR and Central Luzon	Non-linear	Unrestricted constant and no trend	4: 2014M05 ^{ns} , 2017M04 [+], 2019M01 ^{ns} , 2021M01 [-]	AIC	(3,2,1,1)
[4] CALABARZON	Ilocos Region and Cagayan Valley	Non-linear	Unrestricted constant and unrestricted linear trend	1: 2018M01 ^{ns}	Adjusted R2	(1,5,9,2)

Dependent Variable	F-Bounds [d]	I(0)	I(1)	t-Bounds [e]	I(0)	I(1)
[1]	11.16	3.36	4.52	-6.68	-2.86	-3.78
[2]	10.44	3.36	4.52	-6.44	-2.86	-3.78
[3]	17.21	3.36	4.52	-7.36	-2.86	-3.78
[4]	7.21	4.20	5.32	-4.59	-3.41	-4.16

[a] Linear model means all the independent variables have a symmetric relationship with the dependent variable. Non-linear model means at least one of the independent variables has an asymmetric relationship with the dependent variable.

[b] Case refers to the deterministic specifications of the model. This includes five cases: (1) no constant and no trend, (2) restricted constant and no trend, (3) unrestricted constant and no trend, (4) unrestricted constant and restricted linear trend, and (5) unrestricted constant and unrestricted linear trend.

[c] The break dates are significant at 5% level of probability based on the linear or non-linear ARDL estimation, except for those with ns that means not significant at 5% level of probability.

[d] The p-value of the F-Bounds test is less than 0.05. The critical values are taken from Pesaran, Shin and Smith (2001). The test statistic is greater than I(0) and I(1) critical values, implying the presence of long-run relationship between the dependent and independent variable/s.

[e] The p-value of the t-Bounds test is less than 0.05. The critical values are taken from Pesaran, Shin and Smith (2001). The test statistic is greater than I(0) and I(1) critical values, implying that the equilibrating relationship is non-generate or usual cointegration.

Dependent Variable	ECM [f]	p-value	Speed [g]	t-Bounds	I(0)	I(1)
[1]	-0.85	0.00	1.18	-6.79	-2.86	-3.78
[2]	-0.34	0.00	2.90	-6.53	-2.86	-3.78
[3]	-0.40	0.00	2.51	-8.39	-2.86	-3.78
[4]	-0.28	0.00	3.60	-5.44	-3.41	-4.16



Dependent Variable	Jarque-Bera [h]	p-value	LM(1) [i]	p-value	LM(p) [i]	p-value
[1]	0.56	0.76	0.40	0.53	0.84	0.58
[2]	2.37	0.31	0.01	0.92	1.42	0.24
[3]	3.23	0.19	0.06	0.80	0.39	0.76
[4]	0.82	0.66	0.04	0.85	0.66	0.52

Dependent Variable	ARCH (1) [j]	p-value	ARCH(p) [j]	p-value
[1]	5.87	0.02	1.43	0.18
[2]	0.03	0.87	0.50	0.61
[3]	1.47	0.23	1.22	0.30
[4]	1.62	0.21	0.82	0.44

Dependent Variable	Ramsey RESET F-statistic [k]	p-value	CUSUM [l]	CUSUM of Squares [m]
[1]	1.66	0.20	Stable	Stable
[2]	1.31	0.26	Stable	Stable
[3]	0.64	0.42	Stable	Stable
[4]	2.18	0.14	Stable	Stable

[f] The error correction term (ECT) is significant at 1% significance level. This also implies the presence of cointegration between the dependent and independent variables.

[g] Speed of adjustment computed as $-1/ECT$ denotes the length of time in months needed to return to long-run equilibrium path after a shock.

[h] The p-value of the Jarque-Bera (JB) normality test is greater than 0.05. This implies the presence of normality.

[i] The p-value of the Breusch-Godfrey (BG) Serial Correlation LM test is greater than 0.05 for order one and two or p (i.e., optimal lag length). This implies the absence of serial correlation.

[j] The p-value of the Autoregressive Conditional Heteroskedasticity (ARCH) test is greater than 0.05 for order one and two or p (i.e., optimal lag length). This implies the absence of heteroskedasticity. The problem of heteroskedasticity in Central Visayas and Northern Mindanao was corrected using HAC covariances (Pre-whitening with lags = 1, Quadratic-Spectral kernel, Andres bandwidth).

[k] The p-value of the Ramsey RESET test is greater than 0.05. This implies that the model has no specification errors.

[l] CUSUM – Cumulative Sum of Recursive Residuals test and [m] CUSUM of Squares – Cumulative Square Sum of Recursive Residuals test show that the test statistics plotted at a 5% significance level for the estimated coefficients of the model lay within the critical boundaries. This implies that the estimated coefficients of the model are stable.



Cointegration Analysis of the World's Black Pepper Export Market among Major Producers

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Abstract

Pepper, the world's most used spice has been widely used ever since ancient times. This spice has a high value in terms of monetary due to its medicinal properties. This berry-like spice has never lost its popularity as the world's most traded and used spice. In response to its market value, a study was conducted to analyse the market price movement of black pepper among four world major producers – India, Indonesia, Vietnam, and Malaysia. This study addresses the co-movement among these four major pepper-producing markets by setting the world's top producer Vietnam, as the dependent variable whilst India, Indonesia, and Malaysia are set as the independent variables. Due to the high price fluctuation of this storable commodity and significant price diversity in different markets, market integration among major producers is essential to study. The unison among the global pepper market is important, not only regarding producers and consumers but also in terms of profit maximization and economic risk management. The study uses the Johansen cointegration approach and the vector error correction model to analyse and evaluate the presence and strength of co-movement of price amongst the market, from the perspective of export freight on board price. The study has found that there are co-movements in the market—Vietnam, India, Indonesia, Malaysia, and Sri Lanka, despite obvious price differences and frequent fluctuations. The markets are found to be operating as a single organism. The convergence of pepper prices is found to be significant, and the model is stable for the export of black pepper.

Keywords: Black Pepper, Johansen Cointegration, VECM

JEL code: C10, C31, Q11

SDG goals: Reduced Inequalities; Peace, Justice, and Strong Institutions

Introduction

Origin and History of Black Pepper

Pepper, or *Piper nigrum* L., is a plant originating from the Western Ghats of India. The worth of the peppercorn in the form of monetary and medicinal value has made it to be well-known throughout the world dating back as early as the time of Queen Sheeba and King Solomon (B.C. 1015–B.C. 66) (Nair, 2020). Wars and colonization have happened throughout history, just for precious spices like pepper (Thomas & Sanil, 2019; Tripathi & Raut, 2006).

Thomas and Sanil (2019) in their paper on 'Competitiveness in the Spice Trade from India' stated that spices are the most traded agricultural commodity across the globe. Spices like pepper form a vital component of trade, influencing the dynamics of economic, social, and political growth across the world.

Today, pepper still remains the world's oldest and most traded spice followed with vanilla and ginger (International Trade Centre, 2018). This small, berry-like spice is widely traded in the form of black and white pepper. Due to its widespread distribution, since ancient times, pepper has now become one of the popular spices used in many cuisine and medicine from east to west (Parry, 1969).



Sivaraman, Kandiannan, Peter, and Thankamani (1999) state that this plant is being grown extensively in tropical nations. The pepper plant is highly adaptable, growing from sea level to 1500 metres above mean sea level. It may be found between 20°N to 20°S of the equator. This plant belongs to the humid tropical family and requires 2000–3000 mm of annual rainfall, tropical temperatures, high relative humidity, and minimal fluctuation in day length throughout the year.

Black Pepper Production and Economy

Based on the annual statistical report by International Pepper Community (2019), the total global production of black pepper for the year 2019 was 479,068 tonnes, with a cultivated area of 493,400 hectares, approximately. Countries that are majorly producing pepper are Vietnam, Indonesia, Sri Lanka, India, Malaysia, Brazil, China, Madagascar, Thailand, Cambodia, Ecuador, and others. The purpose of cultivation was to supply for the domestic and international demands. The value of the global pepper industry is currently worth 1.298 billion USD. The demand for black pepper is fuelled by major importing countries such as the United States, Germany, Egypt, Netherlands, Pakistan, Russia, France, Poland, South Korea, Turkey, and others, which are involved in the re-export of the product.

The statistics released by International Pepper Community (2019) also indicated that among all the top producing countries, Vietnam holds the highest production of black pepper, with 257,000 tonnes, approximately, which accounts for approximately 53.6 percent of the total global production. It is also the largest exporter of black pepper in the world, with 257,396 tonnes exported in 2019, which exceeded its level of production, with a value of 631 million USD. The excess demand for the export of black pepper was catered by importing pepper from other producing countries such as Brazil, Malaysia, and Indonesia and re-exporting (International Pepper Community, 2019).

The remaining 46.4 percent of the production of black pepper were contributed by Brazil (15.8 percent), India (9.7 percent), Indonesia (6.26 percent), Malaysia (3.73 percent), Sri Lanka (3.98 percent), Cambodia (3.46 percent), Thailand (1.04 percent), Madagascar (0.83 percent), and others, including China and Ecuador (1.6 percent) (International Pepper Community, 2019). India holds the largest cultivation area with 134,838 hectares (International Pepper Community, 2019). Yet, the polyculture cropping system implemented depleted the yield efficiency of the pepper crops by causing diseases and nutrient competition (Nair, 2020; Ravindran & Kallapurackal, 2012).

Black Pepper Price Variation in Markets

Due to differences in geographical positions of the countries, the market price of a commodity may vary from one place to another. Difference in market prices, due to geographical difference is a natural market phenomenon (Rashid, Minot, & Behute, 2010). The difference of price is due difference in government policy, service tax, transportation cost, competition, and other variable cost in production and supply chain.

Due to variability in price, market integration across different countries is essential to prevent any form of exploitation or unfair competition (Rashid et al., 2010). Market integration is defined as the similar pattern of movement in price across different markets over a long period of time. The correspondent movement in the same direction of a market price, due to another market's movement, is proof of market integration. Evidence of excellent market convergence is defined as prices from physically split regions moving together; this suggests that the



underlying market is sufficiently active and linked to allow price discrepancies to be arbitrated away with ease. Prices that are not strongly integrated, on the other hand, may indicate the presence of frictions, such as market power or transportation bottlenecks (Birge, Chan, Pavlin, & Zhu, 2020).

Previous Studies on Market Price Integration

Prabha, Sivakumar, Murugananthi, and Palanichamy (2022) studied the market integration of India coffee (Arabica and Robusta coffee) price by comparing between domestic and international markets from the year 2008 to 2020. Two significant worldwide markets, New York (for Arabica) and London (for Robusta), as well as three significant Indian local markets, Bangalore, Chennai, and Hyderabad, were chosen for the study. The Johansen Cointegration Test and the Vector Error Correction Model (VECM) were used by Prabha et al. (2022) to examine the effectiveness of the Arabica and Robusta markets. From the study it was found that only Robusta markets were integrated in the long run.

Another similar study conducted Sivasankari & Vasanthi (2015) on black pepper domestic and international market utilised the Engle-Granger Test, as only 2 variables were tested. The monthly prices were compared from the year 2000 to 2012. From the results, Sivasankari & Vasanthi (2015) found that the domestic and international market were at unison suggesting that the markets are efficient and effective in mitigating price instability.

Khatkar, Singh, Karwasra, & Bhatia (2013) used the Johansen Cointegration Test and VECM to study the market integration domestic mustard markets in India. Out of four markets tested only two markets were found to be cointegrated.

Pardhi, Singh, Tingre, and Potdar (2022) studied the market integration of mango prices between Varanasi, India and international market. Varanasi was selected purposively as it is the major producing state. The semi-annual data were collected from 1993 to 2015. Johansen Cointegration Test and VECM were used to analyse the markets. From the results, both markets were found to be cointegrated.

Study purpose/Aim

Policy action is needed to reduce unpredictability and preserve market sustainability. India, Indonesia, Sri Lanka, Malaysia, and Vietnam are the permanent members of the International Pepper Community (IPC), an intergovernmental organisation of pepper-producing nations that is vital to the promotion, coordination, and harmonisation of all pepper-related economic activities, including ongoing price reviews.

The aim of this paper is to determine whether the prices of various black pepper markets with lion shares are parallel to each other. It is essential to compare one market price with the other to ensure that the markets are competitive and efficient in the long run. A cointegration analysis is implemented to evaluate the equilibrium of export prices of pepper.

Methodology

The economic growth within regions and countries varies at different magnitude. Difference in space also means different environment, culture, institution, policy, law, technology, innovation, etc. All this difference changes the value of a product in terms of input and output. This causes the price of product to differ from one place to another.

All firms at different space will experience a deviation in the price of inputs which will result in divergence of the output price from other markets, hence leading to price differential of commodities (Schrimper, 2001). However, this price differential scenario is subjected to



arbitrage, a scenario where inefficient markets are taken advantage by exploiters to benefit from the price differences.

Steinwender (2014) reported that despite various efforts to implement fairtrade and Law of one price, many empirical studies have documented a large deviation in price encouraging arbitrage. Hence understanding the properties of commodity price variability is important especially to countries that are relying on a few commodities with lion's share in the global market to generate income (Conforti, 2004). A high variability and a lack of integration in prices has severe consequences on commodity dependent countries. Furthermore, market integration is one of the vital aspects in evaluating the impacts of market development and liberalisation policies (Sivasankari & Vasanthi, 2015).

This study is constructed based on the theory of the law of one price (LOOP) which states that 'when items are distributed effectively throughout marketplaces, the price difference between the same goods in two locations shouldn't be greater than the cost of transportation.' The primary focus of this study is to determine the integration of export price among major producers.

To study the price, a time series has to be tested for its' unit root to identify whether its' trend is stationary or stochastic. A time series that has a stochastic trend and permanent effect of shocks in price will have a unit root. In contrary, a time series that is stationary in a long-run deterministic process is proven to have price shocks that would revert back with temporary effect.

In order to analyse the non-stationary time series, the series has to be detrend. This could be done by differencing the series N times. Variables that are stationary in the same order and have a stationary linear combination are considered cointegrated.

The two well established approach for cointegration analysis are the Engle-Granger (1987) two step estimation method and Johansen's (1997) maximum likelihood method. The Engle-Granger method has a limiting factor where there the estimation is limited to two variables. Since there are more than two variables, the suitable methodology to be implemented for the estimation is the Johansen's method which enables multivariate framework.

The cointegration analysis evaluates the co-movement of a long-term good price within an equilibrium model. Market integration is a phenomenon in which two or more markets are linked together through their geographical separation. The term "market integration" is often used to refer to "spatial integration." When markets are linked together, they are said to be running as a single system.

Data Collection

To evaluate the efficiency of the pepper markets of different countries, secondary data on monthly exports prices for black pepper were collected from International Pepper Community's Pepper Statistical Yearbook 2019. The countries selected for the analysis were based on significance in production capacity and availability of data. In this study, four major producing countries-Vietnam, India, Indonesia, and Malaysia were selected for analysis. Data collected were monthly average prices from January 2010 to December 2019.

Statistical Analysis



The cointegration analysis were focused on main producing and exporting countries as target variables, where the top producer Vietnam represents dependent variable, whilst India, Indonesia and Malaysia as independent variable. The movement behaviour of pepper prices throughout the years was studied. The patterns of movement were identified by screening the movement of prices from one year to another year using the plotted linear graph pattern.

The stationarity of the variables must be ensured in order to translate the sequence into a cointegration equation. The term "stationarity" refers to a sequence that has no pattern and a constant mean and variance. In contrast, the non-stationary time series' mean, variance, and co-variance all fluctuate over time because it lacks a tendency to revert to its long-run average value. Stationary variables refer to variables with constant mean, variance, and covariance through time, which means they are not random.

Unit root tests for each variable in the regression equation should be used to convert non-stationary time series variables into stationary before performing a regression. If the series have unit roots, then all of the typical regression findings might be false and inaccurate. The term for this issue is spurious regression.

If a series has to satisfy the Johansen Cointegration test, it must be stationary at first difference and non-stationary at level. However, the data used in the analysis must be at level. If the data is found to be stationary at level, the analysis for cointegration will be deterred and proceed will vector autoregression (VAR) model.

The stationarity of the variables was determined using the Augmented Dickey-Fuller (1979) test, Phillips-Perron (1988) test and Kwiatkowski–Phillips–Schmidt–Shin (1992) test which are unit root test.

For the Augmented Dickey-Fuller (ADF), the test is based on the t-statistic of β_1 , which can be calculated using the equation:

$$\Delta P_t = \beta_0 + \beta_1 P_{t-1} + \sum_{k=1}^N \delta_k \Delta P_{t-k} + \eta_t \quad (1)$$

where P_t is equal to $t - t-1$. Although it is a t-statistic, the hypothesis is not distributed in the same way as the student-t. The ratio is contrasted to the fundamental values of Fuller (1976). Meanwhile for Phillips-Perron, the test can be calculated using the equation:

$$P_t = \beta_0 + \rho \beta_{t-1} + \eta_t \quad (2)$$

Where, ρ is a corrected form of T-test which corrects serial correlation and heteroskedasticity in error term η_t non-parametrically by modifying the Dickey-Fuller statistics. The test uses the same asymptotic distribution as the ADF t-statistic.

The PP test does not use specified lags and it is robust to the general forms of heteroskedasticity compared to the ADF test.

For Kwiatkowski–Phillips–Schmidt–Shin, the equation has three components that are deterministic trend, random walk, and stationary error term. The test can be calculated using the equation:

$$P_t = r_t + \beta t + \varepsilon_t \quad (3)$$

where r_t is a random walk, βt is a deterministic trend and ε_t is a stationary error.

The null hypothesis for the ADF and PP are in the same direction where H_0 is non-stationary. While KPSS has a contradictory null hypothesis to ADF and PP, where H_0 is stationary.

The optimal lag length for the overall series was selected using the Hannan-Quinn criterion (HQC), Schwartz Bayesian Information Criterion (SBIC) and Akaike Information Criterion (AIC) for accuracy.

The Multivariate Johansen Cointegration Test was used to investigate the existence of a long-term equilibrium after performing unit root tests on the analysed time series and confirming that all time-series are integrated in the same order.

Johansen (1988) introduced the Maximum Likelihood (ML) method, which was later extended by Johansen and Juselius (1990). In contrast to the Engle-Granger test, which can only evaluate two variables, the ML technique allows for several cointegration vectors in a multivariate structure.

The Johansen cointegration test has no endogeneity since it is based on a simplified version of the Vector Autoregression (VAR) model. As a consequence, the number of variables chosen for normalization in regression remains constant. As a result, Johansen's Cointegration Test is the best option.

In a nonstationary VAR (vector autoregression) with restrictions imposed, known as a VECM (vector error correction model), the Johansen approach implies a maximum likelihood system that identifies a number of cointegrating vectors in a nonstationary VAR (vector autoregression) with restrictions imposed. The estimation model of Johansen can be written as follows:

$$\Delta P_t = \sum_{i=1}^{k-1} r_i \Delta P_{t-i} + \Pi P_{t-k} + \mu + \alpha \beta t + \varepsilon_t \quad (4)$$

Where, $P_t = (P_{1t}, P_{2t}, \dots, P_{nt})$ is a $n \times 1$ vector of the n -cointegrated variables, which are meant to be integrated of order $I(n)$; $\mu = (\mu_1, \mu_2, \dots, \mu_n)$ is a $n \times 1$ vector of intercepts; $\beta' = (\beta(1), \beta(2), \dots, \beta(r))$ is the $n \times r$ cointegrating matrix made of the r -cointegrating vectors. β' constitutes a long-run cointegrating relationship between variables; α represents the matrix $n \times r$ of the r -adjustment coefficient for each n variables. Hence r is the number of cointegrating relationship among the variables, where $0 < r < n$. α estimates the speed of adjustment of the equilibrium; r_i represents $n \times n$ matrixes of the autoregressive coefficient; $\sum_{i=1}^{k-1} r_i \Delta P_{t-i}$ is a short-run integrant or a vector autoregression; $\varepsilon_t = (\varepsilon_{1t}, \varepsilon_{2t}, \dots, \varepsilon_{nt})$ is a vector which implies uncorrelated white noise disturbances of $(0, \Sigma)$.

If the cointegration among the markets are confirmed, then VECM model is used to explore dynamic (short run) cointegration relationship among three or more variables.

Johansen (1991) proposes two probability ratio tests: The Trace test and Maximum eigenvalue test. The trace statistics is often used compared to Maximum eigenvalue since there is yet to be a solution to the multiple-testing problem (Kuzmenko, Smutka, Strielkowski, Štreimikis, & Štreimikienė, 2020). The Trace statistic is used to evaluate the null hypothesis of at most r cointegrating vectors against a general alternative hypothesis of than r cointegrating vectors. The remaining $(K - r)$ eigenvalues are zero if the number of cointegrating equations is limited to r or less. Johansen (1995) derives the trace statistic's distribution as follows:

$$(\lambda - \text{trace}) = -T \sum \ln(1 - \lambda_i) \quad (5)$$

where T denotes the number of observations and λ_i is the approximate eigenvalues. Large values of the trace statistic for any given value of r are proof against the null hypothesis that the VECM contains r or less cointegrating relations.

The variables were normalized, resulting cointegrating relationship such that the coefficient is equal to one. Any variable could be selected to normalize the data, as Juselius (2006) states that, the ratios among coefficients in cointegrating relationships are the same regardless of which variable is used. In this analysis, the largest producers, and exporters of each type of pepper product will be selected for normalization.

The validity and the strength of the model is tested after performing cointegration. Normality disturbance (Jarque-Bera Test), Heteroskedasticity (Breusch-Pagan- Godfrey Heteroskedasticity Test and Autoregressive Conditional Heteroskedasticity (ARCH) Test), serial correlation (Breusch-Godfrey Serial Correlation LM Test) and specification error (Ramsey's Regression Equation Specification Error Test) are tested as post-estimation analysis.

All tests are performed using E-views 10 statistical software (IHS Markit Ltd, London, England).

Results and discussion

Graphical Illustration for the Time Series

Prior to carrying out further analysis for the time series, the stationarity of the four different series is being predicted by plotting the graphs in the linear form, as can be seen in Figure 1. All the plotted time series suggested that there are stochastic and random walk trends in the series. Hence, it is predicted to be non-stationary at level. All the time series indicates similar movement and trend, yet their relationships are vague and equivocal.

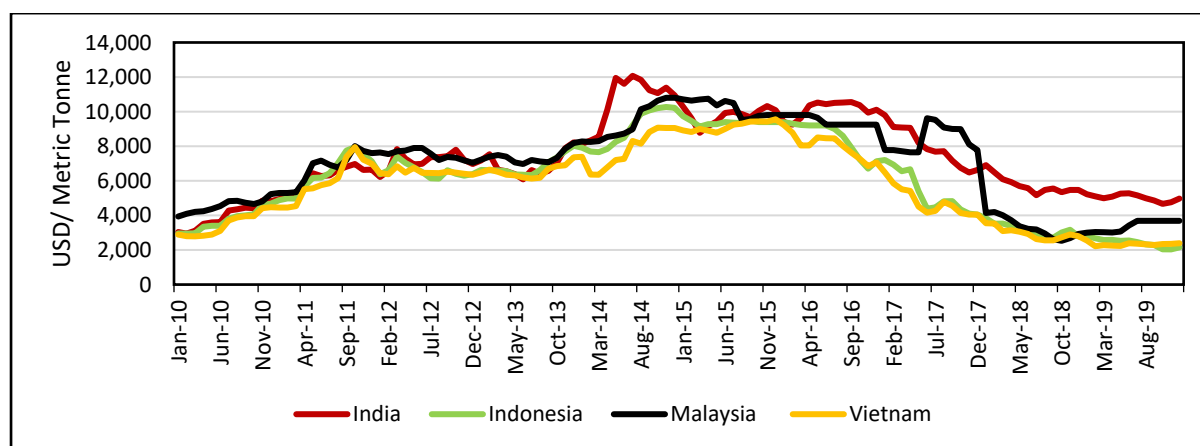


Figure 1. Black Pepper Export Price for India, Indonesia, Malaysia & Vietnam in USD/Metric Tonne for the year 2010 to 2019.

Testing for Unit Root

The series in log form have been tested for unit root using the augmented Dickey–Fuller (ADF) test, Phillips–Perron (PP) test and Kwiatkowski–Phillips–Schmidt–Shin (KPSS) test. The Schwarz Information Criterion was used for the ADF test lag selection and Newey–West Bandwidth was used for PP and KPSS Bandwidth selection.

All the series has proven to have a unit root at level. Meanwhile, at first difference all the series has indicated to be stationary at 1 percent significance of the critical value as shown in Table 1. Hence, the cointegration test can be carried out, furthering with Vector Error Correction Model (VECM).

Table 1. Unit Root Test for Export Black Pepper Price Series.

		ADF		PP		KPSS
Series		Probability	Statistics	Probability	Statistics	LM Statistic
Vietnam	Level	0.766	−1.651	0.769	−1.643	0.304 ***
	First Difference	0.000	−9.034 ***	0.000	−8.932 ***	0.091
India	Level	0.691	−1.815	0.690	−1.816	0.303 ***
	First Difference	0.000	−9.286 ***	0.000	−9.286 ***	0.061
Indonesia	Level	0.767	−1.649	0.860	−1.385	0.311 ***
	First Difference	0.000	−8.689 ***	0.000	−8.027 ***	0.077
Malaysia	Level	0.816	−1.523	0.766	−1.651	0.277 ***
	First Difference	0.000	−9.431 ***	0.000	−9.565 ***	0.060

Notes: ADF and PP H_0 : The series is non-stationary; KPSS H_0 : The series is stationary. *** statistically significant at 1 per cent level. For Unit Root Test for 120 observations: From Fuller (1976): −4.038 at 1%, −3.448 at 5%, −3.149 at 10%; From Philip-Perron (1988): −3.486 at 1%, −2.885 at 5%, −2.579 at 10%; From Kwiatkowski–Phillips–Schmidt–Shin (1992): 0.216 at 1%, 0.146 at 5%, 0.119 at 10%.

Multivariate Cointegration Interpretation

In order to test the presence of cointegration of the vectors, the Johansen maximum likelihood has been implemented as described in the methodology section. The Trace test was selected for the analysis in conjunction with multivariate cointegration testing across all of the studied sequences. The test results are displayed in the Table 2.

Table 2. Cointegration Test for Export Black Pepper Price Series.

Series	Test Specification	Null Hypothesis (Trace Test)
Vietnam/Indonesia/India/ Malaysia	None	Fail to Reject
	Restricted Constant	Fail to Reject
	Linear Trend	Rejected ($r = 1$)
	Restricted Linear Trend	Rejected ($r = 2$)
	Quadratic Trend	Rejected ($r = 1$)

Note: H_0 : Trace test indicates no cointegrating equation at 0.05 level ($r = 0$); H_1 : Trace test indicates 1 cointegrating equation at 0.05 level ($r = 1$); H_2 : Trace test indicates 2 cointegrating equation at 0.05 level ($r = 2$).

Based on the results in the Table 2, it can be concluded that all the series has at least one or two cointegrating vectors. Yet only the target variable, which is the main producer and exporter (key players) will be focused on as described in the methodology. Hence only H_1 will be normalized and interpreted into cointegrating equation.



The VECM dynamics of long-run and short-run coefficient are stated in the Table 3 for each series.

Table 3. VECM for Export Black Pepper Price Series.

Series	Long-Run Relationship	Short-Run Relationship	
	Normalized Cointegrating Coefficients	Error Correction Term (ECT)	p-Value
ECT Coefficient (CoInt.Eq)	-	-0.187 ***	0.004
Vietnam	1.000	0.253 *	0.062
Indonesia	-1.280	-0.027	0.853
India	0.360	0.064	0.574
Malaysia	0.098	-0.031	0.672
Intercept	-0.685	-0.000	0.820

Notes: *** statistically significant at 1 per cent level, * statistically significant at 10 per cent level.

Multivariate Vector Error Correction Model Result

As described by Juselius (2006), any variables can be selected to form a cointegrating equation as the ratio of the coefficients are the same disregard of the variables chosen. Hence, Vietnam was chosen due to its role as the key producer and exporter of black pepper. This is based according to the data provided by International Pepper Community (International Pepper Community, 2019).

Following is the cointegrating equations and their interpretations:

Table 3—Export black pepper price series:

Cointegrating equation:

$$1.000 \times \text{Vietnam} - 1.280 \times \text{Indonesia} + 0.360 \times \text{India} + 0.098 \times \text{Malaysia}$$

- $\hat{\alpha} = (0.253; -0.027; 0.064; -0.031)$

- $\hat{B}' = (1; -1.280; 0.360; 0.098)$

Coefficient Interpretation:

- 1% increase in Indonesia's export price resulted in an increase of 1.280% in Vietnam's export price.
- 1% increase in India's export price resulted in a decrease of 0.360% in Vietnam's export price.
- 1% increase in Malaysia's export price resulted in downward movement of 0.098% in Vietnam's export price.
-

In the long-run connections of black pepper export prices series, Indonesia-Vietnam has the strongest relationship. While India-Vietnam is more than three times weaker compared to Indonesia-Vietnam. The link between Malaysia-Vietnam has the weakest connection, where it is thirteen times weaker compared to Indonesia-Vietnam's. Meanwhile, the short-run ECT coefficient indicates an adjustment of 18.7 percent each period. The negative and statistically significant value shows that there is a long-run causality diverted from the independent variables to the dependent variable. The speed of adjustment for the variables ranged from 2.7 to 25.3 percent, with only with Vietnam being statistically significant.



Post-Estimation Diagnostic Analysis

The validity of each model has been tested using the residuals. Post estimation of the series includes test for serial correlation, heteroskedasticity, normality of disturbance and specification error. The results of the tests for the series are shown in Table 4.

Table 4. Post-Estimation Analysis for Black Pepper Export Price.

Diagnostic Test	Null	<i>p</i> -Value	Conclusion
Breusch-Godfrey Serial Correlation LM Test Chi-Square Probability	No serial correlation	0.7934	Null Accepted
Autoregressive Conditional Heteroskedasticity (ARCH) Test	No conditional heteroskedasticity	0.2901	Null Accepted
Jarque–Bera Normality Test Probability	Disturbance is normally distributed	0.0012	Null Rejected
Ramsey’s Regression Equation Specification Error Test	No specification error	0.0511	Null Accepted

Breusch–Godfrey serial correlation LM test was employed to examine whether correlation existed inside the model. Since the null hypothesis for the series was unable to be rejected, the test findings demonstrated that there is no serial correlation.

The estimation for heteroskedasticity was implemented using the Breusch-Pagan-Godfrey Heteroskedasticity Test. The result for the series has shown that there is no heteroskedasticity for each series as the null hypothesis is failed to be rejected.

Jarque–Bera normality test were used to estimate the normality disturbance. According to the outcome of the test, export price series has rejected the null hypothesis at 1 percent statistical significance. These indicates that the residuals are not normally distributed.

In fact, the residuals are most likely not natural because the time series under analysis represent pricing; this suggests that the data originated from a process with "heavy tails" (Kuzmenko et al., 2020). It may occur from significant shifts in the state of the world economy, which would make achieving a regular distribution very difficult. Concurrently, theoretically, a failure of the Jarque–Bera test would point to an inadequate number of delays selected for the model—a possibility unrelated to our model. Generally speaking, it should be mentioned that a failed Jarque–Bera test is a reasonably typical event that won't materially affect the results, especially when dealing with tiny data sets (Sukati, 2013).

For a number of reasons, pepper markets—one of the fastest-growing developing markets—are definitely worthwhile researching. Some of the issues include large regional differences in the market, noticeable price volatility, ongoing changes in consumer behaviour, quick supply and stock expansion due to increased speculative trading activity, the significant influence of protectionist measures, and more.

When there is spatial integration, the price shock due to change in demand or supply in a market will be transmitted to another market, inferring that all markets integrated will have an equal impact.



As was already established, a wide range of protective and supportive mechanisms that are used unevenly in various nations define the food market, including the pepper market, as do significant price disparities between particular countries (and even markets within a single area). Preserving food safety, market stability, and rural livelihoods are the main drivers for government intervention. These interventions usually lead to a limitation or absence of price transmission between markets, which is the opposite of free market dynamics. Stated differently, poor transmission and pricing obfuscation are linked to market fragmentation in the expansion of pepper markets.

Lack of integration amongst market due to protectionism leads to autarky price in domestic markets, which leads to deadweight loss and inefficient economy, which consequently suffocates the freedom of the producers and consumers. Autarky price annihilates opportunities for spatial arbitrage, leading to prices moving independently in the same or opposite direction in each market.

Market integration through free trade leads to an efficient and functional market system, which ensures food safety through the responds of market's demand and supply movement internationally. Producers, such as farmers, will be able to control and schedule production and storage by predicting excess demand and supply. Free trade enables better price which gives producers an opportunity to obtain higher income through competitive price. Besides that, it also enables agriculture diversification and improve nutrition.

All of these factors piqued the curiosity to explore the degree of interconnection between major producing countries (represented by Vietnam, Indonesia, India, and Malaysia). The export market price were studied to analyse the presence of long-run equilibrium.

From the analysis conducted, the price series have revealed that there is presence of mutual interaction among the selected pepper markets despite an obvious diversification in prices among them. The co-movement amongst the market have proved that the goal or hypothesis of 'cointegrated market' has been achieved.

The findings of this study supports the previous study by Sinharoy and Nair (1994) on international trade and pepper price variation, which stated that the movement of prices of pepper have been synchronized indicating an integration in the world pepper market. Hema et al. (2007), whom studied the same relationship, also indicated that prices have quick to move towards equilibrium in the long run in this period of time frame compared to pre-liberalization period.

The study conducted by Sabu et al. (2019), on price variability of pepper markets in the state of Kerala, India, indicated that the price variability was insignificant when related to the net income of the farmers. This shows that the price transmission of the pepper markets is symmetric.

The extent of the strength of the co-movement amongst the markets has significantly bolstered the understanding of the current industry trend. All series has proven that the market system is converging to equilibrium and the models estimated are stable.

For further study, panel data analysis as described by Taasim, Pinjaman, and Albani (2021) and Akhyar, Ilham, and Subhan (2023) can be conducted to obtain information on individual



markets behaviours across time. Whereas, for future study on market asymmetries, the non-linear autoregressive distributed lag (NARDL) model as described by Taasim (2021), Chowdhury, Meo, Uddin, and Haque (2021), and Kashif et al (2023) could be employed for robust statistical analysis.

Conclusion

The study has found that there are co-movement amongst the market, despite the obvious price difference and frequent fluctuations. The short-run ECT coefficient indicates an adjustment of 18.7 percent for export price for each period. The speed of adjustment of the variables indicates that only Vietnam was statistically significant in terms of the speed of adjustment for the variables, which ranged from 2.7 percent to 25.3 percent. This suggests that the bodies involved in the trade of pepper could help in enhancing the efficiency of the marketing system and reduce market distortion, in terms of speed of adjustment.

Overall, this study inferred that, the price movement in a market is reflected on the other markets. Hence, the market system is at unison supporting the previous study conducted by Sivasankari and Vasanthi (2015). For the market to remain competitive and integrated, studies on market frictions and free trade policy are essential to mitigate large deviation from LOOP (Froot, Kim, & Rogoff, 1995; Steinwender, 2014). Comprehending the types of frictions that impede cross-market arbitrage is a fundamental goal in global commerce (Anderson & Van Wincoop, 2004; Steinwender, 2014).

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Attitudes towards Risk and Optimal use of Inputs in Maize Production in the Mekong Delta, Vietnam

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Abstract

The paper is aimed at measuring the risk attitude of maize farmers and testing the relationship between farmers' risk attitudes and optimal use of inputs in production. The experimental method of Eckel and Grossman (2002) associated with the constant partial risk utility function was employed to measure the farmers' risk attitude. Then, allocative efficiency coefficients were calculated from the output elasticities of inputs estimated from the Cobb-Douglas production function associated with the profit-maximizing condition in using inputs. The data was collected from a survey of 130 farm households located in large and concentrated maize production areas in the Mekong Delta. It is found that the majority of farmers are found to be risk-averse, accounting for 69.05%. Generally, the more risk averse the farmers are, the less purchased inputs are used in production. Then, most of farmers are not able to maximize profits.

Keywords: Risk attitude, maize production, input use, profit maximization.

JEL code: C93, D01, D13

SDG goals: No Poverty, Responsible Consumption and Production

Introduction

Agricultural production is usually confronted with a wide range of risks due to climate changes, market volatility and social uncertainty. In coping with risks, farmers have to make decisions on production in an uncertain environment (Ellis, 1993). Every farmer may make different production decisions based on their attitude towards risk (Reynaud and Couture, 2012). Farmers who are risk averse are often less willing or slow to apply innovations than the others though these actions are able to improve their productivity and income (Antle and Crissman, 1990, Ellis, 1993, Liu, 2013). In addition, farmers with a risk-averse attitude are more likely to use inputs that are below the economically optimal level (Ellis, 1993). Then, the assumption of profit maximization may not be hold. Therefore understanding the farmer's attitudes toward risk is very important in order to understand the farmer's behavior, thereby planning production management strategy, technology transfer and building supportive policies in agriculture (Young, 1979).

Although many scholars believe that farmers in developing countries, who are generally small and poor producers, are risk-averse, little is known about the actual patterns of their risk preferences. Very few empirical studies have been conducted to measure the attitude toward risks and the distribution of farmers according to their attitude. Farmer's attitudes toward risks may vary according to changes in the socio-economic conditions, particularly the changes in household income and ability to transfer risks to third parties (Yesuf and Bluffstone, 2009). For this reason, attitudes toward risks need to be measured at each stage of socio-economic development to timely provide empirical evidences of farm behaviors.

In this paper, we measure attitudes toward risks, and then, test the relationship between farmers' risk attitudes and optimal use of inputs in hybrid maize cultivation in the Mekong Delta. The paper contributes to literature in two points. *First*, we are the first to conduct empirical research



using the method of Eckel & Grossman (2002) in order to measure attitudes towards risks of farmers in the Mekong Delta. We designed a game with real payoff in which farmers were asked to select risk options whose expected rewards linearly increased with risks due to increased variance to explore their risk attitudes. This method can be extended to measure farmers' attitudes toward risks with different production activities in the region. Understanding the farmer's attitudes and the distribution of the households according to the attitude helps policy makers develop policies that support farmers and restrict the negative effects of risk aversion. *Second*, we explore the relationship between farmers' risk attitudes and optimal use of inputs in production. This provides empirical evidence about the choice of input use among farmers with various attitudes towards risk.

The paper proceeds as follows. Section 2 provides the theoretical background of the study. Section 3 presents the research method. Section 4 describes the data. Section 5 presents the estimation results and discussion and Section 6 concludes.

Theoretical background

Risk refers to a situation where probabilities can be attached to the occurrence of events which produce different outcomes of a decision making process (Ellis, 1993). Risk refers to the difference between actual results and expected results in uncertain situations (Le Khuong Ninh, 2016). In agricultural production, risks are popular and various. Musser and Patrick (2002), Hardaker et al (2004), Drollete (2009), and Aimin (2010) document that there are 5 types of risks, including production, market, institutional, personal and financial risk. In general, when the risks occur, it may lead to the uncertainty about the income that the farmers generate from production. Under uncertain circumstances, farmers may differ in the ways they make production decisions according to their attitudes towards risk. In this study, risks are regarded as the occurrence of uncertain events that may affect the households' income irrespective to the types of risks.

An individual's attitude towards risk is viewed as how the individual acts in response to a risky situation (Dave et al., 2007; Pennings and Garcia, 2001; Weber and Milliman 1997). Each individual has different perception of risk depending on their psychological characteristics, social environment and natural conditions (Slovic et al., 1982). Therefore, each individual may have different attitudes towards risk, that is, some are risk-averse, some are risk-neutral and others are risk-loving (or risk-taking).

Walker and Jodha (1986) postulate that attitude towards risk is expressed by the caution in making investment decisions, as well as the use of resources for production activities. Risk-averse individuals prefer alternatives that, in effect, ensure the security of their income or well-being even though the benefits may be much lower than those with more risk (Ellis, 1993). Meanwhile, risk-taking people prefer options with high income despite high probability of failure (Ellis, 1993). Lipton (1968), Binswanger (1980), Walker and Jodha (1986) document that poor farmers are generally risk-averse because they are not able to cover their household expenses if they suffer losses in crops. Then, risks prevent poor farmers from investing in activities with high expected returns associated with higher risks (Yesuf and Bluffstone, 2009).

When confronting with choices in the case of risk, individuals choose the one that produces maximum expected utility (von Neumann & Morgenstern, 1944). That is, the Decision Maker (DM) will compare his/her expected utility with the total utility generated from the results multiplied by the corresponding probability. Specifically, a person with a risk-averse attitude will obtain more utility from a certain amount of money than those from the expected amount



under an uncertain condition though he/she knows that the former is certainly less than the latter. This means that individuals are willing to give up the difference between these two values to gain certainty. In contrast, a person with a risk-loving attitude will expect the value that can be delivered in the event of greater risk than under certain conditions, even if the risk is known. The individuals with neutral risk attitude will be indifferent between the value received under certain conditions and the expected value received under the risky condition unless the difference between them exists. These individuals are only concerned with the expected value regardless of the chance of the event.

Much effort has been made to examine the effects of the farmers' risk preferences on the economically optimal use of inputs. Ellis (1993) built a theoretical model representing the relationship between the use of input factors in the uncertain conditions with the risk attitudes, as shown in Figure 1.

Figure 1 shows three response curves of output (in value) to a single variable input, say, units of nitrogen fertilizer. $TVP1$ represents the total value product response to the input use in a "good weather". In contrast, $TVP2$ represents the total value product with respect to the input use in "bad weather". $E(TVP)$ represents the expected value of the product corresponding to the farmers' subjective probabilities of a "good" and "bad" season. $P1$ and $P2$ are the subjective probabilities associated with the occurrence of these events. $TVP1$ and $TVP2$ are described as the outcomes of events or states of nature. The TC curve represents the total cost of input use, linearly increasing with the input use as input price is constant.

The input use at $X2$ represents the allocative efficiency on $TVP2$ as the bad weather occurs. The individual who decides to use this input level obtains a profit of ce if the "good" season occurs. On the contrary, if the season is "bad", the farmer obtains a small profit of de . Whichever season may occur, the individual is able to make profit. The individual who makes the choice at $X2$ is described as risk-averse because this person prefers the safety of acting as if the worst possible outcome will happen, even though the probability, in her/his opinion, of the bad season is small.

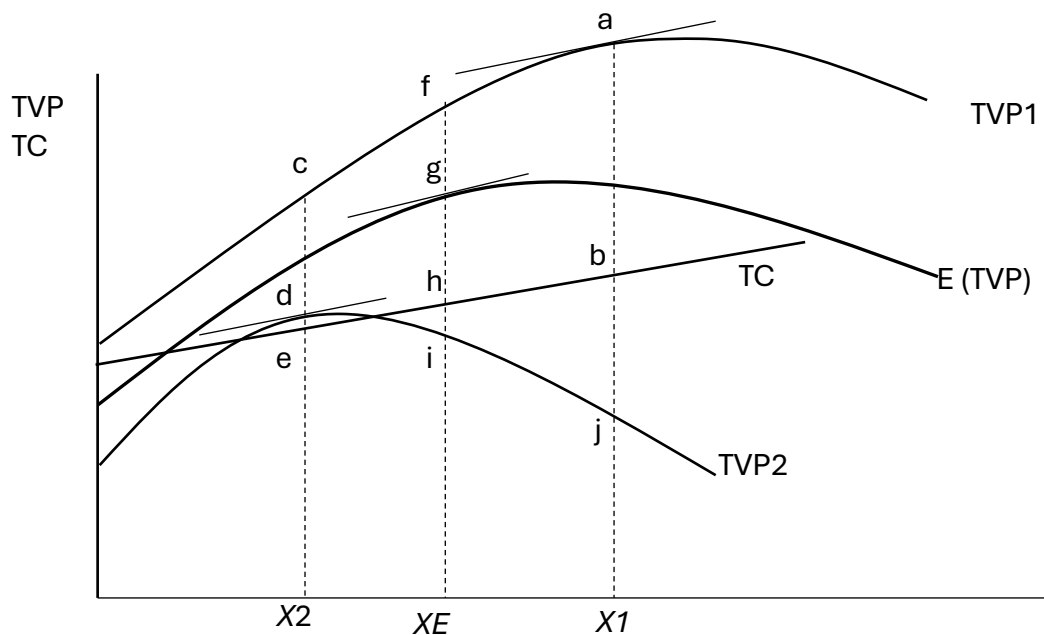


Figure 1. Production decisions under risk
Source: Ellis (1993)

On the contrary, a individual with a risk-loving attitude is likely to use the input at X_1 that corresponds to the allocative efficiency on TVP_1 . If the good season occurs, he/she gets a big profit of ab . If the season is bad, the individual will suffer a substantial loss of bj . This choice shows that the individual prefers a chance at the largest possible profit, even though he/she knows that it is uncertain. Otherwise, the risk-neutral individual will decide to use the input at XE , that is consistent with the allocative efficiency with a balanced assessment of the average outcome of “good” and “bad” seasons.

This theoretical framework describes the risk in terms of the “income variance” approach. Under uncertainty, income from production varies with possible events. Risk-averse farmers are likely to use the input levels that ensure the safety of their income. Input uses with safe outcomes are typically less than those with maximum expected outcomes and then, well below the ones that yield the highest possible outcome.

Several empirical studies have clarified the impacts of attitude toward risk on the use of inputs and then, on production efficiency. Picazo-Tadeo & Wall (2011) claimed that the input use in the production would be affected by the risk attitude. Then, risk attitudes did have an impact on the efficiency of the resource allocation (Wolgin, 1975). Kumbhakar (2002) also found that attitude towards risk had an important impact on the use of inputs as well as the supply of outputs. Similarly, many other studies also identified risk preferences of farmers as key determinants of the use of inputs (Antle, 1987; Ghadim et al., 2005; Paulson and Babcock 2010; Dercon and Christiaensen, 2012). In addition, Loehman and Nelson (1992) found that optimal use of inputs will be influenced by the differences in attitude toward risk of individuals.

Nmadu et al. (2012) stated that farmers with risk aversion would use inputs such as fertilizers and seeds at amounts lower than the required level to get maximum expected profit. Farmers

with a risk-averse attitude choose to use less inputs in production and accept higher income trade-offs. It is seen as a way to maximize the utility in terms of risk (Sandmo, 1971; Anderson et al, 1977).

Research methods

Measuring the attitude towards risk

Based on the theoretical background of expected utility, many authors have developed models and methods for measuring risk attitudes. Pratt (1964) and Arrow (1965) were the first authors to propose a measure of attitude towards absolute risk based on utility theory as follows:

$$R(x) = -\frac{U''(x)}{U'(x)} \quad (1)$$

where U is a utility function of von Neumann-Morgenstern characterized by following properties: i) first-order derivative is positive, $U' > 0$, and ii) second order derivative is negative, $U'' < 0$, and x is wealth or income. Both Pratt (1964) and Arrow (1965) hypothesize that a risk-averse person exhibits a diminishing marginal utility to x . Hence, the positive, zero and negative indicator R represents the risk-averse, risk-neutral and risk-taking behavior, respectively.

To measure the risk attitude of a decision maker, utility function with constant partial risk aversion coefficient (CPRA) is usually applied. This utility function is commonly used in empirical studies (Binswanger, 1980; Humphrey and Verschoor, 2004; Mosley and Verschoor, 2005; Wik et al., 2004; Yesuf and Bluffstone, 2009). In particular, CPRA utility function takes the following form:

$$U(x) = (1-r)x^{1-r} \quad (2)$$

where r is the constant partial risk factor and x is the income level of expected equivalent certainty. Individuals with $r > 0$ can be considered risk-averse people, $r < 0$ is risk-taking people and $r = 0$ is risk-neutral people.

Several methods are applied to measure attitudes toward risks. They can be econometric methods and experimental methods. For the econometric methods, the parameters of risk attitude are estimated for the population of producers, based on their actual behavior under the assumption of expected utility maximization (Moscardi and de Janvry, 1977, Antle, 1987, Wik et al., 2004). Pope (1982) argues that these methods are based on structural models of the supply and demand forces to identify risks. However, the resulting risk parameters may be confounded since individuals may reveal greater risk aversion than reality in the context of limited resources and imperfect markets that the individual is facing (Eswaran and Kotwal, 1990; Singh et al., 1986; de Janvry et al., 1991). For experimental methods, risk coefficients are estimated through experimental elicitation techniques based on hypothetical questions about risky options or risky games with pay-offs (Binswanger, 1980, 1981, 1982, Eckel and Grossman, 2002, Wik et al., 2004). Charness and Gneezy (2012) believe that there are many experimental methods in measuring attitude towards risk such as Questionnaire method; the Steam ball modeling method; Method Gneezy and Potters; The Eckel and Grossman method and the multi-price list method. However, Charness (2013) argues that the Eckel and Grossman methods are fairly simple and clear professional methods for exploring individual attitudes



towards risk. Dave et al. (2010) also demonstrate that this method is quite reliable in measuring attitudes to risk and is less complex than the other methods, particularly suitable for respondents who has low computational ability. Therefore, the authors apply the experimental method developed by the Eckel and Grossman (2002) to measure the attitude towards risk of hybrid maize farmers in the Mekong Delta.

To measure the risk attitude of each farmer, the research team selected the respondents who took decisive role of and directly participated in the hybrid maize production for the survey. Investigating farmers' attitudes towards risks with experimental games was conducted on an individual basis. Each respondent was asked to play 3 lottery selection games (with the nature of chance). Of which, games 1 and 3 were based on hypothetical payoffs. For game 2, the respondents were given real payoffs according to their choice and the lottery result (in the form of tossing a coin). The combination of 3 games was aimed to check the robustness of the resulting player's attitude towards risk, by comparing results among games. In addition, to ensure the players understand the nature of the games, the interviewers would first explain the players the nature of the games. The result of a player's final choice in each game was only recognized when the player had a reasonable interpretation of the reason for their choices (Barry, 2014). The organization of the games is presented in details below.

Game No.1:

The purpose of the game is to preliminarily identify the participants' attitude towards risk. In addition, this game is also intended to test the player's understanding of the game and to detect the ones who make inconsiderate decision, affecting the elicited attitude towards risk. Below is how to proceed the game:

Farm household heads are asked to take turn to answer all 7 questions. Then, they will have the right to choose either the hypothetical reward "A" or "B" corresponding to the questions. If choosing reward "A", the participant will receive the value of the award, which is certain (without risk). In contrast, the reward will be determined through the results of a coin toss (tail or head). If the head appears, the participant will receive 100,000 Vietnamese dong; otherwise, there is no reward. This option is risky but may let them have a chance to get a higher value of reward. The game is continued by this way until the participant decides to choose the reward "B" at which the switch point is determined at that question and the game will stop.

The interviewer observes and identifies the one making the decision to change from option "A" to "B" in that question and marks "x" in the transfer point column. Then, they will move on to Game No. 2. Table 1 shows the questions and hypothetical rewards in Game No. 1.

Table 1. Game 1 to preliminarily determine risk attitude

Unit: VND thousand				
Questions	Reward A	Reward B Probability: 50 – 50		Switch point
		Head (High payoff)	Tail (Low payoff)	
Questions 1*: How old are you?	100	100	0	1*
Questions 2: what grade are you in?	90	100	0	2
Questions 3: How many years of experience do you have production?	70	100	0	3



Questions	Reward A	Reward B Probability: 50 – 50		Switch point
		Head (High payoff)	Tail (Low payoff)	
Questions 4: How much is the production area?	55	100	0	4
Questions 5: How much is the productivity?	25	100	0	5
Questions 6: Who do you sell products for?	15	100	0	6
Questions 7: What is the selling price?	05	100	0	7

Source: Authors' design

Games No. 2:

Game 2 is the most important game since it is used to determine a player's risk attitude. It is the lottery game with real payoff according to the choice of the player. The player's attitude towards risk is manifested in their decision-making in the game that is designed to have different levels of risk. The way the game is proceeded is presented as follows: Participants are asked to choose one of the six options, from A to F in Table 2. Players will receive real payoff based on tossing a coin with a probability of 50% for the head or the tail, equally.

The base reward value is 50,000 VND, which is 2.2 times of the hourly wage of hired labor in the rural region. This design aims at attracting the attention and thinking of farmers in making decisions in the game. In addition, the game is also designed to prevent players from making losses (the smallest reward is zero), in order to avoid farmers thinking of choosing a safe option.

Table 2. Games 2 to determine risk attitude

Options	<i>Unit: VND thousand</i>			
	Head (Low payoff)	Tail (High payoff)	Expected return	Standard deviation
A	50	50	50.0	0.0
B	45	60	52.5	7.5
C	35	90	62.5	27.5
D	20	125	72.5	52.5
E	10	140	75.0	65.0
F	00	150	75.0	75.0

Source: Authors' design

Features of the game:

Option A is the safest option whose standard deviation is 0. Options from B to E are designed so that expected values linearly increase with risk, expressed as the increasing standard deviation. Option F is designed to have the same expected value as option E but with a higher standard deviation.

The risk-averse people tend to choose options from A to D, the risk-neutral people tend to choose option E and the risk-taking people tend to choose option F. The coefficient of risk attitude for each option is determined by the constant partial risk aversion coefficient (CPRA):

$$U(x) = (1-r)x^{1-r} \quad (3)$$

in which r is the coefficient of risk aversion and x is the income of certainty equivalent to expectation. The individual's risk attitude coefficient is determined by solving the equation for the expected utility of expectation between two adjacent options.

Game No. 3:

Game 3 is designed to consider whether a player's risk attitude changes with increased reward value. However, the game is proceeded with hypothetical pay-offs. Outcomes of Game 3 are used to compare with those of Game 2, to reinforce confidence about the eliciting method in the Game 2. The organization of the game is similar to game 2. The options in this game are shown in Table 3.

Table 3. Games 3 to determine risk attitude

Unit: VND thousand

Options	Head (Low payoff)	Tail (High payoff)	Expected return	Standard deviation
A	100	100	100	0.00
B	80	120	100	28.28
C	70	140	105	49.50
D	30	200	115	120.21
E	10	240	125	162.63
F	00	250	125	176.78

Source: Authors' design

Testing the optimal use of inputs in production and attitude towards risks

On the basis of Ellis' theoretical model (1993) and related studies on the relationship of risk attitudes and input decisions used in production. Verification of optimal input usage can be performed. Accordingly, the optimal input level is determined at the point where the marginal product of each input is equal to the ratio of the input price to the output price. From the Cobb-Douglas production function, marginal product of each input can be derived as follows:

$$\ln Q_i = \alpha_0 + \alpha_1 \ln X_1 + \alpha_2 \ln X_2 + \dots + \alpha_n \ln X_n + \varepsilon_i \quad (4)$$

Partial derivative of an input, for example X_1 , we get:

$$\begin{aligned} \frac{\partial \ln Q}{\partial \ln X_1} &= \alpha_1 \\ \frac{\partial \ln Q}{\partial \ln X_1} &\text{ equivalent to } \frac{\partial Q/Q}{\partial X_1/X_1} \\ \text{Becomes } \frac{\partial Q/Q}{\partial X_1/X_1} &= \alpha_1 \Leftrightarrow \frac{\partial Q}{\partial X_1} = \alpha_1 \times \frac{Q}{X_1} \end{aligned} \quad (5)$$

$\frac{\partial Q}{\partial X_1}$ is the marginal product of the input X_1 (MP_{X_1}). (5) can be written as:

$$MP_{X_1} = \alpha_1 \times \frac{Q}{X_1} \quad (6)$$

The first-order conditions for profit maximization on input X_1 are $MVP_{X_1} = MFC_{X_1}$, can be written as:

$$MP_{X_1} * P_Q = P_{X_1} \Leftrightarrow \frac{MVP_{X_1}}{P_{X_1}} = 1 \quad (7)$$

Substituting (5) into (6), we obtain:

$$\left(\alpha_1 \times \frac{Q}{X_1} \right) \times \left(\frac{P_Q}{P_{X_1}} \right) = 1 \quad (8)$$

Ellis (1993) referred to $\left(\alpha_1 \times \frac{Q}{X_1} \right) \times \left(\frac{P_Q}{P_{X_1}} \right) = k$ as the allocative efficiency ratio (k) for a single

input the conditions for maximizing profit on input is $k=1$. If input X_1 has a ratio $k > 1$ household uses the input X_1 which is lower than the optimal input; however, if input X_1 has a ratio $k < 1$, household uses the input X_1 which is more than the optimal input. Thus, the test of farmer's optimal input can be performed based on the comparison of k and 1.

Data

In the Mekong Delta, hybrid maize production is not widely planted around the region but is concentrated in few areas. For this reason, the authors conducted the survey at two provinces with the leading production areas, namely Dong Thap and Tra Vinh. The selected provinces represent two different ecological zones. While Dong Thap are located at the upper part of the Mekong River, Tra Vinh is at the lower part. These provinces also represent two different ecological regions of the Mekong Delta. Dong Thap represents the watershed of the Mekong River basin and production on alluvial soil, which is very suitable for maize. Meanwhile, Tra Vinh represents the downstream of the Mekong River basin and production on sand land.

In each province, the authors selected districts with large and concentrated production areas. Then, 2-3 communes in each district were randomly selected for the survey. The surveyed households were randomly selected from the list of hybrid maize households provided by the Commune People's Committee. The survey collected information from 130 households. Out of them, 67 were from Dong Thap and 63 from Tra Vinh. The results of the farm household survey show some common characteristics of the hybrid maize farmers in the Mekong Delta, as shown in Table 4.

Table 4. Characteristics of maize farmers

Variables	Mean	Standard deviation
Age of household head (Age)	51.10	11.95
Years of schooling of the household head (Education)	5.08	2.79
Number of people in household (Household size)	4.21	1.42
Number of labor in the household (labor)	2.48	1.43
Numbers of labor in household participating rice production (labor)	2.32	0.99
Years of experience in maize production (Experience)	11.05	8.54
Area (1.000m ²)	5.27	3.36
Income from hybrid maize production (million VND/year)	39.95	32.66



Variables	Mean	Standard deviation
Total income of farmer households (million VND/year)	47.99	44.43

Source: Calculated from survey data, 2018

Figures in Table 4 show that the average age of the household head is 51.10 years old. The mean years of schooling of the heads is quite low, just above 5 years, equivalent to primary education. Low education may be one of the barriers for farmers in acquiring scientific and technological advances in production as well as efficient use of resources in production.

The average household size is 4.21, among them, the average number of members in working age is 2.48, accounting for 59% of the total number of people in the household. The average number of members participating in production is 2.32, accounting for about 94% of the labor force in the farm household. These statistics show that hybrid maize production is one of the important income-generating activities of the sampled households in the study area so that households allocate a great proportion of human resource to it.

The mean years of experience in hybrid maize production is 11 years. The average maize production area is 5.27 thousand square meters per farm household. The experience and production area of households largely vary across households, as shown by the large standard deviation of these variables. The average income from hybrid maize production per household is 39.95 million VND/year, accounting for 83.25% of the total annual income of the farm households.

Table 5 provides additional qualitative characteristics of farm households. Up to 91,27% of household heads are male while women household heads only account for about 8,73%. The percentage of households participating technical training is relatively small, only about 36,51%. In addition, the number of households participating in local mass organizations is low, about 15,87%. In hybrid maize production, up to 76.73% farmers report they often face diseases on crops.

Table 5. Qualitative characteristics of maize farmers

Qualitative characteristics	Proportion (%)
Gender of household head (1=Yes, 0=No)	91.27
Participating in local mass organizations (1=Yes, 0=No)	15.87
Participating training (1=Yes, 0=No)	36.51
Pests and diseases (1=Yes, 0=No)	76.73

Source: Calculated from survey data, 2018

Results and discussion

Farmer's attitudes toward risk

Farm households' choice through Game No. 1 showed that most of them decided to choose switch points with safe characteristics or low level of risk. This initially shows that most of the farmers involved in hybrid maize production have a common feature of being quite risk aversion.

Table 6. The results of games 1

Switch point	Frequency	Proportion (%)
1*	05	3.82
2	07	5.56
3	04	3.17
4	14	11.11
5	22	17.46
6	12	9.52
7	67	53.17

Source: Survey results in the study area.

Results of Game No. 2 are shown in Table 7. This is an important experimental game, which is used to determine the coefficient of attitude towards risk of each farmer.

Table 7. Risk coefficients and classification of risk attitudes by game 2

Choice	Head (Low payoff)	Tail (High payoff)	Risk attitude classification	Risk coefficient
A	50	50	Extremely averse	>10
B	45	60	Severely averse	10 - 1,00
C	35	90	Intermediate	1,00 - 0,62
D	20	125	Moderate	0,62 - 0,18
E	10	140	Slight to Neutral	0,18 - 0
F	00	150	Neutral to loving	<0

Source: Survey results in the study area.

The production of hybrid maize confronts many types of risks for different reasons. The occurrence of risks may cause the potential loss of income from production activities. Farmers with a risk-averse attitude do not often choose risky options even though they know that they may bring about higher income.

Based on the options that the farmers select when participating in the game, the risk coefficient of each farmer is determined on the basis of the CPRA utility function. In particular, a farmer's decision to choose option "B" means that he/she will be indifferent between options "A" and "B", as well as between options "B" and "C" (i.e. $U(E_A) = U(E_B)$ and $U(E_B) = U(E_C)$). Then $(1-r)U_A^{1-r} = (1-r)U_B^{1-r} = (1-r)U_C^{1-r}$. Therefore, the risk coefficient for partial risk r is determined by solving the equation for the indifference (equal expected utility) between the two adjacent options. A farmer decides to choose option "A" which means that he is indifferent between option "A" and "B", that is: $(1-r)50^{(1-r)} + (1-r)50^{(1-r)} = (1-r)45^{(1-r)} + (1-r)60^{(1-r)}$. Then, solving this equation, we determine $r = 10$ similar r -values for the determination of the r -value given at other selection points are shown in Table 7. An individual's attitude towards risk includes the following levels: Extremely averse; Severely averse; Intermediate; Moderate; Slight to Neutral; Neutral to loving (Miyata, 2003; Weixler-Landis, 2014).

The results of Game No.2 also showed that most of the farmers involved in hybrid maize production in the study area are risk-averse. The number of households who are slight to neutral to risk accounts for a significant proportion, nearly 12% of the total number of households. This result shows that there will be many households willing to take risks to participate in new investment options with higher profit and corresponding risks.

In addition, we also consider whether the attitude towards risk changes when the pay-offs increase which is provided from Game 3.

Table 8. The results of games 2 and 3

Choice	Risk attitude	Games 2		Games 3	
		Frequency	Proportion (%)	Frequency	Proportion (%)
A	Extremely averse	62	49.21	63	50.00
B	Severely averse	25	19.84	21	16.67
C	Intermediate	17	13.49	16	12.70
D	Moderate	08	6.35	11	8.73
E	Slight to Neutral	03	2.38	02	1.59
F	Neutral to loving	11	8.73	13	10.32

Source: Calculated from survey data.

Although the experimental games were organized differently, the results of the farmer households' distribution of attitudes towards risk were almost similar among all games. These help reinforce the reliability of the elicited risk attitudes. The resulting risk attitude is consistent with those of Lipton (1968), Binswanger (1980), Walker and Jodha (1986), Wik et al (2004), Yesuf and Bluffstone (2009). They argue that farm households in developing countries are often small and poor and hence, they cannot suffer the losses in production since it may lead them to starvation. Therefore, the poor households are more likely to choose the option according to the principle of "safety first". However, the elicitation also shows the number of neutral and risk-loving households account for a significant proportion of nearly 11% of the total number of households. This result shows that many farmers are willing to take risks to participate in new production strategies with higher profitability associated with higher risks.

Optimal inputs in production and attitude towards risk

To simplify the classification of risk attitudes, households are, then, assigned to three generalized groups, namely: "*Risk aversion*" including households in "*Extremely averse*" and "*Severely averse*" groups; "*Risk neutral*" including households in "*Intermediate*" and "*Moderate*" groups and "*Risk-loving*" including households in "*Slight to Neutral*" and "*Neutral to risk-loving*" groups. Given this risk attitude classification, about two thirds of the maize farm households are risk averse. 20% of farm households are neutral to risk while households with risk-loving attitude account for 11%.

Based on the output elasticities of each input estimated from the production function in combination with the profit-maximizing condition in using inputs ($MVP=MFC$), the allocative efficiency coefficient (k) of each input were calculated. The allocative efficiency coefficients on inputs were presented in Table 9.

Table 9. Allocative efficiency coefficient (k) of the inputs

Inputs	Coefficient (k) on sample	Allocative efficiency coefficient (k)			Difference		
		Risk-loving (1)	Risk neutral (2)	Risk aversion (3)	(1)-(2)	(2)-(3)	(1)-(3)
Seed	9,068 ^{***}	6,887	8,469	9,591	-1,582 ^{ns}	-1,122 ^{ns}	-2,705 ^{ns}
Nitrogen	3,355 ^{***}	3,011	2,127	3,763	0,884 ^{**}	-1,637 ^{ns}	-0,753 ^{ns}
Phosphate	1,807 ^{***}	3,043	1,060	1,823	1,983 ^{***}	-0,762 ^{ns}	1,221 [*]

Inputs	Coefficient (k) on sample	Allocative efficiency coefficient (k)			Difference		
		Risk-loving (1)	Risk neutral (2)	Risk aversion (3)	(1)-(2)	(2)-(3)	(1)-(3)
Potassium	3,734 ^{***}	5,072	2,683	3,820	2,389 [*]	-1,137 ^{ns}	1,252 ^{ns}
Pesticides	0,002 ^{***}	0,004	0,001	0,002	0,003 ^{**}	-0,001 ^{ns}	0,002 ^{ns}
Labor hired	1,684 ^{***}	1,666	1,210	1,823	0,456 ^{**}	-0,613 [*]	-0,157 ^{ns}
Farmer's labor	0,193 ^{***}	0,287	0,196	0,177	0,091 ^{ns}	0,019 ^{ns}	0,109 ^{**}

Source: Survey results in the study area.

Note: ^{***}, ^{**}, ^{*}, and ^{ns} indicate the level of significance at 1%, 5% and 10%, respectively

Most of the allocative efficiency coefficients (k) of inputs were higher than 1, which means that most of the inputs were used less than the optimal levels. Other inputs such as pesticides and farmer's labor have allocative efficiency coefficients (k) less than 1, which means that they were used more than optimally. Although the behavior of households using inputs was various, the number of inputs using was not at the optimal level (because only $k > 1$ or $k < 1$). The estimation results show that farmers choose the amount of inputs mainly based on experience and have little adjustment to changes in prices, so it is difficult to maximize profits in the use of inputs. On the other hand, prices often change and that is a factor that farmers cannot control.

The purchased inputs such as nitrogen, phosphate, potassium, and hired labor of the “*Risk neutral*” household group are used closer to the optimal level and allocative efficiency coefficients (k) of these factors are less than “*Risk-loving*” household group. In addition, allocative efficiency coefficients (k) of the phosphate of “*Risk aversion*” households group are lower than the “*Risk-loving*” households group. The allocative efficiency coefficients (k) of the hired labor in “*Risk aversion*” group is higher than that of the “*Risk neutral*” households group. For inputs purchased from outside, the group of “*Risk neutral*” households used closer to optimal level compared to other groups of households.

In particular, the farmer's labor input has allocative efficiency coefficients (k) gradually decrease corresponding with an attitude toward risk aversion increases. This means that a more risk-averse household is the farmer's labor using over more than optimal inputs level.

In general, most farmers are risk-averse so they often use inputs, especially purchased inputs, below the economically optimal level. This makes the level of economic efficiency achieved by the household low and reduces the profit earned from growing corn. This result can lead to solutions to reduce the risk aversion of farmers.

Participating in local mass organizations will help farmers share and learn information and experiences in production and business. Grasping more information about production and the market helps farmers better cope with risks and thereby use inputs more appropriately.

Participating in technical training helps farmers reduce their risk-averse attitude. When farmers participate in training, farmers will improve their technical skills in selecting production inputs, and applying advanced technologies to bring about more efficiency.

The government needs to research and build a pilot agricultural insurance service model on corn. Insurance services reduce uncertainty in production and thereby help farmers choose to use inputs more effectively.

Conclusion

By applying the Grossman-Eckel experimental method associated with the CPRA utility function to measure the attitude towards risks of farmers growing hybrid maize in the Mekong Delta, we find that most farmers are risk-averse. In particular, the proportion of risk-averse farmers is estimated at 69% while that of the risk-loving ones accounts for only 11%. In addition, the results show that the most of inputs used are not at the optimal level. In particular, inputs purchased from outside were used closer to the optimal level for the group of “Risk neutral” households compare with groups of households having attitudes toward risk other. However, the farmer’s labor input was used over more than optimal inputs level, and closer to optimal inputs level corresponding with attitude toward risk-loving increases.

Although many studies showed that the risk aversion of households could lead to the ability to allocate resources to use inputs less than optimal input use. However, the results of the study did not show a significant difference in the optimal use of inputs among three groups of farmer's attitudes towards risk. The cause of this problem may be an unsatisfactory sample size, which leads to a large standard error of the estimate. Therefore, the authors propose that the study should be conducted on a greater sample size and larger scope of research area, which will be able to give more significantly the results.

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Track 4

Natural resource and nature positive system transformation



Study on Marketable Rice Varieties, Strength, Weakness of Rice Marketing and Value Added Products in Nay Pyi Taw Union Territory, Myanmar

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Abstract

Agri-processing and value addition are expanding recently, focusing on rice value added products based on the diversification of rice varieties. This study aimed to explore information about marketable rice varieties and commonly used rice varieties for marketed snacks and noodle in four markets, Nay Pyi Taw. Based on the findings, the top five marketed rice varieties were Manawthukha, Shwebo Pawsan, Pyapon Pawsan, Machando, and Ayeyar Padaethar in Nay Pyi Taw. Among the strengths of rice market, the major strength was the high demand for quality rice (88.67%), while the major weakness was price fluctuation (66.04%). Approximately 42.86% of the samples used two types of rice varieties, including Pawsan and Manawthukha, Pawsan and Pawsanhmwe, Manawthukha and Sticky rice, Machando and Sticky rice for rice snacks. Mostly, sample rice noodle mills used one type of rice variety such as Manawthukha, Byawt Tun and Byawt Thukha for rice noodles. According to the results, head rice and aged rice types were mainly used for rice snacks and rice noodle. Popular marketed rice varieties and commonly used rice varieties for snacks and noodle will be useful for farmer's decision making in the selection of rice varieties to grow. Moreover, information about rice varieties will be useful for rice breeding programs and distribution strategies as the demand driven plan formulation for the future research of rice industry in Myanmar.

Keywords: Marketable rice varieties, Strength, Type of rice, Value-added products, Weakness

JEL code: D01, L66, M12, O12

SDG goals: Zero Hunger; Industry, Innovation, and Infrastructure; Responsible Consumption and Production; Partnerships for the Goals

Introduction

The economy of Myanmar depends largely on agricultural sector. The sector includes crops, livestock and fishery sub-sectors which contribute 23.7% of GDP and 35.1% of total export earnings. In 2021-2022, a total of over 7.05 million hectares of paddy was cultivated and over 0.88 million metric tons of rice was exported (MOALI, 2022, p.16). During 2011-2012, the total sown area of rice was 7.59 million hectares and the total sown area of rice increased steadily starting in 2012-2013. The average yield of rice was increasing from 3.83 MT/ha to 3.97 MT/ha during the period of 2011-2012 to 2015-2016 (MOALI, 2021, p. 18). Ayeyarwaddy, Bago, Sagaing and Yangon Regions, Shan State are the largest growing areas for paddy in 2021-2022 (MOALI, 2022, p. 6). In 2021-2022, total rice sown area was 80,392 ha and in which mostly grown paddy varieties were Manawthukha, Sinthukha, Thai Hnankauk, Ayeyarmin, GW-11 at Nay Pyi Taw (DOA, 2023). In Nay Pyi Taw, the most common production of rice varieties in monsoon season were Sinthukha (67,294 ton/year),



Manawthukha (36,101 ton/year), Superhnankauk (4,744 ton/year), Ayeyarmin (2,534 ton/year) and GW-11 (582 ton/year). The most production of rice varieties in summer season were Superhnankauk (14,553 ton/year), Thai Hnankauk (4,575 ton/year), Sinthukha (2,470 ton/year), Palethwe (507 ton/year), GW-11 (462 ton/year) and Manawthukha (126 ton/year) (MOALI, 2022, p. 19). In 2023, Shwebo Pawsan and Ayeyarmin rice varieties of price have got highest price and then Manawthukha and Sinthukha have got lowest price in the markets (DOA, 2023, p. 13). According to the secondary data, there were different type of sowing rice varieties and selling in the market. It was one of the crucial points to find out the marketed rice varieties and problems of rice sellers in the local market. In the rice market, Sumimpex (2024) stated that inadequate transportation systems and storage facilities present challenges for Myanmar's rice industry. Addressing these infrastructure limitations is crucial to ensuring efficient supply chain management, preserving the quality of rice exports, and meeting timely delivery demands in the global market. In addition, price fluctuation of rice is one of the issues for buyers and seller's current duration due to high cost of production and transportation. This condition connected the changes of the rice market's growth and demand. Theingi Myint (2007) described that minimal price fluctuation support to maintain an economic stability. Therefore, the diversification of rice varieties in the market needs to identify potential demand and marketable rice varieties.

Nowadays, rice based traditional snacks are widely made by small local businesses in different regions. Rice can be processed into snacks, rice noodles, rice bread and other traditional foods (Joseph et al., 2020, p. 85). According to the literature findings, sticky rice is commonly used in different types of rice snacks throughout Southeast and East Asia (Kime & Tom, 2008, p. 1). In Myanmar, the lower amylose (sticky) rice varieties were mainly used to make various rice snacks such as Khaw-poke and Mont-poung in Shan State (Nang Shwe Yamin Oo & Aung Ko Ko, 2020, p. 46). Also, sticky rice such as Shinsun (Japonica) and Hangang and non-sticky rice such as Dongjin (Japonica) and Samgang (Indica) used for rice snacks (Shin and Dong, 1989, p. 824).

In this research paper, exploring of rice varieties can identify the potential demand such as the marketable rice varieties and by-products in the market. Marketable rice varieties were Pawsan, Ayeyarmin, Manawthukha and Sinthukha in Nay Pyi Taw (DOA, 2023, p.13). In Myanmar, the most popular consumed and preferred rice varieties were Pawsan, Ayeyarmin and Manawthukha rice varieties (Theingi Myint et al., 2016, p. 14). Product quality and consumer preferences were different depend on the use of rice varieties (Marie et al., 2019, p. 2). And also, textural, cooking and sensory properties depend upon the rice flour obtained from different rice varieties (Xiao Fu, 2008, p. 15). In the meantime, it is need to explore the information about the marketable rice varieties and commonly used of rice varieties for value added products in selected markets. Under these circumstances, the following research questions were raised (1) what are the marketed rice varieties in the selected local markets and (2) what are the strengths and weaknesses of rice marketing, Nay Pyi Taw Union Territory? and (3) what are commonly used of rice varieties and types of rice are used for making rice snacks and rice noodle?

Therefore, the specific objectives are to study the marketable rice varieties and buying sources of rice, to identify the strengths and weaknesses of rice marketing and to investigate the ratio and types of rice and rice varieties used for rice snacks and rice noodle in the selected markets, Nay Pyi Taw Union Territory.

Methodology

The study was carried out in four selected markets in the Nay Pyi Taw Union Territory: Ahayathukha market (Kin Mon Tan village, Pyinmana Township), Thapyaygone market (Zaputhiri Township), Myo Ma market (Ottarathiri Township), and Pobba market (Pobbathiri Township). A field survey was conducted in the selected markets and rice noodle mills at the study area during September and October 2023. Personal interviews were used with the stratified random sampling procedure (Dan, 2023, para. 3). Total sample size was 94 respondents, including 53 rice wholesalers and retailers, 31 rice snack sellers from four selected markets. Additionally, there were 10 rice noodle mills from Pyinmana Township. The collected information were marketable rice varieties, pricing details, sources and origins of rice, strengths and weaknesses of rice marketing by responses of rice wholesalers and retailers. Collected data for rice snack sellers encompassed details on the items sold, use of rice varieties for snacks, types of rice used, the most commonly used rice varieties. Regarding the selected rice noodle mills, the collected data included information about the use of rice varieties and types of rice for rice noodles.

Descriptive analysis

Both quantitative and qualitative data were initially collected and then compiled using the Microsoft Excel program. Descriptive analysis, a component of numerical methodology, was employed, utilizing measures such as frequency, percentage, average, minimum, and maximum to explore various aspects including selling rice varieties and prices, buying sources and origin of rice, strengths and weaknesses of rice marketing, items related to rice snacks, use of rice varieties and types of rice for snacks, the most commonly used rice varieties and use of rice varieties and types of rice for rice noodles. The findings were presented using tables, graphs and charts.

Results and discussion

Grouping of selling rice varieties and buying sources of rice varieties

In the study markets, the selling of rice varieties by sample rice wholesalers and retailers was categorized into three groups as shown in (Figure 1). Approximately 73% of the sample were selling between five and ten rice varieties, while about 18% were selling between eleven and fifteen rice varieties. Additionally, approximately 7% of the sample were selling fewer than five rice varieties.

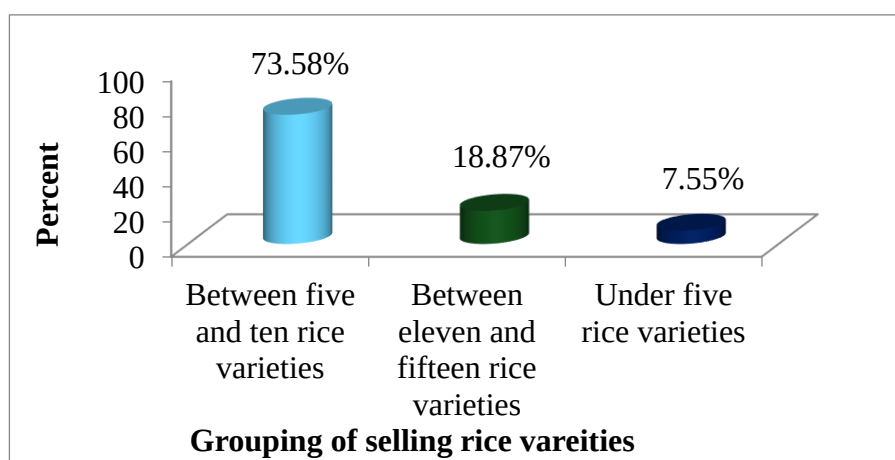


Figure 1. Grouping of selling rice varieties (n=53)

Source: Own survey, 2023

The buying sources of marketable rice varieties are detailed in Figure (2 and 3). Based on the response of the sample rice wholesalers and retailers, the majority of respondents (83.02%) mainly bought rice from rice wholesalers and respondents (28.30%) bought rice from rice millers. Major buying sources of rice were Nay Pyi Taw and Yangon Region with (29.79%) and Sagaing Region (23%) was second highest buying source of rice.

Mainly bought rice varieties by sample rice wholesalers and retailers from Nay Pyi Taw which were Manawthukha (77%), Palethwe (71%), Thai Hnankauk (60%), Ayeyar Pawsan (47%), Ayeyarwaddy Pawsan (37%) rice varieties presented in (Figure 4).

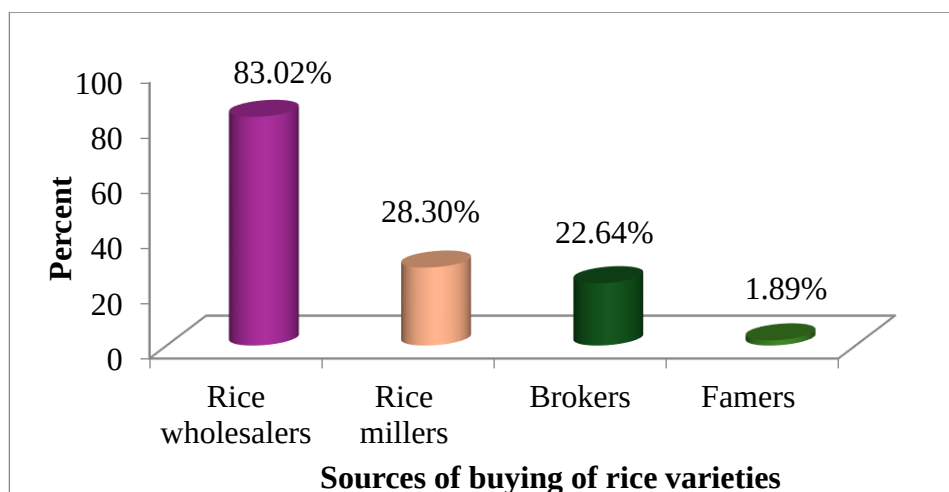


Figure 2. Buying sources of rice of respondents (n= 53)

Source: Own survey, 2023

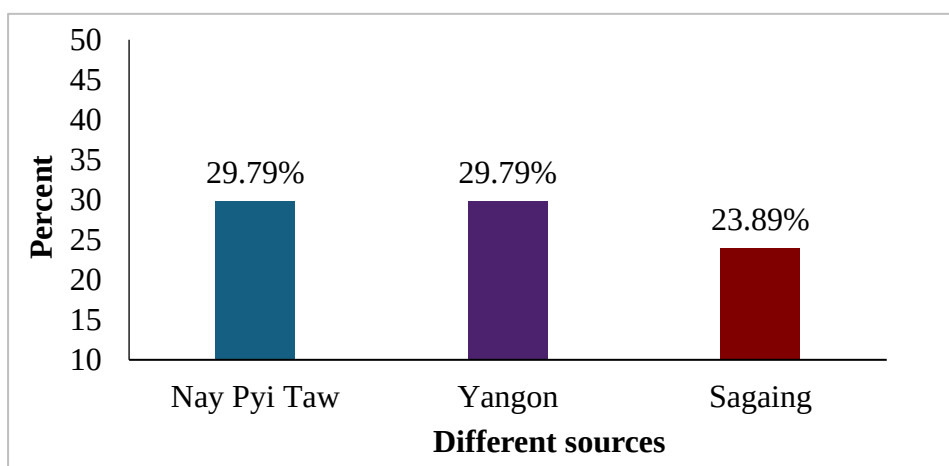


Figure 3. Different buying sources of rice (n= 53)

Source: Own survey, 2023

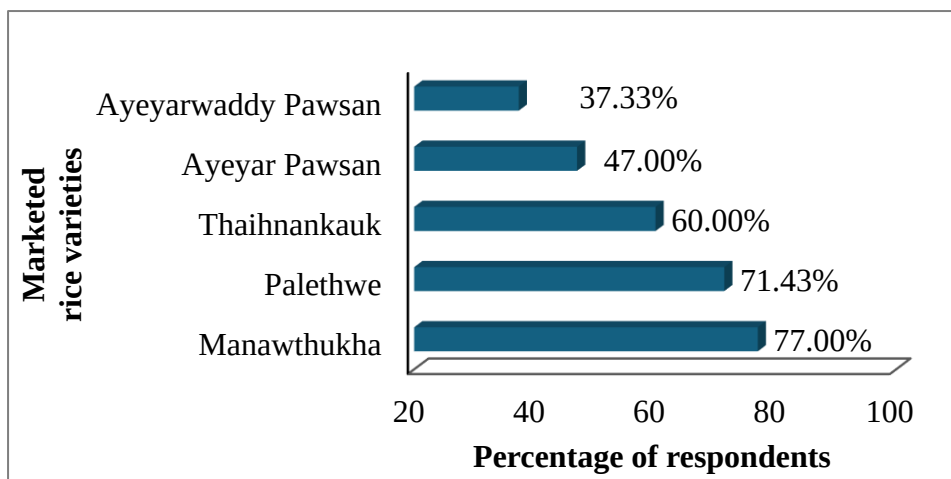


Figure 4. Selected marketed rice varieties from Nay Pyi Taw

Source: Own survey, 2023

Top 20 marketed rice varieties in Nay Pyi Taw

According to the findings, the following rice varieties were marketed: Manawthukha, Shwebo Pawsan, Pyapon Pawsan, Machando, Ayeyar Padaethar, 90-Days, Thai Hnankauk, Sticky rice, Zeera, Ayeyarmin, Pawsan, Theingi Pawsan, Sinthwelatt, Sinthwe, Ayeyarwaddy Pawsan, Shwebo Ayeyarmin, Myaungmya Pawsan, Ayeyar Pawsan, Palethwe, Pathein and Pawsan. In addition, the top five rice varieties can be selected according to different types and regions based on the group sold in the markets, which are Manawthukha (92.45%), Shwebo Pawsan (62.26%), Pyapon Pawsan (47.17%), Machando (47.17%) and Ayeyar Padaethar (43.40%). The detailed average selling prices of the top 20 marketed rice varieties are described in Appendix 1. According to the (DOA, 2023, p. 13) described that Shwebo Pawsan, Ayeyarmin, Manawthukha and Sinthukha are the most marketed rice varieties which are mostly the same findings in the study.

Strengths and weaknesses of rice marketing

The strengths of sample rice wholesalers and retailers in rice marketing were high demand of quality rice (88.67%), easily accessible in the markets (60.38%), suitable for rice storing (18.87%), gain the profit (5.66%) and getting guarantee for rice quality (3.77%) as showed in (Figure 5). Therefore, the major strengths of sample rice wholesalers and retailers answered that high demand of quality rice and easily accessible in the markets.

The weaknesses of sample rice wholesalers and retailers in rice marketing were price fluctuation (66.04%), limited rice transaction (62.26%), storage losses (32.08%), obtaining a lower profit (18.87%), high transportation costs (7.55%), advance payment of rice (1.89%) and labour scarcity (1.89%) as illustrated in (Figure 6). Therefore, the majority of samples mentioned that price fluctuation and limited rice transactions were the weaknesses of rice marketing by sample rice wholesalers and retailers.

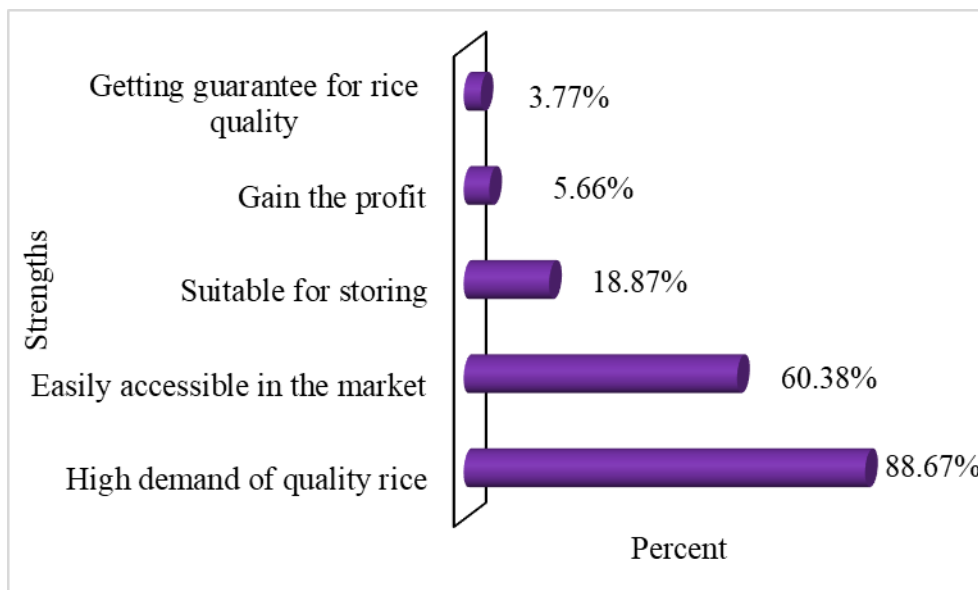


Figure 5. Strength of rice marketing by sample rice wholesalers and retailers (n=53)
Source: Own survey, 2023

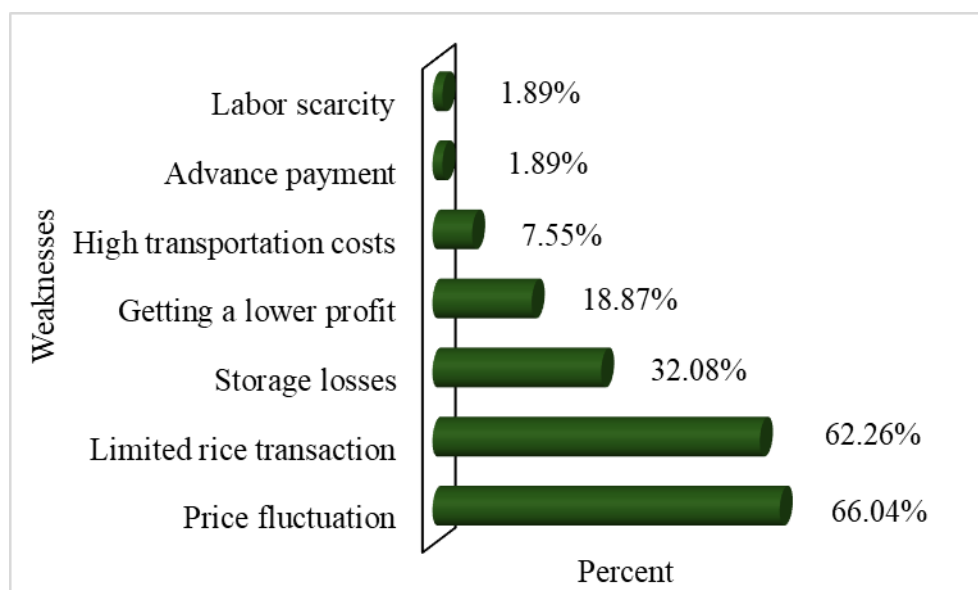


Figure 6. Weakness of rice marketing by sample rice wholesalers and retailers (n=53)
Source: Own survey, 2023

Grouping of selling items of rice snacks by sample rice snack sellers

According to result finding, there were three groups based on selling types of rice snacks. In which approximately 61% of the sample rice snack sellers were selling fewer than three items of rice snacks about 22% were selling exactly three items. The remaining 16% of sample rice snack sellers sold between four and five items of rice snacks. Consequently, the majority of sample rice snack sellers mainly sold fewer than three items of rice snacks.

Use of rice varieties and types of rice for rice snacks

In selected markets, the sample rice snack sellers were categorized into five groups based on the number of rice varieties were sold (Figure 7). Among them, 42.86% of the sample used two types of rice varieties, 32.86% of the sample used only one type, 14.29% of the sample used three types, and nearly 10% of the sample used four types of rice varieties. In which most of the sample used one type of rice variety and two types of rice varieties for rice snacks.

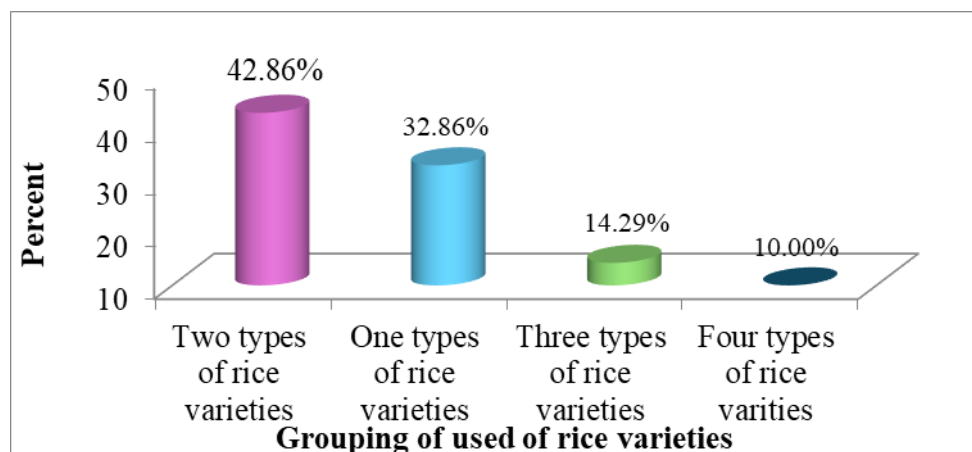


Figure 7. Grouping of use of rice varieties by sample rice snack sellers (n=70)

Source: Own survey, 2023

In one type of rice variety include Sticky rice, Manawthukha, and Pawsan in which Sticky rice was the most popular, with 56.52% of sample rice snack sellers using it (Figure 8). Other rice varieties like Manawthukha and Pawsan were used by a few sample rice snack sellers. Additionally, there were five groups which are including two types of rice varieties. These two types of five groups included Pawsan and Manawthukha, 90-Days and Sticky rice, Pawsan and Pawsanhmwe, Manawthukha and Sticky rice and Machando and Sticky rice varieties. Mainly, approximately 36% of the sample used Pawsan and Manawthukha rice varieties and about 23% of the samples used 90-Days and Sticky rice varieties, for rice snacks (Figure 9). The most commonly used rice varieties for making rice snacks were Sticky rice, Manawthukha, Pawsan, and Machando rice varieties. Most respondents used Sticky rice and Manawthukha rice varieties for making rice snacks. Among different types of rice varieties by sample rice snack sellers, the majority of samples mostly used head rice and aged rice when they produced different types of rice snacks.

In this study, as described in (Figure 10), Sticky rice found the most common use for rice snacks. According to the Nang Shwe Yamin Oo and Aung Ko Ko (2020) mentioned that sticky rice was commonly used for making snacks. As the reported of the author Jehangir et al. (2019) described that both broken and head rice were used for the primary by-products produced and also other co-products of rice processing. Based on the result of this study, sticky rice was used more than non-sticky rice for making rice snacks by the samples in the selected areas. Moreover, head rice type found that it was used more than broken and half-broken rice for snacks by the samples.

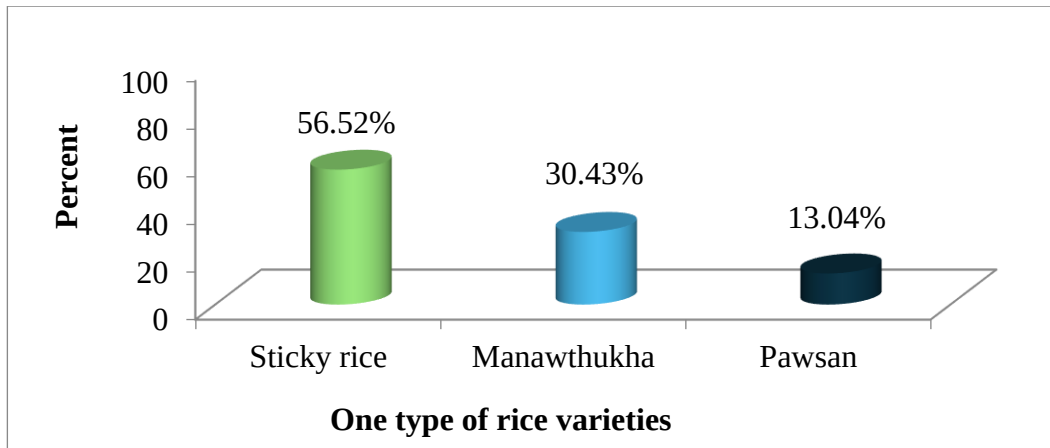


Figure 8. One type of rice variety used in making rice snacks (n=23)

Source: Own survey, 2023

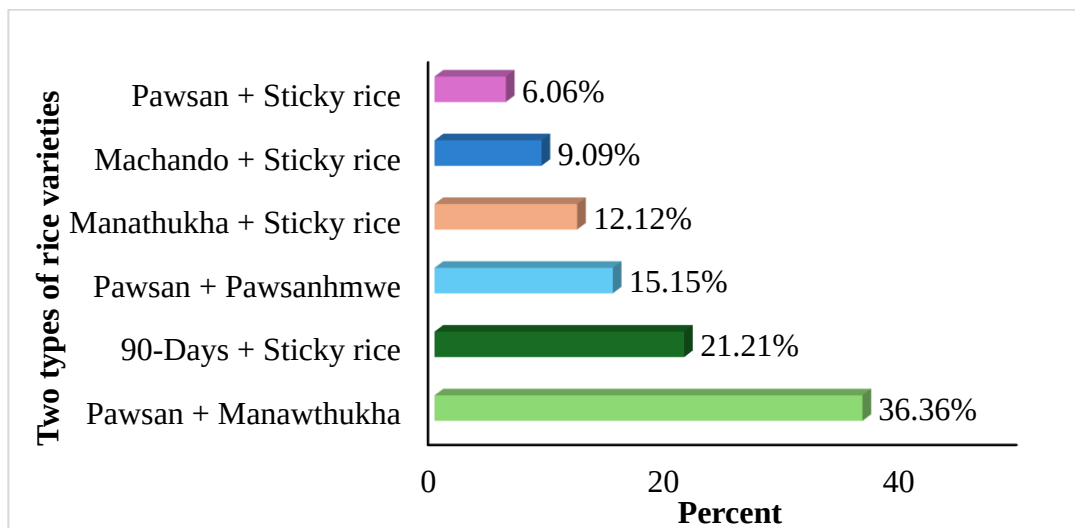


Figure 9. Two types of rice varieties used in making rice snacks (n=30)

Source: Own survey, 2023

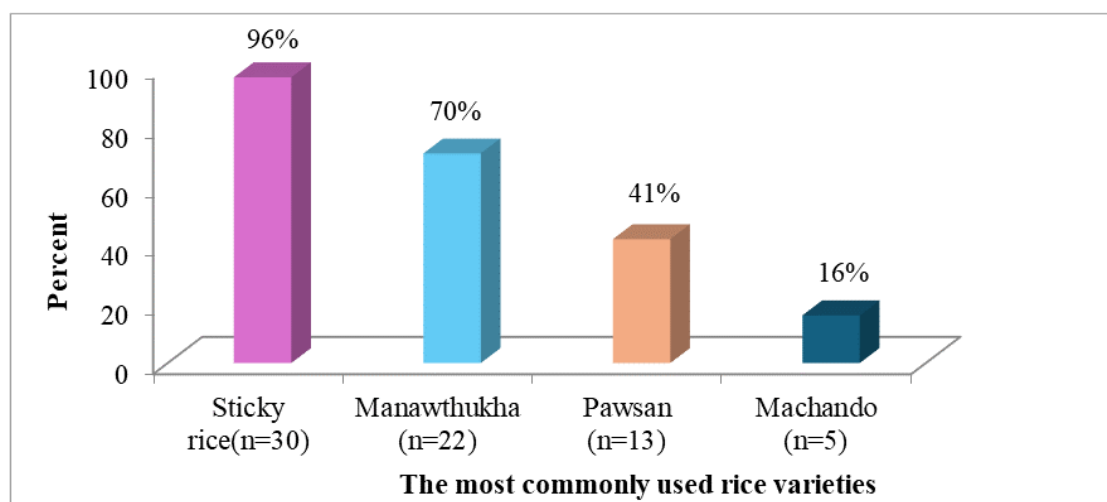


Figure 10. Most commonly used four rice varieties for rice snacks (n=31)

Source: Own survey, 2023

Grouping of use of rice varieties and types of rice varieties for rice noodle

There were two groups of the use of rice varieties: one type of rice variety and two types of rice varieties, as shown in (Figure 11). The results indicated that, for one type of rice variety, Manawthukha (70%), Byawt Tun (10%), and Byawt Thukha (10%) rice varieties were used. Additionally, Manawthukha and Machando rice varieties were utilized, with about 10% of the sample using only these two types for rice noodle. According to the results of Wood and Rebecca Theurer (2019), rice noodle is often made from non-sticky rice. According to the results of Bienvenido & Alistair (2009), high-amylose content rice (the rice grains cook dry and become hard upon cooling) was used in rice noodles. Based on the result, non-sticky rice found that it was used more than sticky rice for making rice noodle by the samples in the selected areas.

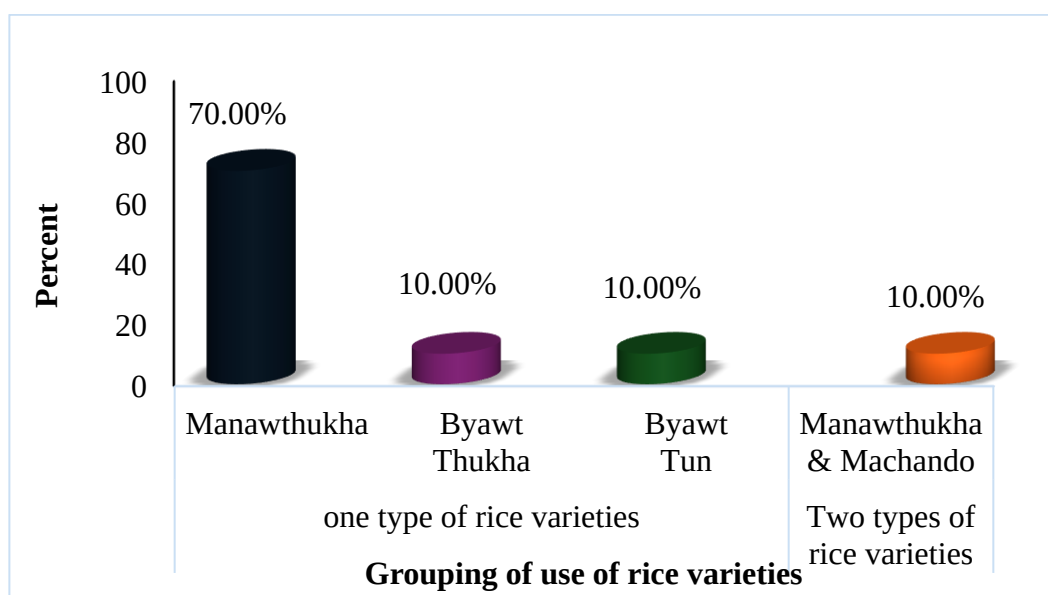


Figure 11. Grouping of used of rice varieties by sample rice noodle mills (n=10)

Source: Own survey, 2023

Conclusion

The marketable rice varieties diversified in different names and prices in the selected areas. According to the findings, the top five marketed rice varieties in the study areas were Manawthukha, Shwebo Pawsan, Pyapon Pawsan, Machando, and Ayeyar Padaethar. Manawthukha, Palethwe, Thai Hnankauk and Ayeyarwaddy Pawsan rice varieties were mainly purchased from Nay Pyi Taw. The major strengths of rice marketing were the high demand for quality rice and easily accessible in the markets, while the main weaknesses were price fluctuations and limited rice transaction. According to the results for rice snacks, there were two types of rice varieties, including different mixed rice varieties such as Pawsan and Manawthukha, 90-Days and Sticky rice, Manawthukha and Sticky rice and Machando and Sticky rice varieties used for rice snacks. The analysis revealed that the most commonly used rice variety for rice snacks was Sticky rice. Based on the results for rice noodle, the majority of sample rice noodle mills used only one type of rice variety, including Manawthukha, Byawt Thukha, and Byawt Tun rice varieties.

Mostly, head and aged rice were used not only for rice snacks but also for rice noodles. It can be concluded that the Manawthukha rice variety was the most commonly used for rice noodle. Therefore, the popular marketed rice varieties and commonly used rice varieties for snacks



and noodles will be useful for farmers' decision-making in the selection of rice varieties to grow. Moreover, information about rice varieties will be useful for rice breeding programs and distribution strategies as the demand-driven plan formulation for the future research of the rice industry in Myanmar.

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Appendix

Appendix 1 Top 20 marketed rice varieties ratio and price of rice (n=53)

No.	Marketed rice varieties*	Ratio of marketed rice varieties	Price (US\$/kg)		
			Average	Maximum	Minimum
1	Manawthukha	92.45	0.79	0.92	0.65
2	Shwebo Pawsan	62.26	1.39	1.46	1.31
3	Pyapon Pawsan	47.17	1.13	1.30	0.93
4	Machando	47.17	0.95	1.12	0.84
5	Ayeyar Padaethar	43.40	1.12	1.23	1.07
6	90-Days	39.62	0.79	0.83	0.77
7	Thaihnankauk	37.74	0.64	0.72	0.61
8	Sticky rice	33.96	1.05	1.12	0.98
9	Zeera	32.08	0.74	0.83	0.65
10	Ayeyarmin	30.19	1.42	1.55	1.32
11	Pawsan	28.30	1.25	1.48	1.01
12	Theingi Pawsan	26.42	1.42	1.52	1.34
13	Sinthwelatt	24.53	0.84	1.08	0.78
14	Sinthwe	18.87	0.81	0.90	0.72
15	Ayeyarwaddy Pawsan	16.98	1.15	1.27	1.10
16	Shwebo Ayeyarmin	16.98	1.32	1.36	1.27
17	Myaung Mya Pawsan	15.09	1.18	1.27	1.10
18	Ayeyar Pawsan	15.09	1.13	1.34	0.97



No.	Marketed rice varieties*	Ratio of marketed rice varieties	Price (US\$/kg)		
			Average	Maximum	Minimum
19	Palethwe	13.21	0.64	0.72	0.60
20	Pathein Pawsan	11.32	1.06	1.14	0.95

Source: Own Survey, 2023

Note: 1 bag (24 pyi) of rice= 51kg, US\$ to Myanmar Kyats-2100 (Date - 11.1.2023)

* describe- the names of these marketed rice varieties are the common names used in the market.



The Impact of Climate Change on Indonesian Rice and Coffee Sectors

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Abstract

Rice and coffee are strategic agricultural commodities in Indonesia. Rice is Indonesian main staple food and coffee is globally traded commodity that grown by Indonesian smallholders. There is growing concern regarding its production that sensitive to the change of temperature, rainfall and humidity. Therefore, it is important to conduct a study on the impact of climate change on rice and coffee production in Indonesia. The objective of the study is to assess the impacts of climate change on Indonesian macroeconomic performance and sectoral output. This paper using Computable General Equilibrium model with three simulations of productivity change under two climate scenarios of RCP 4.5 and RCP 8.5. Climate change that reduces rice and coffee productivity affects Indonesia's macroeconomic performance. Climate change will reduce real GDP, real household consumption and exports. On the other hand, climate change will increase Indonesia's imports. Changes in macroeconomic performance in all scenarios of RCP 8.5 are worse than scenario 4.5. It is identified that climate change poses a negative risk to the quantity and quality of rice and coffee output and has a spiraling impact on increasing domestic prices, hence decrease the competitiveness. Climate change also contributed to reducing real income of households particularly for agricultural workers, agricultural entrepreneurs and low-income households in urban areas. Government climate change adaptation policies for rice and coffee are very important to overcome the decline in productivity and production. In addition, government should develop financial support and risk management system targeted towards vulnerable groups affected by climate change.

Keywords: climate change, yield, production, CGE

JEL code: Q10, Q54, Q59

SDG goals: Climate Action, Zero Hunger, No Poverty

Introduction

According to the latest IPCC (Intergovernmental Panel Climate Change) report, climate change over the past 30 years has reduced global agricultural production in the range of 1-5% per global decade, with particularly negative effects for tropical cereal crops such as maize and rice (Porter et al, 2014). Challinor et al (2014) say that at low levels of warming (+2^oC), agricultural productivity is likely to decline worldwide, but particularly in the tropics.

Demand for agricultural commodities is increasing along with population growth. This needs to be balanced by increased production of agricultural commodities as well. However, in the cultivation of agricultural commodities, there are challenges that need to be addressed, especially with regard to environmental conditions that are also changing. Environmental conditions are one of the factors that determine success in the development of agricultural business cultivation. Suitable climatic, soil and biophysical conditions need to be analyzed as a basis for developing crop commodities in an area (Sarkar et al. 2014; Bonfante et al. 2018). The mismatch of these environmental conditions with plant growth requirements will have an impact on the low productivity of agricultural commodities.

Land suitability for agricultural commodity cropping areas is determined by soil typology, climatic and biophysical conditions. Fertile soil with sufficient nutrient content is an ideal area



for planting. Ideal climatic conditions are also required so that extreme climatic stresses do not result in reduced production or crop failure. In food crops such as rice, the availability of water, especially from rain, is an important factor. Long drought stress in rice plants results in crop failure (Zhong et al., 2010; Estiningtyas et al, 2012). In plantation crops such as coffee, suitable temperature and rainfall conditions determine the ideal cultivation location (Camargo, 2010; Davis et al., 2012).

Another challenge facing the agricultural sector is climate change, which has an impact on economic value. Some of the studies below look at the impact of climate change on the economic value of rice and coffee, both in terms of production and increased rice prices. For example, research conducted by Jati (2018) analyzed the effects of the rainy and dry seasons on rice prices. The data used were daily rice stocks and prices from January 29, 2014 to January 29, 2018. The ARMA (0,1)-ARCH (1) model with a dummy variable, namely the dry season, significantly affects the conditional variance of rice prices more than the rainy season dummy variable. Stakeholders need to pay more attention to rice price fluctuations, especially when the dry season dummy variable is significantly more influential than the rainy season dummy variable. Another study conducted by Rum and Sihalo (2017) tried to answer commodity price anomalies based on the level of climate change vulnerability. The results show that the level of climate change vulnerability has an impact on the volatility of rice commodity prices in Indonesia. The results show that the volatility of rice commodity prices is related to the level of regional vulnerability to climate change. Regions vulnerable to climate change tend to have higher price volatility than regions not vulnerable to climate change.

Sadelina (2020) said the impact of climate change is the increase in climate extremes. Climate change creates striking temperature anomalies such as the El Nino and La Nina phenomena or commonly referred to as the ENSO (El Nino Southern Oscillation) phenomenon. The ENSO phenomenon causes fluctuations in rainfall, which has an impact on the agricultural sector, especially the plantation subsector. This study examines the impact of climate change on coffee prices using the static panel data method. The data used in this study are 12 affected provinces with a span of 2010 to 2017. The ENSO phenomenon is shown through rainfall indicators. The results obtained in this study were that El Nino had a significant effect in increasing coffee prices, and was followed by other factors, namely the price of substitute goods (chocolate prices), productivity and Real GRDP. Another study conducted by Bongase (2017) said the increase in temperature and water shortage will negatively affect the suitability of coffee production in the lowlands and vice versa. It is estimated that in the future the impact of climate change on coffee production will not only be a threat to small-scale farmers but also all coffee industry players including consumers. In this scenario, coffee production will also tend to decline globally, particularly in Africa. Coffee prices vary inversely with changes in production and cause the largest price increases. Only half of the area currently available for coffee production in 2050. 2.5 times the current area will be needed to meet future demands. Declining yields and rising prices will evidently reduce the coffee market by more than 5 million tons per year. As a result, many researchers believe that the area suitable for coffee production will decrease by 16% by 2050, especially for arabica coffee.

Studies on the impact of climate change on rice and coffee production that have been conducted previously generally only focus on the impact on production and prices of these commodities. However, both agricultural commodities have an important role in food security and exports, so it is urgent to analyze the impact of climate change on macroeconomic and sectoral performance. Therefore, the objectives of this study are:



1. Analyze the impact of climate change on rice and coffee commodities on Indonesia's macroeconomic performance.
2. Analyzing the impact of climate change on rice and coffee commodities on Indonesia's sectoral performance
3. Analyzing the impact of climate change on rice and coffee commodities on Indonesia's households' welfare

Methodology

The model used to answer the objective of research on the impact of climate change on Indonesia's economic performance uses the latest version of Wayang and INDOF (Warr et al. 1998; Wittwer 1999; Warr 2005; Oktaviani 2010). This model as a reference is built based on the 2016 Indonesian Input-Output Table and the SAM Table which was officially published by the Central Statistics Agency. The basic data disaggregation constructed includes the disaggregation of households, industries, and commodities. Microeconomic behavior is assumed to be in a state of maximizing profit for each producer, as well as maximizing utility for consumers. In the simulations carried out in this study, the final product market, intermediate products, and production factors are assumed to be in equilibrium and determined endogenously in the model. However, variations of these assumptions are possible by modifying the closure.

Model Theoretical Structure

Theoretically, the structure of the model used is relatively conventional with the form of a linear economic model in proportional change, which is often referred to as the Johansen Model. The analytical structure of the model used includes important components, such as:

- Demand for household consumption of agricultural commodities for each type in 10 household groups.
- A factor demand system, based on CES production technology assumptions, which relates to the demand for each primary factor of production.
- There are differences between educated and uneducated workers in sectoral production functions.
- Leontief's assumption for intermediate goods. Each intermediate is assumed to be demanded at a fixed proportion of gross output in each sector.
- Sources of domestic and imported demand in each production activity have integrated the Armington elasticity principle of substitution.

Model Empirical Review

- Industry
The national model covers 185 sectors with a reporting focus on the rice and rice sectors
- Commodity
This model includes two types of commodities, namely producer and consumer goods. Producer goods come from domestic and imported sources. All 185 producer goods in principle have the opportunity to be imported.
- Factors of Production
The mobility of factors of production is critical in the general equilibrium economic model system, where the term mobility is more accurately defined here as activity mobility between industries rather than geography. The greater the mobility factor, the better the model's capacity to simulate the response of an economy related to economic changes.



- **Model Scope: Time Dimension**
The model used in this study is operated in a long run mode related to the mobility of production factors.

Equation System

The theoretical structure in the CGE model usually consists of a system of equations that describes the demand for labor, demand for production factors, demand for intermediate inputs, demand for combinations of factor inputs and intermediate inputs, demand for combinations of output, demand for investment goods, household demand, exports and demand. other end, margin demand, selling price, market balance, indirect taxes, GDP receipts and expenditures, trade balance, rate of return on capital, investment and capital accumulation and debt accumulation. The general specifications of the CGE model include 14 blocks, namely:

- labor demand
- primary factor demand
- input demand between
- composite demand for primary factors and intermediate inputs
- Commodity composite of the output of an industry
- demand for investment goods
- household demand
- export and other final request
- margin request
- Price at buyer level
- market balance
- indirect tax
- GDP in terms of income and expenditure
- trade balance and other aggregation

Each production process, each industry can produce several commodities. The sectors use primary factors and intermediate inputs. Any intermediate inputs can be obtained from both the domestic and import markets. The primary factors used are labor, land and capital. Some basic assumptions that must be considered are: (1) separation between input and output (separable), (2) tiered stages and (3) hierarchical structure based on constant elasticity of substitution (transformation). From the production structure, it can be derived directly regarding the demand for primary factors and intermediate inputs. Primary factor demand is determined based on the production function while the intermediate input demand is proportional to a type of output.

Closure of the CGE Model

Closure is the classification of the variables contained in the CGE model into endogenous and exogenous variables. Endogenous variables are variables whose values will be determined (to solve problems), while exogenous variables are variables whose values are determined outside the model. With this grouping, simulation scenarios of the impact of a policy can be carried out through a shock to exogenous variables in accordance with the desired objectives of the simulation for prediction purposes or long-run analysis.

Policy Simulation

Shock simulation of climate change in the long term (2021-2100) defined in the study uses a productivity decrease for coffee and rice commodities. There are three simulations used,



namely: (i) The decline in productivity of rice and coffee based on the median value of the median shock of decreasing productivity in all districts; (ii) The decline in productivity of rice and coffee based on the minimum value of the median shock of decreasing productivity in all districts; (iii) The decline in productivity of rice and coffee is based on the average value of the median shock of decreasing productivity in all districts. In each simulation, there are two assumptions of future climate projection scenarios that are compared, namely: (a) RCP 4.5 which results in a decrease in air temperature and an increase in rainfall and (b) RCP 8.5 tends to decrease rainfall and increase temperature. In general, it can be identified that the magnitude of the decrease in rice productivity of RCP 8.5 is more significant than that of RCP 4.5.

Table 1. Justification of the Shock

The Median Value of the median shock all off the districts levels in Indonesia					
Scenario 1		Productivity	2021-2050	2051-2080	2081-2100
	Paddy	4.5	-1.53%	-2.89%	-3.35%
		8.5	-1.95%	-4.75%	-7.50%
	Arabica	4.5	-12.03%	-25.43%	-29.71%
		8.5	-15.12%	-39.51%	-63.18%
	Robusta	4.5	1.09%	0.76%	0.71%
		8.5	0.93%	-0.58%	-2.66%
The Median Value of all off the districts levels median values in Indonesia					
Scenario 2		Productivity	2021-2050	2051-2080	2081-2100
	Paddy	4.5	-19.72%	-23.00%	-21.20%
		8.5	-20.39%	-45.11%	-34.93%
	Arabica	4.5	-100.00%	-100.00%	-100.00%
		8.5	-100.00%	-100.00%	-100.00%
	Robusta	4.5	-25.39%	-34.33%	-39.14%
		8.5	-46.69%	-51.67%	-68.59%
The Average value of the median shock all off the districts in Indonesia					
Scenario 3		Productivity	2021-2050	2051-2080	2081-2100
	Paddy	4.5	-1.18%	-2.55%	-3.07%
		8.5	-1.42%	-4.36%	-7.20%
	Arabica	4.5	-13.59%	-25.54%	-30.11%
		8.5	-16.15%	-40.79%	-60.61%
	Robusta	4.5	2.26%	2.00%	2.12%
		8.5	2.30%	0.89%	-1.39%

Source: Authors Calculation

Results and discussion

The Impact of Climate Change on Rice and Coffee Commodities on Indonesia's Macroeconomic Performance

Climate change affects changes in the productivity of rice and coffee commodities and will affect Indonesia's macroeconomic performance in the future. Table 3 shows that macroeconomic performance due to climate change is seen from changes in several macroeconomic indicators, namely the Consumer Price index, real Gross Domestic Product (real GDP), consumption, and trade.

Based on Table 3, the overall simulation scheme reduces Indonesia's real Gross Domestic Product (GDP). From the production side, the decline in real GDP was due to a decrease in rice



and coffee production due to climate change, ranging from -.2-0.51% at RCP 4.5 and 0.3-0.85% at RCP 8.5. When viewed from the expenditure side, the decline in real GDP was due to a decline in household consumption and exports. The decrease in real GDP in simulation 2 was the highest compared to other simulations considering that there was a higher decline in productivity for rice (especially). This indicates the urgency of climate adaptation to address the negative impacts of climate change on Indonesia's national income in the future.

The decline in rice production due to climate change will affect the supply of these commodities in Indonesia. The decrease in supply of the commodity will increase the price of the commodity. The increase in the prices of commodities will cause cost push inflation where inflation. The increase in inflation (Consumer Price Index) due to climate change ranged .01-0.18% at RCP 4.5 and 0.1-0.41% at RCP 8.5. The increase in inflation in simulation 2 is the largest of the other simulations at 0.14-0.41%. The increase in inflation in simulation 2 representing RCP 8.5 scenario is the largest compared to other simulations.

Table 3. Impacts of Climate Changes in Rice and Coffee Sector on Indonesian Macroeconomic Condition

Description			Consumer price index	Real GDP from expenditure side	Export volume index	Real household consumption	Import volume index
Scenario 1	4.5	2021-2050	0.02	-0.03	-0.02	-0.06	0.01
		2051-2080	0.03	-0.06	-0.05	-0.12	0.02
		2081-2100	0.03	-0.07	-0.06	-0.14	0.02
	8.5	2021-2050	0.02	-0.04	-0.03	-0.08	0.01
		2051-2080	0.04	-0.10	-0.08	-0.21	0.02
		2081-2100	0.06	-0.17	-0.14	-0.34	0.03
	4.5	2021-2050	0.16	-0.45	-0.37	-0.90	0.08
		2051-2080	0.18	-0.53	-0.43	-1.06	0.09
		2081-2100	0.16	-0.51	-0.42	-1.01	0.07
Scenario 2	8.5	2021-2050	0.14	-0.51	-0.42	-1.01	0.05
		2051-2080	0.41	-0.95	-0.77	-1.93	0.24
		2081-2100	0.27	-0.81	-0.67	-1.63	0.13
	4.5	2021-2050	0.01	-0.02	-0.02	-0.04	0.01
		2051-2080	0.02	-0.05	-0.04	-0.11	0.01
		2081-2100	0.03	-0.06	-0.05	-0.13	0.02
	4.5	2021-2050	0.01	-0.02	-0.02	-0.04	0.01
		2051-2080	0.02	-0.05	-0.04	-0.11	0.01
		2081-2100	0.03	-0.06	-0.05	-0.13	0.02
Scenario 3	4.5	2021-2050	0.01	-0.02	-0.02	-0.04	0.01
		2051-2080	0.02	-0.05	-0.04	-0.11	0.01
		2081-2100	0.03	-0.06	-0.05	-0.13	0.02



Description		Consumer price index	Real GDP from expenditure side	Export volume index	Real household consumption	Import volume index
8.5	2021-2050	0.01	-0.03	-0.02	-0.06	0.01
	2051-2080	0.04	-0.09	-0.08	-0.19	0.02
	2081-2100	0.06	-0.16	-0.13	-0.32	0.03

Source: Authors Calculation

In line with the decline in national income, household real consumption also decreased. The decrease in real household consumption occurred in all What needs attention is the decline in Indonesia's trade performance in the future due to climate change. The decline in rice productivity due to climate change affects Indonesia's competitiveness in the international market. Malahayati et al. (2021) show that Indonesia's current export performance is still dependent on non-oil and gas commodities, especially plantation commodities. The decline in exports occurred in all simulations both in RCP 4.5 and RCP 8.5 scenarios. The decrease in exports of coffee commodities is feared to worsen the trade balance because it is accompanied by an increase in imports. The increase in imports occurred in all simulations, ranging from 0.01 to 0.08 percent (RCP 4.5) and 0.01 and 0.24 percent (RCP 8.5), as it is expected to be driven by reducing domestic coffee supply.

The Impact of Climate Change on Rice and Coffee Commodities on its Output, Price and Export

In theory, the impacts of climate change can be classified into two groups, namely biophysical impacts and socio-economic impacts. Biophysical impacts include psychological effects on the quantity and quality of food crops and plantations, changes in the quality and quantity of land and water, increases in weeds and pests, shifts in the impact of spatial and temporal distribution and increases in sea level and sea salinity. The direct and apparent impact of climate variability occur in decline of rice of yield leading towards decreasing output in each scenario. The magnitude of rice production loss was estimated to be more significant in RCP 8.5 scenario and when simulation 2 was applied. It was estimated that the rice production will go down by 6.90 percent during the period 2021-2050, 14.73 percent 2051-2080, and 11.64 percent during the period 2081-2100. This is similar to the previous studes (Naylor, 2001 and Naylor, 2007) as the temperature changes plays a major factor in influencing year-to-year variation in rice output. Our estimates were significantly higher than that of predicted by Oktaviani et al (2011). Oktaviani et al (2011) also assessed the potential impacts of global climate change by linking IMPACT and Indonesian CGE Model-INDOF and showed that the rice production loss in Indonesia reached 2.94 percent by 2030.

Table 3. Impacts of Climate Changes in Rice Sector on Indonesian Rice and Coffee Output

Output	Period	Sim 1		Sim 2		Sim 3	
		Paddy	Coffee	Paddy	Coffee	Paddy	Coffee
4.5	2021-2050	-0.49	-0.40	-6.54	-12.28	-0.38	-0.18
	2051-2080	-0.94	-1.23	-7.64	-14.65	-0.83	-0.91
	2081-2100	-1.09	-1.48	-7.11	-15.78	-1.00	-1.14
8.5	2021-2050	-0.63	-0.62	-6.90	-17.65	-0.45	-0.31



Output	Period	Sim 1		Sim 2		Sim 3	
		Paddy	Coffee	Paddy	Coffee	Paddy	Coffee
	2051-2080	-1.56	-2.36	-14.73	-19.86	-1.43	-2.04
	2081-2100	-2.47	-4.21	-11.64	-23.71	-2.37	-3.74

Source: Authors Calculation

Meanwhile, the risks of climate variability are enormous in coffee sector both for Robusta and Arabica coffee. Our modeling results showed that the potential loss of production will reach 17.65 percent during the period 2021-2050, 19.86 percent 2051-2080, and 23.71 percent during the period 2081-2100 under the simulation 2 and RCP 8.5 scenario. A systematic literature review conducted by Bilen et al (2023) also supports this finding by showing that most of the literatures analyzing the influence of climate change on coffee production were negative. This is mainly because global climate change reduces suitable areas for coffee cultivation, and rising infestations and distribution of insect pests and diseases that reduce coffee berry quality and yield.

The socio-economic impact apart from the decline in production and productivity as well as a decrease in the share of GDP in the agricultural sector is fluctuations in the prices of agricultural products. The decline in agricultural production on the one hand, while on the other hand the consumption of agricultural commodities is increasing, especially food as a result of an increase in population, pushing the prices of agricultural commodities to increase. Busnita, Oktaviani, and Novianti (2017) also support the argument with their study. This study showed that the Indonesia's temperature changes are not only cause surge in rice prices but also the rice price fluctuation or volatility. Using the ARCH-GARCH methods and VECM (Vector Error Correction Model), this study highlighted that changes of the temperature will cause higher fluctuation in rice prices and eventually will stabilized after 60 months.

Table 4. Impacts of Climate Changes in Rice Sector on Indonesian Export and Import

Table 7. Impacts of Climate Changes in Rice Sector on Indonesian Export and Import									
Indicator	Productivity	Period	Sim 1		Sim 2		Sim 3		
			Paddy	Coffee	Paddy	Coffee	Paddy	Coffee	
Export	4.5	2021-2050	-1.19	-0.91	-15.60	-28.20	-0.91	-0.39	
		2051-2080	-2.27	-2.80	-18.20	-33.66	-1.99	-2.07	
		2081-2100	-2.63	-3.38	-16.85	-36.36	-2.40	-2.58	
	8.5	2021-2050	-1.52	-1.40	-16.29	-40.72	-1.10	-0.69	
		2051-2080	-3.74	-5.40	-35.40	-45.34	-3.43	-4.67	
		2081-2100	-5.92	-9.65	-27.69	-54.54	-5.67	-8.58	
	Import	4.5	2021-2050	3.97	2.93	51.84	91.12	3.05	1.25
			2051-2080	7.54	9.04	60.50	108.76	6.64	6.66
2081-2100			8.75	10.89	55.98	117.52	7.99	8.32	
8.5		2021-2050	5.07	4.52	54.09	131.65	3.68	2.22	



Indicator	Productivity	Period	Sim 1		Sim 2		Sim 3	
			Paddy	Coffee	Paddy	Coffee	Paddy	Coffee
		2051-2080	12.43	17.45	117.78	146.31	11.40	15.06
		2081-2100	19.67	31.16	92.02	176.24	18.86	27.70

Source: Authors Calculation

The economic assessment of the follow-on impacts of climate-induced productivity changes yielded also impact son imports and exports. For changes in trade, the RCP8.5 scenario has a larger impact than the RCP 4.5 scenario. For rice, consequence of a decrease in rice productivity is that nationally there is a potential decrease in export yields ranging from 2 percent - 35 percent and an increase in import needs reaching a maximum range of 117 percent which will occur in scenario 8.5. What really needs attention is that the decline in rice production will have a spiraling impact, namely increasing the relative prices of rice and rice commodities, thereby reducing their competitiveness for exports. The decline in rice exports is in the range of -0.31 to -35 percent in the RCP 4.5 scenario and -0.5 to -52 percent in the RCP 8.5 scenario. Meanwhile, more significant impacts hit coffee trade as export will expected to go down by 54.54 percent and imports rising up to 176.24 percent in simulation 2. Climate change adaptation actions are urgently needed so that Indonesia can maintain its position as a coffee exporting country.

The Impact of Climate Change on Rice and Coffee Commodities on Indonesia's Household Welfare

Real income distribution is a variable that is used as a proxy for livelihood impacts from climate change policy simulations. The simulation results show that climate change in rice and coffee commodities can represent an income shock as indicated by a decrease in real income for all household groups, both in rural and urban areas. The highest decline in real income occurred in the rural 1 group of agricultural workers, followed by Rural 2 which were agricultural entrepreneurs. Low-income households in urban areas (urban 5) decreased their welfare more significantly than other urban household groups. The comparison of scenarios shows that scenario 8.5 is predicted to have a relatively significant decrease in income, thus indicating the risk of vulnerability related to poverty in both rural and urban areas. The multidimensional consequences of the decline in real income are also related to the potential decline in Indonesia's food security status, considering that the contribution of food products to Indonesian household consumption patterns is very dominant. Food availability continues to play an important role as an important dimension of food security where the supply of food and agricultural commodities is to maintain a stable expansion of food consumption and to offset fluctuations in production and prices.

Table 4. The Impacts of Climate Change on Real Household Consumption

Scenario	Period	rural1	rural2	rural3	rural4	rural5	urban1	urban2	urban3
4.5	2021-2050	-0.03	-0.03	-0.03	-0.03	-0.04	-0.03	-0.03	-0.01
	2051-2080	-0.07	-0.06	-0.06	-0.06	-0.08	-0.05	-0.06	-0.01
	2081-2100	-0.08	-0.07	-0.07	-0.07	-0.09	-0.06	-0.07	-0.01
8.5	2021-2050	-0.04	-0.04	-0.04	-0.04	-0.05	-0.03	-0.04	-0.01
	2051-2080	-0.11	-0.10	-0.10	-0.09	-0.13	-0.09	-0.10	-0.02
	2081-2100	-0.18	-0.17	-0.17	-0.15	-0.21	-0.14	-0.17	-0.03



Scenario	Period	rural1	rural2	rural3	rural4	rural5	urban1	urban2	urban3
4.5	2021-2050	-0.48	-0.45	-0.45	-0.41	-0.56	-0.39	-0.46	-0.08
	2051-2080	-0.56	-0.52	-0.53	-0.48	-0.66	-0.46	-0.53	-0.09
	2081-2100	-0.54	-0.50	-0.51	-0.46	-0.64	-0.44	-0.51	-0.08
8.5	2021-2050	-0.54	-0.50	-0.51	-0.46	-0.64	-0.44	-0.52	-0.08
	2051-2080	-1.02	-0.95	-0.96	-0.88	-1.19	-0.83	-0.96	-0.17
	2081-2100	-0.87	-0.81	-0.81	-0.74	-1.02	-0.70	-0.82	-0.14
4.5	2021-2050	-0.02	-0.02	-0.02	-0.02	-0.03	-0.02	-0.02	0.00
	2051-2080	-0.06	-0.05	-0.05	-0.05	-0.06	-0.05	-0.05	-0.01
	2081-2100	-0.07	-0.06	-0.06	-0.06	-0.08	-0.06	-0.06	-0.01
8.5	2021-2050	-0.03	-0.03	-0.03	-0.03	-0.03	-0.02	-0.03	-0.01
	2051-2080	-0.10	-0.09	-0.09	-0.09	-0.12	-0.08	-0.09	-0.02
	2081-2100	-0.17	-0.16	-0.16	-0.14	-0.20	-0.14	-0.16	-0.03

Source: Authors Calculation

Note:

- Rural 1 are agricultural workers.
- Rural 2 is an agricultural entrepreneur.
- Rural 3 is a low class non-agricultural household in rural areas, namely low class free entrepreneurs, administrative staff, mobile traders, free workers in the transportation sector, individual services, and unskilled laborers.
- Rural 4 is non-labor force in rural areas, which includes non-labor force and unclear groups in rural areas.
- Rural 5 is non-agricultural households in the upper class, including upper class independent entrepreneurs, non-agricultural entrepreneurs, managers, military, professionals, technicians, teachers, administrative workers and upper class salespeople.
- Urban 1 is a non-agricultural household of the lower class in urban areas, which includes low-income free entrepreneurs, administrative staff, mobile traders, free workers in the transportation sector, individual services and unskilled laborers.
- Urban 2 is non-labor force in urban areas, including non-labor force and unclear groups.
- Urban 3 is non-agricultural households in the upper class, such as upper class independent entrepreneurs, non-agricultural entrepreneurs, managers, military, professionals, technicians, teachers, managerial workers, and upper class salespeople.

Conclusion

1. Climate change that reduces rice and rice productivity affects Indonesia's macroeconomic performance. Climate change will reduce real GDP, real household consumption and exports. On the other hand, climate change will increase Indonesia's imports. Changes in macroeconomic performance in all scenarios of RCP 8.5 are worse than scenario 4.5.
2. Climate change poses a negative risk to the quantity and quality of rice and coffee output and has a spiraling impact on increasing domestic prices. An increase in domestic prices has the potential to reduce Indonesia's trade competitiveness, especially as a major producer and exporter of coffee due to an increase in relative prices.
3. Climate change in rice commodities can represent an income shock as indicated by a decrease in real income for all household groups, both in rural and urban areas. The highest decline in real income occurred in the rural 1 group of agricultural workers, followed by Rural 2 which were agricultural entrepreneurs. Low-income households in urban areas (urban 5) decreased their welfare more significantly than other urban household groups.



Recommendation

1. Adaptation climate policies on rice and rice commodities requires multi approach to enhance the resilience of both production systems to climate change, safeguarding livelihoods, food security, and sustainability. Government and related stakeholders should develop heat-tolerant and drought-resistant varieties of rice and coffee, strengthen extension officer to provide training on climate smart agricultural practices, and improved infrastructure (irrigation, post-harvest facilities) to enhance the resilient of rice and coffee production. Production stability is very much needed to maintain Indonesia's position as one of the largest coffee exporters in the world.
2. Government should develop financial support and risk management towards climate change, such as providing financial incentives (subsidies and low-interest loan) to encourage rice and coffee farmers to invest in climate adaptation measures, establish crop insurance to protect and stabilize farmers income, and strengthen social safety nets.

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Valuation of Reef Tourism: A Preliminary Review and Lessons Learned for a Study in the Philippines

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Abstract

Coral reefs are globally important ecosystems known for their high productivity and biodiversity. These reefs offer various ecosystem services, including provisioning and regulation. The coastal environment of the Philippines is rich in a diversity of reef species and associated marine organisms, attracting tourists each year, making the country a major tourist destination in Asia, and generating livelihoods for coastal communities. Recent studies suggest declines in reef diversity and abundance due to destructive fishing methods, industrial and agricultural waste, and unsustainable urban development, threatening the tourism sector and the economic opportunities provided by the reefs. This study compiles and synthesizes existing published research articles on valuation methods commonly used to assess the benefits of reef-related tourism. Articles published in Science Direct, Scopus, and Web of Science journals were searched using the PSALSAR framework. The initial search results of 7,982 using specific terms and Boolean operators were further refined, yielding 21 articles deemed eligible for annotation and preliminary review. Results of synthesis revealed that, despite the considerable number of studies on valuation, few focused on reef-related tourism. The articles encompassed a wide range of study sites, coastal habitat characteristics, and list of tourism activities. Valuation studies for reefs are commonly conducted in sites either in protected areas e.g., marine parks or popular tourist destinations e.g., Great Barrier Reef. Moreover, economic value is obtained from revenues earned, taxes collected, tourist expenditures and cost of handling reef-associated tourism activities. In this manner, the reef is undervalued as it only reflects the indirect use value of the ecosystem services e.g., supporting, cultural. Consequently, valuation studies that measure the economic value of provisioning services e.g., fish catch, fish population, and downstream employment is lacking. There is a significant monetary amount missing in reports that represent the reef's value in providing food and employment to the most vulnerable sector – the coastal community. Thus, reefs in the Philippines remain exploited and non-prioritized for national programs in the absence of comprehensive valuation.

Keywords: Coral reefs, reef tourism, PSALSAR framework, Q22, Q56

JEL code: Q22, Q56

SDG goals: Life Below Water, No Poverty, Zero Hunger

Introduction

The coastal zone of the Philippines is teeming with diverse coral species, vibrant marine life, and well-functioning interconnected ecosystems, e.g., coral reefs, seagrass, and mangroves. With more than 16,800 sq km of coral reefs, it is the global center for marine biodiversity. The central region, from Luzon to Mindanao, has more marine species per unit area than any other place on the planet, making it a popular tourist destination among beach lovers, divers, hobbyists, and even underwater explorers. Coastal and ocean-based tourism accounts for approximately 50 percent of all global tourism, equal to US\$4.6 trillion, or 5.2 percent of the global Gross Domestic Product (GDP). In the Philippines, tourism contributes 12.7 percent



(2019) and 6.2 percent (2022), respectively, to GDP (PSA). In particular, the dive-tourism industry contributed significantly to the Philippine economy in 2023, generating over PhP 73 billion - twice the amount in 2022 (PhP 37 billion). The recent staggering support of the government to expand the tourism industry ascertains the potential of the sector to boost local and national economies in the long run.

The reef-related tourism activities and support services generate billions of dollars in revenue and provide jobs and income for thousands in the community. As such, healthy (i.e., “high percentage of live coral cover; Licuanan, 2017) reefs are valuable natural resources that must be protected to ensure the continued growth of the tourism industry. In a related development, the Philippines is one of the signatories to the new Global Biodiversity Framework for the commitment to protect 30 percent of terrestrial and marine ecosystems by 2030 (Fabro, n.d.).

As part of the coral triangle, the Philippine coral reefs play a vital role in maintaining the biodiversity of the region and serve as important breeding and nursery grounds for many commercially important fish. Healthy reefs are crucial for the vibrant tourism and substantial key to food and livelihood security of coastal communities - the poorest and most food insecure of the economy, which accounts for 70 percent of the population (Rivera et al., 2020, Northrop et al., n.d.; Westlund et al., 2017). The poverty incidence among fishing households was the highest among all economic sectors in 2012, at 25.2 percent, while having direct access to fisheries resources (Cabral & Geronimo, 2018). Coral-reef fish from municipal fish catch and invertebrates gleaned from intertidal zones are the major food sources of coastal communities, yet they are the most underestimated and underappreciated. Despite the food security and downstream employment of the ecosystem services the reefs provide, it remains a challenge for the government to convince them of the valuable direct and indirect benefits derived.

Aside from fisheries products, reefs also provide coastal protection from storms and waves, further contributing to the well-being and livelihood of coastal residents. Unlike mangroves and seagrass, reefs take millions of years to regenerate or recover from any negative impact of anthropogenic activities. As such, the establishment of marine protected areas is a common resource management approach. As of 2022, the megadiverse Philippines has 248 protected areas, which cover 7.8 million hectares, equivalent to 15.4 percent of its land area and 1.4 percent of its territorial waters (Fabro, n.d.).

Recent research provided strong evidence that the diversity and abundance of reefs are declining due to overfishing, destructive fishing, pollution (from household, industrial, and agricultural sources), massive outbreaks of predatory starfish, invasive species, and sedimentation from improper land use practices. Nonetheless, the most serious problem coral reefs are facing today is rising seawater temperatures because of climate change (Burke et al., 2011). The Philippines sits in the Pacific Ring of Fire, where earthquakes and volcanic eruptions can trigger unexpected destructive events like tsunamis. Tsunamis carry large ocean waves that, upon drawing back into the sea, can be harmful to the marine ecosystem via the bacteria and toxic chemicals from the seashore and nearby coastal communities. These eventually erode the seafloor and destroy the reef (Oregon State University Newsroom, 2011). However, with and without these unpredictable events, the immediate and more important concern is protecting the reefs and paving the way for a targeted future sustainability that benefits not only the people but also the environment. Thus, considering the ecosystem services reefs provide and the threat of degradation, an immediate, scientific, and paradigm-shifting kind of action is imperative.



In the meantime, the economic value of ecosystem services has been a popular research area among social scientists for many years. However, scientific studies on the assessment and monitoring of the status of reefs remain incomplete, so the policy-making process is myopic. The same sad situation exists in the megadiverse Philippines, which needs to be addressed as soon as possible. Valuation, being a very important concept, may provide a common language that is acceptable and understandable to all stakeholders. The value derived from valuation is analogous to the currency of the use and non-use, or direct and indirect benefits, of the ecosystem services provided by the reef. Expectedly, the “economic value” becomes the “price tag” of the reefs (and other natural capital), and stakeholders are expected to see the opportunity cost if unsustainable, unrestricted, and unregulated resource use continues. Meanwhile, economic valuation is an evolving concept. Unlike marketable goods, ecosystem services are natural endowments, which implies that the input-output equation varies across resource type, habitat, landscape, ecological processes, and institutions, and largely across countries. Thus, the objective of this systematic review is to explore the variables and reef-associated tourism activities that are valued and widely used to study the benefits of reef tourism. It is hoped that this systematic literature review can help pinpoint the best practices for valuation in other countries that can be adapted to the Philippine situation. It is to be noted that there is a dearth of information on reef valuation specific to the Philippines. Without proper valuation, it will be very difficult to emphasize and sell to the public the idea of conservation and preservation, which have been badly needed since several years ago. This paper hopes to build on the information that will be collected from this systematic literature review to come up with recommendations on what can be applied and done in the Philippine setting.

Methodology

This Systematic Literature Review (SLR) is a rigorous, transparent, and reproducible method for identifying, evaluating, and synthesizing the existing body of research on the topic of the economic value of reef tourism. Literature was screened using pre-specified eligibility criteria that fit the formulated research questions. This SLR compiles a list of valuation techniques used by experts and practitioners to value the benefits derived from coral reefs. The valuation technique that is widely used or practiced and highly recommended is the expected highlight of this review. The study site (i.e., reef system), ecosystem habitat, tourism activity (i.e., snorkelling, scuba diving), and visitor demographics are among the few variables being investigated. The result shall identify the gap, trend, and future direction of the valuation of reef tourism considering the variables specified.

Search Databases

The research databases used in this SLR are Science Direct, Scopus, and Web of Science. The selected databases can be accessed either through an OpenAthens account or via UP mail issued by the University Library of UP Los Baños.

Table 1. List of Search Databases used in this SLR

Search database	Brief description	Database URL
Science Direct (SD)	SD is a bibliographic database of scientific and medical publications, launched in 1997. It hosts over 18 million pieces of literature and academic journals. This is being managed by Elsevier.	https://www.sciencedirect.com/



Search database	Brief description	Database URL
Scopus (SC)	SC is a subscription-based search and citation database of peer-reviewed literature. It is a web source with tools to track, analyze, and visualize a vast number of publication materials. Launched in 2004 and is being maintained by Elsevier. At present, it covers over 200 million publications.	https://www.scopus.com/
Web of Science (WoS)	The WoS is a free bibliographic database that can be accessed online. It consists of peer-reviewed journal articles and book chapters, including open-access publications.	https://www.webofscience.com/wos/woscc/basic-search

Paper Selection Process

In each search database, the following terms and Boolean operators were used, “economic valuation” OR “valuation” AND “reef-related tourism” OR “reef-associated tourism” OR “reef tourism.” Initial search results were screened using the Protocol, Search, Appraisal, Synthesis, Analysis, and Report (PSALSAR) framework. This method is a well-defined, systematic, and repeatable approach to assessing both quantitative and qualitative data. It emanated from the SALSA framework.

Table 2. The PSALSAR method (Mengis et al., 2020)

Steps	Sub-Steps/Objective	Methods
Protocol	• Define the study scope and research question. • Identify inclusion and exclusion criteria. • Develop the search strategy.	• PICOC framework
Search	• Define the study strategy. • Search studies/articles	• Terms and Boolean operators • Search databases
Appraisal	• Select studies based on the predetermined set of criteria. • Assess the quality of studies	• Defining inclusion and exclusion criteria • Quality criteria
Synthesis	• Extract data. • Categorize the data	• Extraction template • Categorize the data on the iterative definition and prepare it for further analysis work
Analysis	• Data analysis • Result and discussion • Conclusion	• Quantitative categories e.g., methods, results • Identify gaps, trends, and future directions across literatures. • Derive implications
Report	• Write a report. • Describe the methods, findings, and implications.	• PRISMA methodology • Summarizing the report result for the larger public

In complement to the PSALSAR, the Population-Intervention-Comparison-Outcome-Context (PICOC) framework was adopted. Through PICOC, the scope of literature is defined, inclusion and exclusion criteria are set, and the search strategy is developed. Table 3 and Table 4 show

the list of research questions developed using the PSALSAR framework presented above. The analysis of this review will then be guided by this list of research questions.

Table 3. The identified objectives and scope using the PICOC framework (Booth et al. 2016)

Concept	SLR Application
Population	Research articles on economic valuation of ecosystem services provided by the coral reefs. Specifically, the benefits derived from reef tourism.
Intervention	Studies that support, complement, or complete the existing valuation process for reef-related fisheries
Comparison	List of tourism activities across study sites.
Outcomes	Assumptions and variables in the valuation equation, derived value
Context	Study sites and purpose of the study

Table 4. List of Research Questions developed from the PSALSAR framework

Steps	Research Questions
Protocol	What is the current valuation method for reef-related tourism?
Search	What are reef-related tourism activities?
Appraisal	What is the widely practiced economic valuation method for reef-related tourism?
Synthesis	What are the limitations and application/use of the derived economic value of reef-associated tourism toward conservation efforts?
Analysis	What are the challenges in conducting economic valuation studies?
Report	What is the lesson learned and the way forward for economic valuation studies?

The quality of the eligible studies was screened and appraised using the PSALSAR framework, the final number of articles is 21. These articles were analyzed to identify gaps, trends, and future directions of economic valuation.

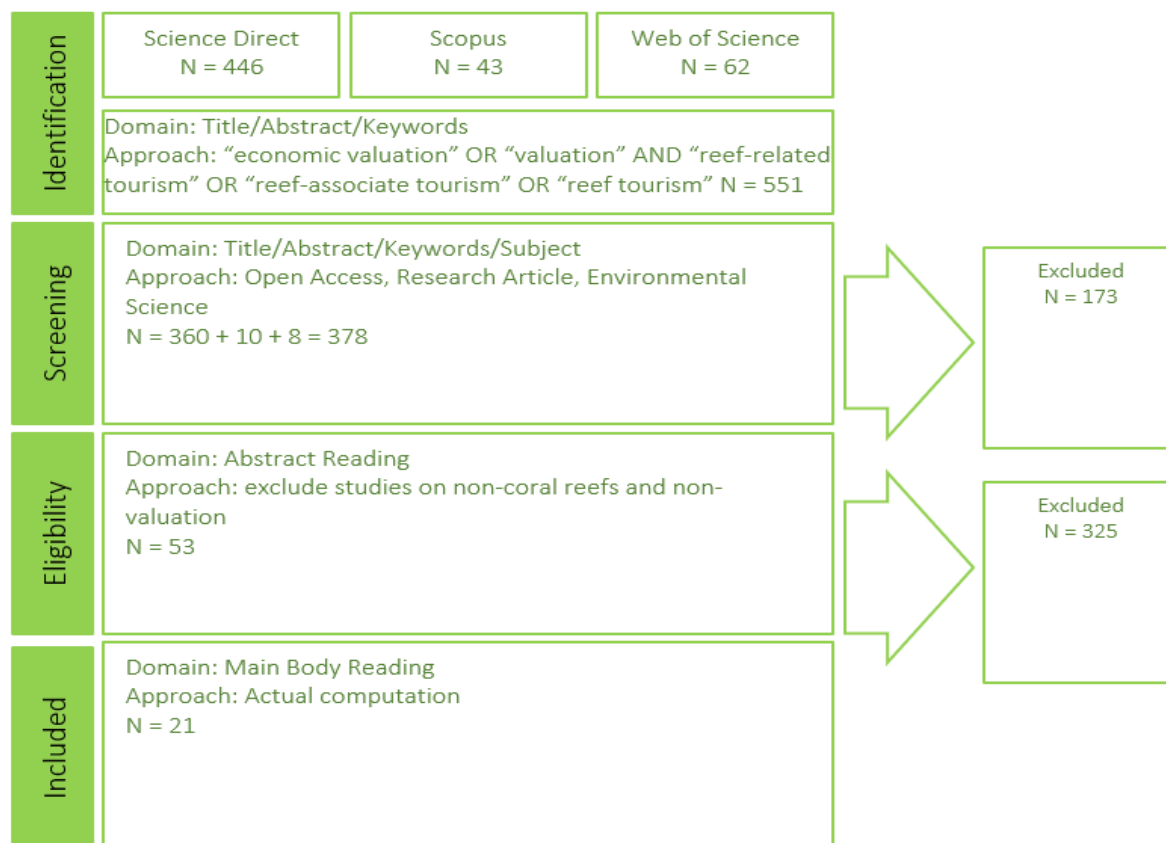


Figure 1. Flow Diagram of the Exclusion and Inclusion Process

Synthesis and Preliminary Review

The 21 articles were annotated and synthesized to identify common concepts and area of the methodology particularly use to measure the value of reef. This preliminary review includes summarizing and comparing study sites, keywords, variables, and tourism activities to highlight possible trend and establish baseline information for reference as applicable in the Philippines. The study site is expected to describe the reef characteristics (i.e., topography, coral species diversity, slope, depth), while keywords and variables show priorities for doing valuation, and list of tourism activity describes the types of activities that comprise the estimation of the economic value.

Results and Discussion

With the large bulk of literature in the initial search results, studies that aim to value tourism were selected. After the abstract reading of the 53 appraised articles, 22 were found eligible for annotation and synthesis. The initial number of results reflects the growing recognition of the importance of valuing natural capital, as human survival greatly depends on it. These studies have been conducted to support conservation efforts on resources, habitats, ecosystems, or landscapes assessed as degrading.

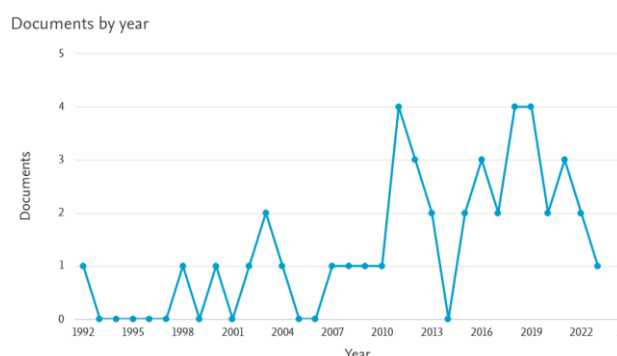


Figure 2a. A Graphic presentation of the initial search results from Science Direct.



Figure 2b. A Graphic presentation of the initial search results from Web of Science.

Tourism Activities and Valuation Techniques Used

There were fewer than the required 20 articles on the economic valuation of reef tourism. As such, the review will include recreation activities associated with coral reefs to identify the trend. The trend in valuation studies is geared towards the establishment or expansion of protected areas, the determination or establishment of a user's fees, and the identification of destructive activities.

Table 5. List of Study Sites and Keywords.

Author and Year	Study Site	Keywords
Drim (1994, 1997, 1999), Great Barrier Reef Marine Park Authority (2000), PDP Australia (2003), Access Economics (2005, 2007, 2009), Deloit (2013, 2017),	Great Barrier Reef (GBR)	Economic Valuation, Coral Reefs, Tourism, Fisheries, Coastal Protection, Multiple Use, Policy, Multiple Countries, Climate Challenge, Social Impact



Farr et al. (2014), Mustika et al. (2016). Rolfe (2021)		
Pendleton (1995)	Bonaire Marine Park	Economic Valuation, Coral Reefs, Tourism, Fisheries, Coastal Protection
Windle et al. (2017)	Gladstone Harbour in Queensland, Australia	Recreation, Non-market valuation, Economic indicator, Aquatic health report card, Gladstone harbour

The articles presented in Table 5 provide a substantial list of literature on coral reefs. Each study used different methods to value the direct and indirect benefits derived from the coral reef ecosystem. The common challenge presented by these studies in valuing the coral reef is the biological and ecological indicators to account for the benefit. Gaps from these studies highlight the limitation of the existing valuation technique. Economic valuation is evolving but its significance should be seriously taken for policy formulation. As a proposed strategy from these studies, information on the economic value should be in conjunction with other forms of information, such as ecological and scientific data.

All the studies provide scientific evidence of the economic value of coral reefs. Its value is expected to significantly increase tourism and is mainstreamed in the national agenda because of the coastal protection it provides against threats of climate change and catastrophic phenomena (i.e., tsunamis and storm surges). The use of economic valuation in policy formulation is in its early stages as minimum requirements have not yet been established. Further, the difficulty of measuring the value of non-market goods and services and the need to consider the full range of coral reef ecosystem services are overwhelming, but they should not impede the need to integrate valuation into policy action toward conservation and protection.

Reef Tourism Activity and Variable Used in the Valuation

There were 125 articles that identify common variables in the economic valuation of reef tourism. The articles were published between 1990 and 2022 and were from Australia, the Caribbean, Indonesia, Mexico, and the Philippines. The common variables include revenue, jobs, taxes, number of visitors, fuel cost, and expenditure, while there are 16 specific variables from the 125 articles reviewed (Table 6). The variables are measurements and indicators of the value generated from reef and reef-related activities in the valuation studies. These variables may directly or indirectly measure the money spent, revenue generated, and potential impacts. Dive tourism expenditures and park fees directly measure tourist spending on diving activities, e.g., fees for guides, boats, equipment rental, etc., and revenue generated from entrance fees charged by marine parks or protected areas that directly support reef conservation efforts.

Business revenues and taxes levied on tourism activities and businesses are indirect measures that capture the economic ripple effect of tourism activities, which includes spending on local businesses like hotels, restaurants, and souvenir shops. Also, taxes levied on tourism activities and businesses contribute to government revenue, potentially used for reef conservation or infrastructure development.

The number of trips is a basic metric that quantifies tourism volume and its potential impact on reefs. This variable indicates trip frequency and provides a trend of individuals visiting specific reefs. It provides insights into tourist behaviour and potential management strategies.



For the variable that considers cost as part of the value of reef tourism, the cost of management and conservation efforts is obtained.

Over the years, the studies have assessed the value of reef tourism in different parts of the world, providing a baseline for understanding the economic importance of reefs. The studies help resource managers, policymakers, and scientists understand the broader economic implications of reef tourism, even in a localized context. The variables identified and values obtained are important evidence that may indicate the status of our natural capital (i.e., reef and fisheries resources), the effectiveness of existing management strategies, and the critical role of stakeholders in the sustainability of resource allocation over time.

Table 6. Summary of variables and tourism activities valued from the Studies

Variables	Tourism Activity
1) Dive tourism expenditures, Government taxes on dive tourism, Direct Park fees, Indirect business revenues from hotels, Dive operations, Restaurants, Air transport Island imports, Travel vehicle cost, Boat use (fuel) cost.	1) Tourism and recreation (in general) 2) Fishing 3) Recreational boating and charter boats
2) Gross Financial Value, Total Economic Contribution, Direct and Indirect financial impact	4) Underwater activities e.g., scuba diving, free diving, snorkelling
3) Productivity Change, Number of trips, Time spends on the recreational activity, Trip frequency	
4) Cost of protection	5) Photography

Conclusion

Within the period for which this systematic review was conducted, there were an increasing number of valuation studies and ongoing research on natural capital and ecosystem services. This implies a growing recognition of the importance and role of natural capital in human survival and development goals. Valuation studies provide insights into its status and the benefits it continues to provide, given existing institutions and efforts. The economic value associated with reef tourism is one critical piece of evidence to formulate and strengthen science-based policymaking focused on multi-sectoral resource-specific action strategies.

For future research, there is an opportunity to explore different valuation techniques and standardize the protocol to establish comparisons of economic value across sites and resources. To be able to standardize the valuation techniques, it should capture market and non-market benefits and may improve investments and stakeholder participation in resource management. In combination with the ecological data, economic value will add to the holistic understanding of reefs and their role in addressing food security and poverty alleviation in coastal communities.

Recommendation

Bridging Gaps by Understanding the Economic Valuation of Reef Tourism in the Philippines

The systematic review has provided valuable insights on valuation of reef tourism yet highlighted the critical gaps and opportunities for further research and policy review. This concept note outlines the ways forward in addressing these gaps and proposed strategies for future valuation studies specific for Philippines. The review showed that there is limited focus on the Philippine reef tourism, leading to sparse data on the specific contribution of dive



tourism in the Philippine economy. Apparent also is the minimal attention given to research that explore and understand the economic implications of government regulations such as taxes on dive tourism in the Philippines, among others.

Based on all the insights obtained from the review, this section is a concept proposal covering some identified gaps that are contextualized in the Philippine setting. Specifically, the preliminary topic is “Ecological and Economic Analysis of Reef Tourism in Siargao, Surigao del Norte, Philippines.” Siargao, is one of the popular tourist destinations in the Philippines in Surigao del Norte. It has rapidly grown in popularity, particularly among surfers seeking world-class waves and pristine coral reefs. Tourism is the island's primary economic driver, contributing significantly to local employment and income generation. In 2022, tourism revenue in Siargao reached ₱3.8 billion, representing a major leap from pre-pandemic levels (Coles, 2022). Most residents depend on the tourism industry, specifically reef-associated tourism, working as boat operators, crews, and tour guides. With the island's growing popularity, reef-associated tourism activities and enterprises continue to evolve and grow in various segments beyond surfing, such as island hopping, scuba and free diving, and eco-tourism.

PROBLEM STATEMENT

Siargao Island's reef tourism industry enjoys rapid growth, driven by increasing inbound tourism expenditure and tourism direct gross value added. This influx generates direct and indirect employment, boosts household financial expenditure, and contributes to government revenue. The revenue and employment derived from tourism significantly support the economy of the island. The economic affluence it has at present and the plan to expand its tourism capability to maximize its potential may result in economic loss in the long run. Unsustainable tourism management practices may degrade coastal habitats, exploit natural resources, and increase waste, which may lessen the value of tourism products and services over time. Specifically, when tourism capacity exceeds its limits and coastal development alters ecosystems, negative externalities such as environmental degradation may arise. This negative externality includes a reduction in tourism expenditure and household financial expenditure disparity.

As an island, Siargao has a limited land area, which adds to the challenge of balancing tourism development with resource limitations and potential land use conflicts. Consequently, residents can be fisheries-resource tourism-dependent or both. This amplifies the need for science-based planning and management to ensure sustainable tourism practices and protect the ecological integrity of the island.

Although significant contribution of eco-tourism to the local economy has been noted, there is a threatening impact of resource depletion, habitat degradation, waste, and pollution that may threaten the long-term economic sustainability of the island. Increasing demand for tourism products and services (i.e., hotels and restaurant infrastructure) increases the pressure on resource extraction and encourages unsustainable tourism practices. Moreover, exceeding the reef's carrying capacity can lead to negative externalities, threatening the coastal ecosystem, disrupting traditional livelihoods, to eventually diminish the resource that attracts tourists—coral reefs. It has been known that the reefs provide important ecosystem services that have long-term and encompassing impact on the well-being of humanity. As such, there is a need to ensure that the ecosystem services that support the tourism industry are accounted for, monitored, and sustainably managed over time. Thus, this proposed ecological and economic

analysis of reef tourism in Siargao, Surigao del Norte. The dearth of studies and information in the Philippines, particularly to the popular and pristine Siargao as proven by the conducted systematic literature necessitate the conduct of this study.

SIGNIFICANCE OF THE STUDY

While the economic benefits and community support for tourism in the Philippines cannot be disregarded, a critical shift in perspective is necessary. Existing research highlight the environmental pressures on reefs from diverse sources, which may cause habitat degradation, resource exploitation, and pollution. There is a gap in management strategies that consider the holistic interplay of carrying capacity, institutional arrangements, and economic welfare. An economic perspective will complement existing studies and provide substantial evidence to highlight the potential risk of economic loss when natural capital remains unprotected due to unaccounted net benefits.

The analysis of the reef tourism industry in Siargao is crucial for understanding the complex interplay between economic development, environmental sustainability, and community well-being. The analysis shall provide insights into the formulation of strategies to maximize economic returns from tourism while minimizing environmental impact and ensuring equitable distribution of benefits.

CONCEPTUAL FRAMEWORK

As shown in Figure 1, this study shall adapt the framework from Benedicto and Libosada (2005). The framework depicts that there are three elements of sustainable tourism composed of ecological (also called environmental), economic, and social components. These are also called the “triple bottom line.” While promoting and doing tourism activities in Siargao, land use and carrying capacity could be altered, thereby imposing costs on the environment. In contrast, the growing number of tourists can keep Siargao’s economy constantly moving due to the tourists’ direct and indirect expenditure within the island, tourism-employed household consumption expenditure, tourism-associated employment, and tourism-associated government expenditures. These two components affect the willingness-to-pay of both the tourists and residents for the conservation of the island’s natural resources.

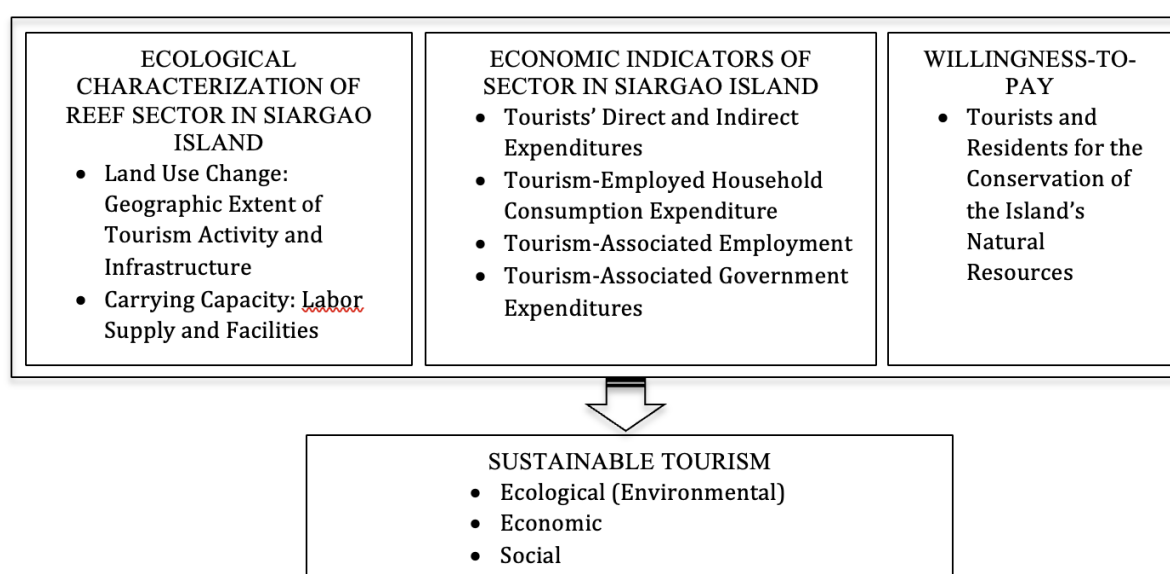


Figure 1. Conceptual Framework of the study as adapted from Benedicto & Libosada (2005)



OBJECTIVES

The study will identify the ecological and economic factors that influence the economic value of reef tourism on Siargao Island, Surigao del Norte. Specifically, it will:

- 1) identify the reef-associated land use change (i.e., coastal development, infrastructure);
- 2) evaluate the present tourism carrying capacity;
- 3) determine the trend in tourism-associated economic indicators, such as tourist direct and indirect expenditure, tourism-employed household consumption expenditure, tourism-associated employment, and tourism-associated government expenditures.
- 4) assess the willingness-to-pay by tourists and residents for the conservation of the island's natural resources (as the basis for the establishment of a user's fee); and
- 5) craft policy recommendations for the conservation of the island's natural resources.

EXPECTED RESULTS

The result of this study will enable the quantification of the carrying capacity of Siargao's reefs for tourism, determine the tourism-associated land use change, trend in economic indicators, and willingness-to-pay for conservation. The ecological and economic analysis will provide science-based inputs in the formulation of resource management strategies and tourism development plans that will balance economic benefits with ecological protection. Such strategies and plans will ensure sustainable resource utilization and equitable distribution of benefits over time. Lastly, this concept hopes to contribute to the existing studies that support the formulation of policies to ensure that sustainable tourism in islands like Siargao will thrive, generate economic prosperity while conserving the very natural resources that sustain it.

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Economic Valuation of Water Provisioning Services in the Recharge Area of Ciburial Spring, Bogor Regency

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Abstract

The rapid global population increase significantly contributes to environmental and natural resource exploitation. This phenomenon happens in Indonesia with a high population reached 278 million people in mid-2023. As the population grows, there is a heightened demand for essential resources, particularly in Bogor Regency, which faces challenges in providing sufficient clean water due to its high population density. The Ciburial spring, the largest and oldest raw water source in Bogor Regency, has experienced a 62% decline in discharge over the past two decades. This reduction is attributed to anthropogenic factors affecting land use change in the recharge area. To ensure water availability, particularly in preserving the green coverage of the Ciburial spring recharge area, effective land cover management is crucial. This research aims to assess the water provisioning services of green ecosystems in the recharge area, with specific objectives of measuring the water yield and estimating the economic value of water provisioning services in the Ciburial spring recharge area. This study is based on the InVEST Seasonal Water Yield (SWY) model and market-based approach. The results show that the potential of water yield or groundwater supply in the Ciburial spring recharge area fluctuated in the past decade, reaching 32,613,565.97 m³ in 2020. The InVEST SWY model also projects water yield for the next 10 years, considering climate scenarios like SSP370 and SSP585. In line with the first objective, the economic value of water provisioning services in the Ciburial spring recharge area was estimated at IDR 30,855,042,497.22 in 2020.

Keywords: direct use value; ecosystem services; groundwater; monetary value; seasonal water yield

JEL code: Q00, Q25, Q51

SDG goal: Clean Water and Sanitation

Introduction

High population growth is a major force underlying environmental degradation and a threat to the sustainable use of natural resources (Maja and Ayano 2021). The quality and quantity of natural resources are declining due to overexploitation, land fragmentation, and intensive agriculture. Over the past 20 years, the global population has increased by 29%, from 6.1 billion to 7.9 billion people (World Bank 2023). Rapid population growth, combined with urbanization and economic development, has led to increased demand for food, energy, and water, putting enormous pressure on the environment (Jiang and Hardee 2011; Molotoks et al. 2018). UN-Water (2018) states that as the population grows, the global water demand is also increasing and will continue to grow significantly in the next two decades. Figure 1 illustrates the increase in world population and the corresponding rise in water withdrawal.

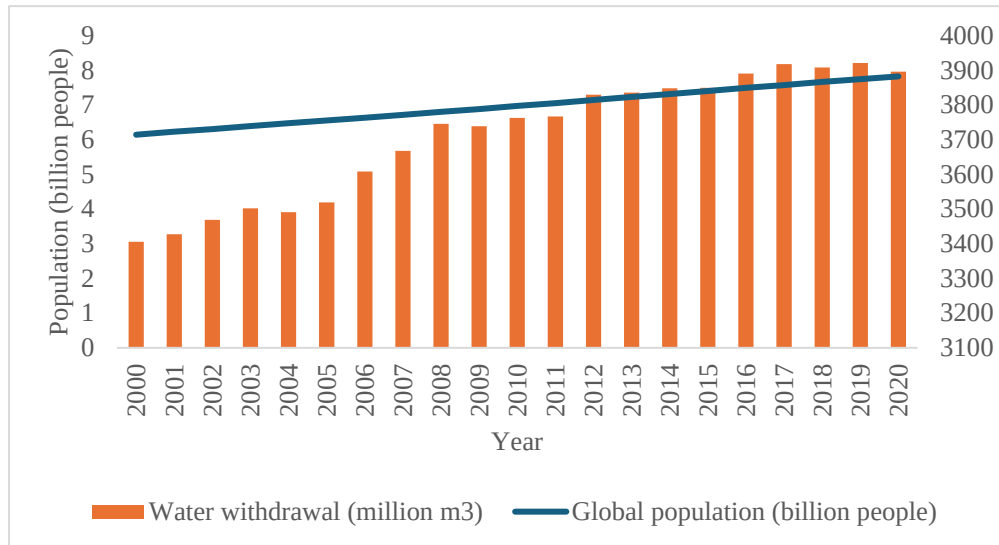


Figure 1. World population and water withdrawal 2000 - 2022 (World Bank 2023)

Globally, water use has increased by about 1% per year over the past 40 years driven by a combination of population growth, socioeconomic development, and changing consumption patterns (United Nations 2023). However, high water demand cannot be entirely met by existing water resources due to high water stress or a high proportion of water used for water availability, leading to water scarcity.

Land use change is a contributing factor to water scarcity. The population increase in an area prompts a rise in food and infrastructure requirements across different sectors, leading to changes in land use. This shift in land use has significant implications for water resources, including alterations in water availability due to reduced catchment areas and degradation of water quality (Jha, 2020). In addition, water scarcity is exacerbated by the impacts of current climate change. Climate change has profound effects on water resources, with phenomena such as rainfall deficits reducing soil moisture, river flow, and groundwater recharge, ultimately leading to water scarcity (UN-Water, 2020).

In watersheds, hydrological processes occurring upstream exert a direct influence on downstream water. Vegetated ecosystems, such as forests in recharge areas, provide crucial ecosystem services related to both water quantity and quality. Forest ecosystems in recharge areas have a significant impact on water quality, as they release water vapor that helps regulate rainfall, protect soil from erosion caused by heavy rainfall, filter pollution, and consequently reduce water treatment costs (Lyons and Gartner, 2017). Moreover, they contribute to water quantity, with research showing that a 1% increase in forest area leads to a 0.93% increase in access to clean water, including from springs (Mapulanga and Naito, 2019). These findings underscore the importance of preserving vegetated ecosystems in water catchment areas, as they play a vital role in generating diverse ecosystem services essential for maintaining water resources.

Indonesia is among the countries worldwide experiencing a consistent increase in population each year. The population of Indonesia rose from 272 million in mid-2021 to 278 million in mid-2023 (Central Bureau of Statistics, 2023a). This population surge is observed across all provinces, with notable growth in West Java Province. In 2021, West Java held the top spot

with a population of 48 million, and this figure increased to 49 million in 2022 (Central Bureau of Statistics, 2023b).

Bogor Regency in West Java province functions as a protective buffer zone for the capital city of DKI Jakarta. This has led to rapid economic development in the region, mirroring the progress in Jakarta. The economic advancements in Bogor Regency contribute to a population increase, driven by urbanization from surrounding areas. Consequently, there is a pressing need to enhance necessities and services, including the provision of clean water in the Bogor Regency area.

In Bogor Regency, Ciburial spring stands out as the largest and oldest source of raw water, serving as a vital resource to meet the water needs of Bogor Regency. Since 1994, the management of Ciburial Spring has been under the joint oversight of the Bogor Regency Government and Tirta Kahuripan water utilities. The discharge of the Ciburial spring exhibits fluctuations from year to year, with an overall trend indicating a decrease from 2005 to 2022, as illustrated in Figure 2.

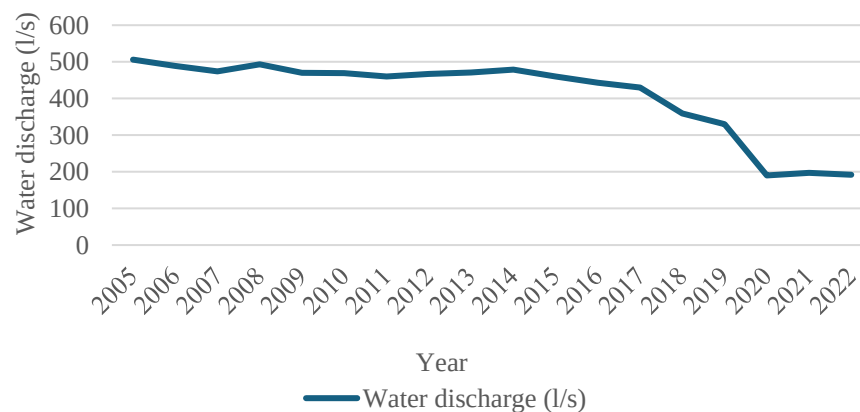


Figure 2. Ciburial spring discharge 2005 - 2022 (USAID 2020)

Figure 2 illustrates that over the period, there was a substantial 62% decrease in the discharge of Ciburial spring. Meanwhile, the demand for clean water in Bogor Regency is anticipated to rise, aligning with the projected population increase of 13.02% by 2035 (Central Bureau of Statistics, 2023c). The reduction in the volume of Ciburial spring is attributed to anthropogenic factors influencing the recharge area. Among these factors, changes in land use have a significant impact on groundwater recharge (Siddik et al., 2022). According to the land cover map, dryland agriculture emerges as the predominant land cover in the Ciburial spring recharge area, constituting 48% of the total area. Additionally, secondary dryland forest cover accounts for 29%, while settlements make up 16% of the recharge area.

The proliferation of anthropogenic factors in the Ciburial spring recharge area poses a significant threat to both water quantity and quality. To maintain water availability in Bogor Regency, effective land cover management in the recharge area is imperative. Among the various land cover types, vegetated areas, especially forests, play a crucial role in ensuring water availability. Forests, covering 30% of the Earth's surface, offer diverse benefits to humans, including vital services such as water provision and regulation (Jenkins and Schaap, 2018). Forest ecosystems play a pivotal role in determining water supply, acting as a prolific



source of clean water through the processes of storing, filtering, and releasing water for downstream use (Bates et al., 2008; Furniss et al., 2010).

The correlation between the upstream ecosystem and water quantity and quality underscores the significance of preserving vegetated ecosystems in the recharge area. The importance of protecting spring catchment areas is explicitly outlined in the Bogor Regency Regional Regulation (2021). To establish protected areas and optimize regional protection functions, the regulation suggests implementing various strategies. One such strategy involves preserving the vegetated ecosystems and restricting the development of built-up areas in riparian zones, lakes, and spring areas.

The description above highlights the crucial role of vegetated ecosystems, particularly forests and agricultural plants in the Ciburial spring recharge area, in ensuring water availability for Bogor Regency. To guide the future management and utilization of Ciburial spring, measuring the potential water supply and assessing the economic value of water provisioning services in the recharge area provides valuable insights to achieve sustainable spring management. Assigning monetary values to ecosystem services is a vital tool for creating awareness and emphasizing the importance of ecosystems to policymakers (de Groot et al., 2012). Additionally, the valuation of ecosystem services aids in decision-making regarding resource allocation among competing uses, particularly when monetary values, often based on market prices, may overlook the rights of future generations (Farley, 2008).

Based on the problem formulation that has been stated, the general objective of this research is to promote the value of ecosystem services, specifically focusing on water provisioning services in the Ciburial spring recharge area. The specific objectives of this study include:

- 1) Measuring the potential water supply in the Ciburial spring recharge area.
- 2) Estimating the economic value of water provisioning services in the Ciburial spring recharge area.

Methodology

This research is conducted at Ciburial Spring, Bogor Regency within the scope of the recharge area covering seven villages. The data collection process was conducted at the Head Office of Tirta Kahuripan Water Utilities, Bogor District. Data was collected from November 2023 to January 2023. The type of data used in this research is secondary data consisting of spatial data from various agencies such as the Ministry of Environment and Forestry (MoEF), the Meteorology, Climatology and Geophysics Agency (BMKG), and water data from Tirta Kahuripan water utilities. Secondary data is then processed using analytical tools through the InVEST, QGIS, and Microsoft Office Excel programs. Table 1 presents the research objectives, data required, and data analysis methods used.

Table 1. Objectives, data, and analysis method of the study

No.	Objectives	Data	Analysis Method
1.	Measuring the potential water supply in the Ciburial spring recharge area	- Land cover - Soil group - Digital elevation model - Rainfall - Evapotranspiration - Biophysical table	<i>InVEST Water Yield Model</i>



No.	Objectives	Data	Analysis Method
2.	Estimating the economic value of water provisioning services in the Ciburial spring recharge area	- Total water yield in the recharge area - Total cost of water production - The volume of water produced	<i>Market Price-Based Approach</i>

1) InVEST water yield model

The measurement of water yield, representing the potential water supply in the Ciburial spring recharge area, was conducted to ascertain the amount of water discharge produced by the area. This assessment was carried out using The Integrated Valuation of Ecosystem Services and Tradeoffs (INVEST) Water Yield Model. According to the Natural Capital Project (2022), InVEST serves as a tool for exploring how changes in ecosystems can influence the benefits that flow to society.

The InVEST Water Yield model estimates the relative contribution of water from different parts of the landscape, offering insights into how changes in land use patterns and climate impact water yield. It is a spatially explicit model that utilizes maps as information sources and generates maps as outcomes. This research employs the Seasonal Water Yield (SWY) analysis model in InVEST to measure the estimated total water yield for a catchment focusing on a baseflow, representing flow during the dry season which potentially becomes groundwater.

The analysis utilizing the InVEST SWY model provides a measurement of historical water yields from 2011 to 2020 and provides predictions of future water yields under two scenarios based on Shared Socioeconomic Pathways (SSPs). SSPs are socio-economic scenarios used to derive emission scenarios, considering both future socioeconomic changes and contributions to mitigating climate change (Siabi et al., 2023). The five SSPs scenarios suggest a temperature increase of 1.5°C in 2021-2040 and 3.3°C-5.7°C in 2081-2100, namely SSP126, SSP245, SSP370, and SSP585 (IPCC 2021). The future water yield prediction model analysis was conducted using the moderate scenario of SSP370 and the pessimistic scenario of SSP585. In the SSP370 scenario, countries tend to withdraw from international cooperative relationships and focus on their own economic goals. Meanwhile, in the SSP585 scenario, humans tend not to take significant actions to address climate change, exacerbating the existing conditions (Irfan 2021; Riahi et al. 2017).

According to Hamel et al. (2020), the InVEST Seasonal Water Yield (SWY) model has simple data requirements, including a globally available Digital Elevation Model (DEM), climate and soil data, and routing. The necessary data for the InVEST SWY analysis in this research are explained below.

Precipitation In general, precipitation refers to the relatively rapid formation of a soluble or solid crystalline phase from a liquid solution phase (Karpinski and Baldyga, 2019). Given that Indonesia is a tropical country, precipitation in this context refers to rainfall. Data on precipitation was sourced from the WorldClim online portal, utilizing monthly precipitation data and future precipitation in raster form (.tif) to generate precipitation maps. The historical climate data used represents a long-term average of precipitation in Bogor Regency.

Evapotranspiration Moreover, the precipitation map serves as the basis for calculating monthly evapotranspiration in the water yield model analysis (Nugroho, 2017). It is strongly

recommended to create a raster map of evapotranspiration based on the precipitation data used (Natural Capital Project, 2023). Monthly evapotranspiration data was generated in raster format using the raster calculator in QGIS.

Digital Elevation Model (DEM) DEM is a representation of the topographic surface of the bare ground on Earth, excluding trees, buildings, and other surface objects, derived from topographic maps (USGS 2023). DEMs offer a fundamental overview of the three dimensions of the Earth's surface and find applications in various disciplines such as geomorphometry, soil science, agriculture, land planning, and hydrology, among others (Guth et al., 2021). The DEM map used in this study was obtained from the Geospatial Information Agency (BIG) online portal.

Soil information The Seasonal Water Yield (SWY) model also necessitates soil information in raster form. The soil group map used is derived from the Bogor District soil map, obtained from the Agricultural Land Resources Research and Development Center (BBSDLP). In Bogor Regency, the predominant soil types include inceptisol, entisol, alfisol, and andosol.

Land use land cover Moving on, the land cover data utilized is sourced from the Bogor District land use map, obtained from the Ministry of Environment and Forestry (MoEF). The most prevalent land cover in Bogor Regency comprises dryland agriculture, followed by mixed dryland agriculture, paddy fields, settlements, secondary land forests, plantation forests, plantations, mining, primary dryland forests, open land, shrubs, and harbors.

Rain events The rainfall event data utilized in this model consists of monthly rainfall data for Bogor Regency, acquired from the online portal of the Meteorology, Climatology and Geophysics Agency (BMKG).

Biophysical table Additionally, the SWY model requires a biophysical table that includes crop coefficient (K_c) and curve number (CN) data for each land cover type in the Ciburial spring recharge area. The K_c value quantifies the actual evapotranspiration (AET) as the water demand by plants (Doorenbos and Fruit, 1977; Allen et al., 1998 in Runtunuwu, 2007). Meanwhile, CN values are utilized to estimate runoff depth directly from rainfall depth by providing an index that describes runoff response characteristics. In this model, the biophysical table will map each land cover and land use code to the biophysical properties of the corresponding land cover class (Natural Capital Project, 2023).

The seasonal water yield measurements in this study were conducted within the recharge area of Ciburial spring in Bogor Regency. The boundaries of the recharge area were delineated as part of the spring vulnerability assessment and action plan for Ciburial by USAID (2020). The recharge area is delimited at UTM 48S, covering an area of 1,163.39 hectares. This delineation serves as the definitive boundary for all analysis outputs.

The final output of the InVEST SWY model is baseflow which means the actual amount of water that infiltrates to soil and reaches the stream. In the InVEST model, baseflow is determined by the local recharge. Local recharge is the amount of precipitation that does not flow as quickflow and evapotranspiration by the vegetation cover and can infiltrate the soil (Halder *et al.* 2022). Natural Capital Project (2023) stated that if the local recharge is negative, then the pixel does not contribute to baseflow so baseflow is set to zero. If the pixel contributed to groundwater recharge, then baseflow is a function of the amount of flow leaving the pixel and of the relative contribution to recharge of this pixel. Baseflow that can be directly derived

from the proportion of the cumulative baseflow leaving cell i , with respect to the available recharge to the upstream cumulative recharge as presented in the equation below.

$$B_i = \max \left(B_{sum,i} \cdot \frac{L_i}{L_{sum,i}}, 0 \right) \quad (1)$$

2) Market-based approach

The ecosystem services concept provides a valuable framework for bridging the connection between people and nature and makes a case for the conservation and restoration of natural ecosystems (Grizzetti *et al.*, 2016). By linking ecological and socio-economic systems, ecosystem services help elucidate the crucial role of ecosystems in supporting human life, fostering greater appreciation, and advocating for the protection of global ecosystems (MARS, 2016).

Ecosystems play a vital role in the global hydrological cycle, contributing to water supply (total water yield), regulation in terms of timing and seasonal flow distribution, and purification, encompassing quality, biological purity, and sediment load (Dudley and Stolton, 2003; Bruijnzeel, 2004; Brauman *et al.*, 2007). Vegetation, especially forests, significantly influences water quantity in watersheds. It is widely assumed that forests, in comparison to grasslands and agriculture, enhance higher evapotranspiration, leading to increased atmospheric moisture, cloud formation, and rainfall (de Groot *et al.*, 2010).

In this study, an economic valuation was performed on the water supply services offered by vegetation ecosystems, particularly forests and agricultural plantations, in the Ciburial spring recharge area. The dominant land cover comprises dry farmland ecosystems and secondary dryland forests. These vegetation ecosystems contribute significantly to water provisioning services, culminating in the emergence of Ciburial spring.

The provisioning services to be assessed in this study are described through a cascade framework, illustrating the supply chain from environmental attributes (natural capital) where ecosystem services are derived through natural processes or human management activities. Figure 3 displays the cascade framework for provisioning services in this study.

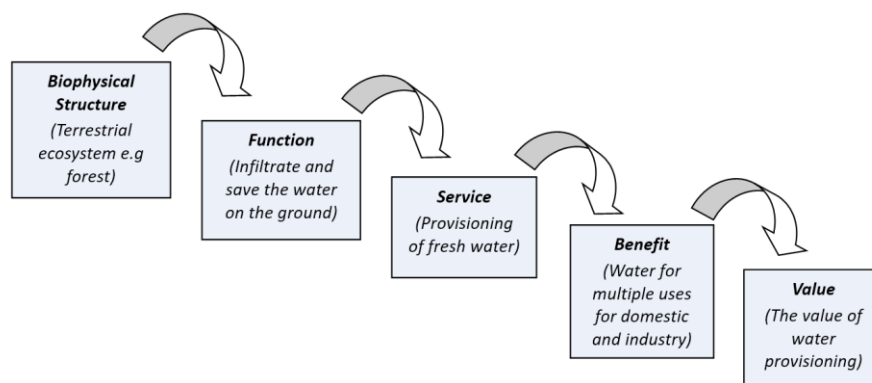


Figure 3. Cascade framework of water provisioning services (modified from Haines-Young and Potschin 2010)

Figure 3 illustrates the flow of the biophysical structure, specifically the water catchment area in the vegetated recharge area, which serves to absorb rainwater and store it in the ground as groundwater. Through this process, the vegetated ecosystem in the recharge area provides the

service of delivering clean water, essential for various domestic and industrial purposes. This study will calculate the value of this water supply service.

Economic valuation is commonly seen as the advantages of employing an ecosystem services framework, enabling the integration of benefits generated by ecosystems into cost-benefit analyses and other standard policy evaluation tools (Fisher et al., 2008). Transforming hydrological services into monetary values facilitates the comparison of these benefits with those produced by other ecosystem services within the same landscape (Brauman, 2015).

The calculation of the economic value of water supply services ideally involves market prices, incorporating components such as the market price of water and the estimated volume of water (Morgan and Orr, 2016). The market price of water can be derived through calculations using the total revenue component and the volume of water from Ciburial spring delivered by Tirta Kahuripan Water Utilities. However, due to limitations in accessing data on total revenue and volume of water delivered to all consumers, this study adopts the marginal cost of water approach.

The market price of water was approximated using the basic water tariff, calculated based on components such as the total production cost of Ciburial spring (IDR) and the volume of water produced by Ciburial spring (m³) in 2019. The total cost represents the overall production cost from January to December 2019, while the volume of water produced is the total net volume from Ciburial Spring during the same period. To adjust for inflation and obtain the total cost in the rate period to be calculated (year 2020), an inflation factor was applied to the total production cost in 2019 using equation (2).

$$TCi = TC \times (1 + i)^n \quad (2)$$

Legend:

TCi : Estimated total cost with inflation in 2020 (IDR)

TC : Total production cost in 2019 (IDR)

i : Average of inflation rate in 2020 (%)

Following the determination of the estimated total cost of producing Ciburial spring water, factoring in inflation for the year 2020, the calculation proceeds to determine the marginal cost. This cost reflects the basic cost associated with the volume of water produced. Equation (3) outlines the formula for calculating the marginal cost of Ciburial spring, acting as a proxy for the basic tariff of water produced from Ciburial spring.

$$MC = \frac{TCi}{Q} \quad (3)$$

Legend:

MC : Marginal cost (IDR/m³)

ETC : Estimated total cost with inflation (IDR)

Q : Volume of water produced (m³)

The application of equation (3) results in a marginal cost figure reflecting the fundamental cost of producing Ciburial spring water. As the base cost equals the base tariff, it is utilized to estimate the economic value of water supply services in the Ciburial spring recharge area (Yustiana et al., 2015).

Following the determination of the basic water tariff, the economic value of water supply services in the Ciburial spring recharge area was calculated using the market price method. This process involved multiplying the estimated water tariff by the water volume. As outlined by Morgan and Orr (2015), the calculation of the value of water supply services using market prices is presented in equation (4).

$$VW = P \times EV \quad (4)$$

Legend:

EV : Value of water provisioning services (IDR)

P : Water tariff (IDR/m³)

Q : Volume of water estimated in recharge area (m³)

Results and discussion

Measuring the potential water supply in the Ciburial spring recharge area

Water yield is a crucial ecosystem service provided by green vegetation, significantly contributing to human welfare. In the Ciburial spring recharge area, vegetation ecosystems play a vital role in generating the water supply service emanating from Ciburial spring. Ecosystems are linked with water production, underscoring the importance of understanding their role in delivering this benefit for human well-being (Karabulut et al., 2015).

The water from Ciburial spring is a crucial resource extensively utilized for both domestic and non-domestic purposes in Bogor Regency, managed by the operator Tirta Kahuripan Water Utilities. However, over the past 15 years, the discharge of Ciburial spring has exhibited a declining trend, attributed to anthropogenic activities altering land use upstream and changes in rainfall intensity due to climate change. If the decline is not addressed, projections suggest that Ciburial spring may face drought in the next 29 years (USAID, 2020).

Land cover conditions in the Ciburial spring recharge area have exhibited variations over time, encompassing types such as secondary forest, plantation forest, shrubs, settlements, dry agriculture, and mixed agriculture. Despite minimal changes in the land cover over the last decade (2011, 2014, 2017, and 2020), there has been a slight increase in the area of mixed dryland agricultural cover and settlements, coupled with a decrease in the area of dryland agricultural cover. However, secondary forest and plantation forest cover have remained unchanged. Figure 4 illustrates the land cover changes in the Ciburial spring recharge area from 2011 to 2020.

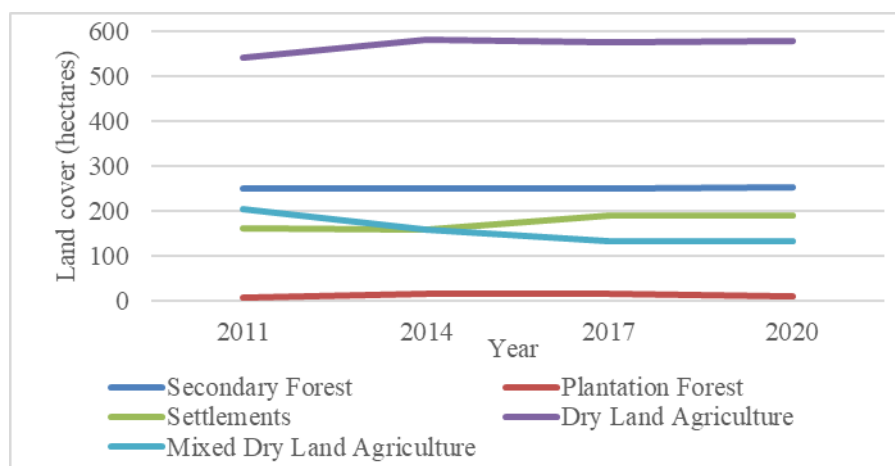


Figure 4. Land cover in the Ciburial spring recharge area (2011 – 2020)

An analysis using the Seasonal Water Yield (SWY) model was carried out to assess the water yield of the Cibural spring recharge area, aiming to understand the potential spring supply. The SWY analysis spanned a decade, specifically focusing on the years 2011, 2014, 2017, and 2020 and in the next two decades from 2021 to 2040 by using climate scenarios. The InVEST-SWY model operates on a pixel-scale water balance, assuming that upper slopes are partially available for a given pixel, influenced by factors such as location, geological characteristics, and land use on the upper slopes (Hamel et al., 2020).

The principal result derived from the InVEST SWY model in this study is baseflow, representing groundwater with the potential to emerge as springs. Baseflow represents the portion of water that effectively infiltrates the ground and reaches streams during the dry season (Halder et al., 2022; Natural Capital Project, 2023). It reflects the river's reaction to groundwater flow entering the stream at a slower rate (Hall, 1968). During the dry season, baseflow typically constitutes the predominant component of river flow in numerous streams, playing a significant role in supporting ecosystem and economic growth (Fan et al., 2013; Banks et al., 2011). Figures 5 and 6 illustrate the variations in both average and total baseflow in the Cibural spring recharge area for the past decade and for the next two decades in two different climate scenarios.

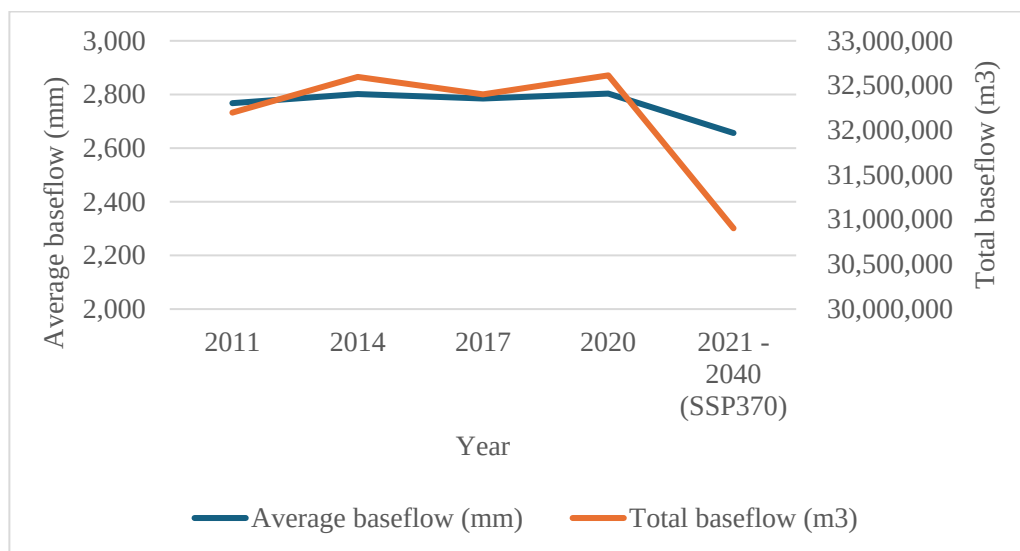


Figure 5. Trend of baseflow yield in the Cibural spring recharge area in 2011 – 2020 and 2021 – 2040 using the SSP370 climate scenario

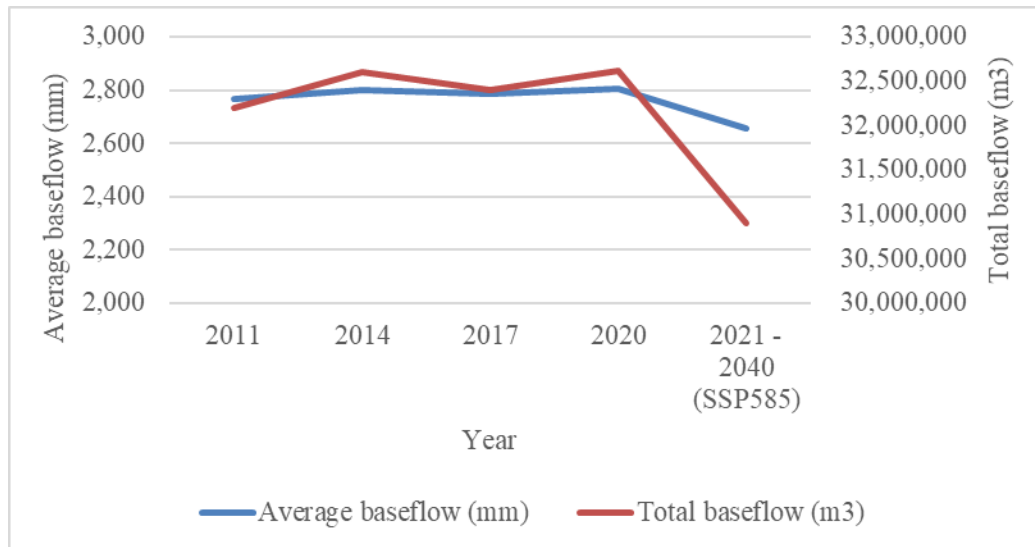


Figure 6. Trend of baseflow yield in the Ciburial spring recharge area in 2011 – 2020 and 2021 – 2040 using the SSP585 climate scenario

According to Figures 5 and 6, both average and total baseflow volumes fluctuated over the past decade and they will decrease in the next 20 years in both climate scenarios, moderate scenario (SSP370) and pessimistic scenario (SSP585). The water yield is primarily influenced by precipitation and evapotranspiration (Yin et al., 2020). Climate change, particularly changes in precipitation and temperature, is identified as a key factor contributing to the enhanced baseflow (Tan et al., 2020). Modifications in evapotranspiration, infiltration, land use, human activities, geography, and soil conditions can also influence alterations in baseflow (Bloomfield *et al.* 2021). Table 3 presents the average and total baseflow yields in the Ciburial spring recharge area in the past decade and the next two decades under the SSP370 and SSP585 scenarios.

Table 2. Average and total baseflow results in the historical and projected Ciburial spring recharge area

Year	Average Baseflow (mm)	Total Baseflow (m ³)
2011	2,767.46	32,196,350.77
2014	2,801.87	32,596,638.48
2017	2,785.10	32,401,539.60
2020	2,803.32	32,613,565.97
2021 - 2040 (SSP370)	2,656.34	30,903,623.95
2021 - 2040 (SSP585)	2,656.64	30,907,114.22

The result of baseflow (water yield) in the Ciburial spring recharge area in the last ten years and in the future projections is also illustrated in the figure below.

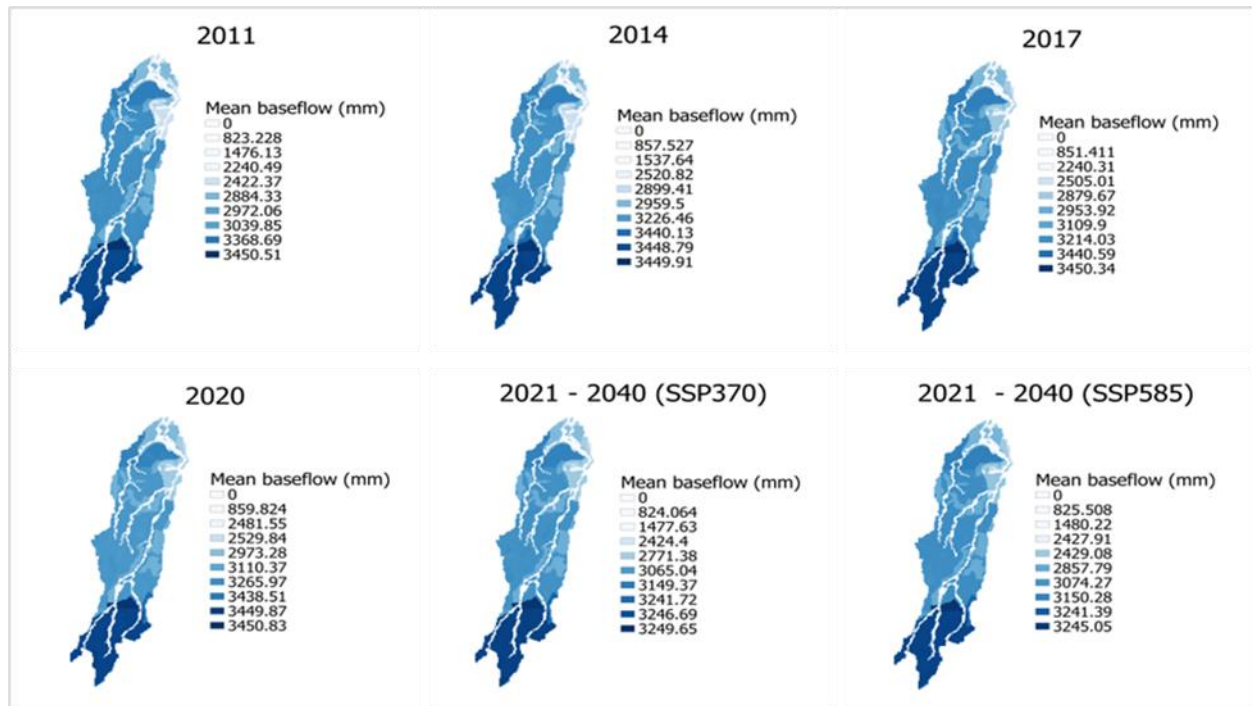


Figure 7. The baseflow in the Ciburial spring recharge area from 2011 to 2020 and from 2021 to 2040 using SSP scenario

Estimating the economic value of water provisioning services in the Ciburial spring recharge area

In 2020, the recharge area of Ciburial spring had approximately 578.76 hectares of dryland agriculture, 252.24 hectares of secondary forest, 189.12 hectares of settlements, 132.6 hectares of mixed dryland agriculture, and 10.6 hectares of shrubs. The vegetation in those land covers provides ecosystem services of water provisioning in this area which is the potential supply for Ciburial spring. Based on the result of objective one, in 2020, the volume of groundwater estimated in this area was 32,613,565.97 m³ with the projection that it will decrease in the next twenty years following the climate scenarios.

The economic value of water provisioning services was estimated by using the market-based approach. The market price of water was estimated using the basic water tariff, calculated based on the total production cost of Ciburial spring (IDR) and the volume of water produced by Ciburial spring (m³) in 2019. The total cost represents the overall production cost from January to December 2019, while the volume of water produced is the total net volume from Ciburial Spring during the same period.

To adjust for inflation and obtain the total cost in 2020, an inflation factor was applied to the total production cost through equation (2), with the average inflation rate in 2020 being 2.04%. Therefore, the estimated total cost of water production in Ciburial spring in 2020 was IDR 12,256,878,097. Subsequently, by using the total cost of Ciburial water production, we generated the marginal cost of water production in Ciburial spring which reflects the basic tariff of water (Yustiana *et al.* 2015). Table 4 provides the calculation of the marginal cost of water.



Table 3. Calculation of marginal cost of water in Ciburial spring 2020

Total cost (IDR)	Quantity of water produced (m ³)	Inflation rate (%)	Total cost with inflation (IDR)	Marginal cost (IDR/m ³)
4,031,867,795	12,955,484	2.04	12,256,878,097	946.08

According to Table 4, the basic tariff of water reflected by the marginal cost of water in Ciburial spring was IDR 946.08/m³. Therefore, the economic value of water provisioning services in the recharge area of Ciburial spring was generated by multiplying the basic tariff of water (IDR/m³) with the estimated water volume in an area (m³) which is provided in Table 5.

Table 4. The economic value of water provisioning services in Ciburial spring recharge area in 2020

Water volume estimated (m ³)	Basic tariff (IDR/m ³)	Economic value of water provisioning services (IDR)
32,613,565.97	946.08	30,855,042,497.22

Table 5 shows that the economic value of water provisioning services in the recharge area of Ciburial spring was IDR 30,855,042,497.22 in 2020. This indicates that the vegetated ecosystems in the Ciburial spring recharge area are crucial and has a high economic value. The forests, agricultural plants, and shrubs in the recharge area play a role in protecting the upstream area, especially ensuring constant accessibility to water, particularly for Ciburial spring.

Conclusion

Water provisioning services stand as a pivotal aspect among the services offered by the ecosystems in the Ciburial spring recharge area. The findings of this study reveal a nuanced trend in the volume of water yield, depicting a subtle fluctuation over the past decade, with an average annual volume of approximately 32 million m³. The stability of water yield during this period can be attributed to minimal changes in land cover within the area.

A noteworthy revelation emerges from the projection analysis, forecasting a potential decrease in water yield to approximately 30 million m³/year over the next two decades. This projection, contingent upon climate changes and assuming no alteration in land cover, signals a future shift in the dynamics of water provisioning services in the Ciburial spring recharge area.

The economic valuation conducted in 2020 estimates the value of water yield to be IDR 30,855,042,497.22 per year, underscoring the economic significance of this crucial ecosystem service. This valuation serves not only as a reflection of the current state but also as a foresight into the potential economic implications of alterations in water yield.

These revelations, encapsulated in the study, hold the potential to elevate awareness among society, regional governance bodies, and academia regarding the importance of preserving the green ecosystem in the Ciburial spring recharge area. Furthermore, the study can serve as a foundational framework for initiatives aimed at maintaining the surrounding Ciburial spring catchment area, aligning with the optimization of regional protection functions as outlined in the Bogor Regency Regional Regulation.



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Track 5

Consumer behavior



Per Capita Fish Consumption in Nay Pyi Taw Union Territory, Myanmar

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Abstract

Eating the nutrients of both plant and animal origin that the human metabolism needs is essential to maintaining a healthy and balanced lifestyle. Fish is the primary food source of animal proteins. Humans require diets rich in high-quality proteins, fats, vitamins, and minerals, especially those found in fish. Numerous researches have investigated fish's nutritional value and role in the human diet from various perspectives. However, there is still a lack of research activities that calculate the fish consumption rate of households. The purpose of this study is to ascertain how much fish each household in Nay Pyi Taw, Myanmar, consumes on a per capita basis. In November 2021, 390 sample households were interviewed. After the data collection, data entry was done using Microsoft Excel, and STATA statistical software was used for analysis. The most popular fish across all sample households were mrigal, featherback, small fish, common catfish, and short-headed catfish. The household level average annual fish intake in the study area was 9.80 kg, which was substantially below than the per capita fish consumption rate (30 kg) indicated by World Fish Myanmar. The research findings provide valuable insights for policy makers who formulate policies about the nation's fish export and production. It would also be helpful to researchers looking into the nation's nutritional status.

Keywords: animal proteins, fish consumption, Nay Pyi Taw

JEL code: D10, E 29, L66

SDG goals: Zero Hunger, Good Health and Well-being, Responsible Consumption and Production, Life Below Water

Introduction

The three most essential basic necessities for human beings are food, shelter, and clothing. Food is a basic need and necessity of life that must be satisfied before any other developmental issue. Nutrition is a physiological phenomenon that plays a major part in giving the body energy it needs to sustain its metabolic processes (Aydemir, 2018, p.145). To sustain a healthy and balanced life, one must eat the foods of both plant and animal origin that the human metabolism requires. The main source of animal proteins in meals is fish. Foods high in quality proteins, lipids, vitamins, and minerals, particularly those found in fish, are necessary for human beings (Che et al., 2022, p.2). Additionally, they can be a great source of important fatty acids. Several researchers have examined the nutritional worth of fish and its significance in the human diet from diverse angles. Moreover, consuming fish may help reduce heart disease, high blood pressure, cholesterol, Alzheimer's disease, and some cancers, according to certain studies (Harvard T.H. Chan School of Public Health, 2008, para. 2 & 6).

Fisheries products are particularly vital in developing nations like Bangladesh, Cambodia, and some of the poorest Asian nations, where they provide 75% of the daily protein needed for human consumption (Menna, 2008, para. 1). In Myanmar, fish is one of the most important sources of animal proteins. Moreover, Myanmar has relied on fisheries as one of the vital component of its food security and economic livelihoods because of its vast coastline, varied inland water bodies, and rich aquatic biodiversity (World Fish, 2021, para 1 & 2). However,

there are few research studies looking at fish consumption rates at the household-level. Therefore, it is needed to explore the per capita fish consumption of the households in Myanmar. If per capita fish consumption is unchecked, aquatic ecosystems would be under tremendous pressure as a result. This paper aims to investigate the amount of per capita fish consumption of the households in Nay Pyi Taw, Myanmar. From the results of this paper, it will be possible to know the status of fish consumption rate at the household level in the study area. The specific objectives of the study are to investigate demographic characteristics, income, and expenditures of sample households and to observe commonly consumed fish items and to identify the per capita fish consumption of sample households in Nay Pyi Taw.

Methodology

The study was conducted by implementing surveys with the respondents who are the residents of Zeyarthiri, Ottarathiri, and Pobbathiri townships in Nay Pyi Taw, Myanmar. In November 2021, the primary data gathering survey was conducted using a structured questionnaire. The purposive random sampling method was utilized when selecting the sample respondents. The potential respondents were based on the fact that they are the main household members managing food at the households to collect data on food consumption changes. The information about the demographic profile, income and expenditure condition, and fish consumption of the sample households were collected. After collecting the data, data entry was carried out in Microsoft Excel and analyzed by utilizing STATA statistical software. Descriptive statistics were used to calculate and investigate the demographic characteristics and per capita fish consumption of the sample households.

When computing per capita fish consumption, the amount of household monthly fish consumption was divided by the total adult equivalent number of the household members. The five age groups were categorized to classify the adult equivalent. As the adult equivalent conversion factors, it takes only 0.5 for a child who is one and under one year old, only 0.7 for an adult who is 60 and over 60 years old, and for a child, who is between 9 and 2 years old. Moreover, it is counted as 1 for people who are between 59 and 19 years old and 1.1 for people who are between 18 and 10 years old (MOHS, 2019, p.36). According to the income level of the sample households, three income groups (Soe, et al., 2023, p.2) were classified into low-income group (between US\$ 28 and US\$ 141 per month), middle-income group (between US\$ 142 and US\$ 245 per month) and high-income group (between US\$ 246 and US\$ 2,030 per month) to identify and compare the per capita fish consumption of different income groups.

Results and discussion

Demographic information of respondents of selected households

The socio-economics characteristics of respondents from sample 390 households are shown in the following tables. The average age of the sample respondents was 44 years, the maximum age was 75 years, and the minimum age was 18 year old. The respondents' average household size was 4. However, there was only one household member in some households, and there were up to 13 household members in other households (Table 1). When conducting the survey, the respondents who were the main cooks at home were interviewed. Therefore, the majority of the respondents were female (95%), while only 5% were male (Table 2).

Table 1. Demographic characteristics of the sample respondents (n= 390)

Items	Unit	Average	Minimum	Maximum	SD
Age	Year	44.24	18	75	12.15
Household size	No.	3.77	1	13	1.75

Source: Survey data of Department of Agricultural Economics, 2021

Table 2. Gender status of the sample respondents (n= 390)

Items	Frequency	Percentage
Male	21	5.38
Female	369	94.62

Source: Survey data of Department of Agricultural Economics, 2021

Based on the education level of the respondents, 40% of selected respondents were graduates from a university. The remaining 18% was primary education level, 23% was secondary education level, and 19% was high school education level (Figure 1). Among the sample respondents, 37% of the respondents were working in the public sector, whereas 24% of them were working in the private sector for their main income source. There were 15% of farmers in the selected households. Some respondents who spend their time by doing housework took account 24% in total (Figure 2).

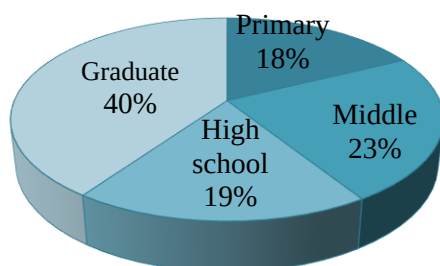


Figure 1. Education level of the sample respondents (n= 390)

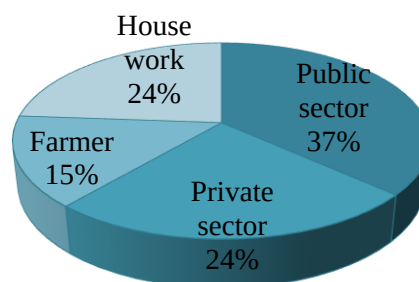


Figure 2. Occupation of the sample respondents (n= 390)

Source: Survey data of Department of Agricultural Economics, 2021

The detailed information about number of household members' distribution by age group of the sample respondents are shown in Table 3. There were 1,467 household members in the selected households. Among them, the majority of household members were between 59-19 years age group (66%). It is followed by 18-10 years age group of household members (15%), ≥ 60 years age group (10%), 9-2 years age group (9%) and $\leq$ one year age group (1%)

Table 3. Household members' distribution by age group of the sample respondents (n= 390)

Age group	Frequency	Percentage
≥ 60 years	142	9.68
59-19 years	963	65.64
18-10 years	216	14.72
9-2 years	133	9.07
$\leq$ one year	13	0.89
Total	1,467	100.00

Source: Survey data of Department of Agricultural Economics, 2021

The consumption rate is different depending on the age group. Therefore, the adult equivalent number of sample household members was calculated to find out per capita fish consumption of the sample household members. Although there were 1,467 household members in the selected household by their age group, only 1,400 household members in total could be found according to adult equivalent ratio (Table 4).

Table 4. Total household members by adult equivalent of the sample respondents (n= 390)

Items	Frequency
Total household members by age group	1,467
Total household members by adult equivalent	1,400

Source: Survey data of Department of Agricultural Economics, 2021

Income, expenditure and food cost information of selected households

The sample households' monthly income, expenditure, food and fish cost has described in Table 5. It was found that the average income of the total household was US\$ 227/month that was used US\$ 165/month as average household expenditure. However, in some households, it was also discovered that all the income was used for the household expenses. The sample households utilized around US\$ 113/month as their average food cost from their average household expenses. In addition, the average expenditure for fish consumption of the sample households was US\$ 8/month, and the range was from US\$ 1/month to US\$ 28/month.

Table 5. Monthly household income, expenditure, food and fish cost of sample households (n= 390)

Items (US\$/month)	Average	Minimum	Maximum	SD
Household income	227.04	28.20	2030.46	177.14
Household expenditure	165.20	28.20	676.82	89.05
Food expenditure	112.82	22.56	394.81	56.00
Fish expenditure	7.59	0.56	28.20	5.21

Source: Survey data of Department of Agricultural Economics, 2021

Note: 1 US\$ = 1773 MMK (Exchange rate of 1st November, 2021)

Commonly consumed fish species of the sample households

There are several species of fish that are usually consumed in Myanmar. The top five commonly consumed fish species among the selected households are summarized as follows (Figure 3). Mrigal, featherback, small fish, common catfish and short-headed catfish were the most consumed fish species by the total sample households. Mrigal was the top-most commonly consumed fish variety ate by 86% of the sample households. The second highest consumed fish item was featherback (41%), followed by small fish (20%), common catfish (19%) and short-headed catfish (15%), respectively. When changing the names of the fish from Burmese to English, the translation document published by the Department of Fisheries, Myanmar was referred (p. 15 & 16).

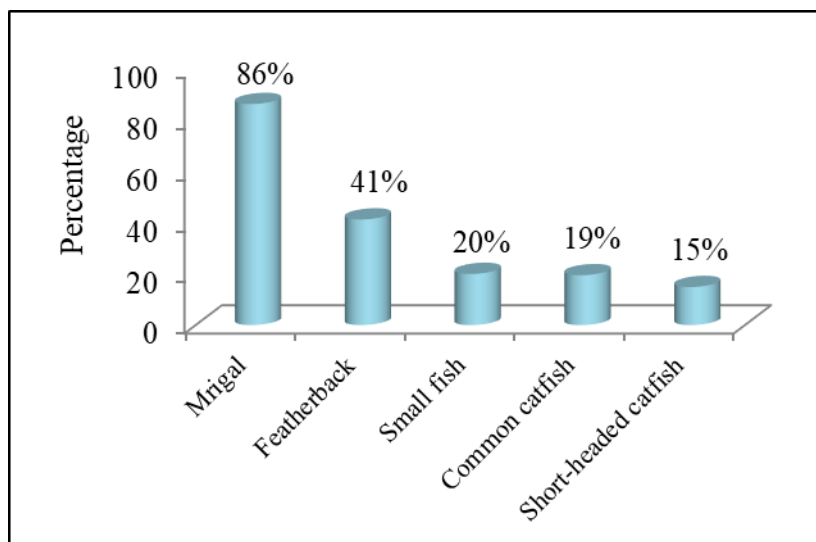


Figure 3. Five most-consumed species of fish of the respondents
Source: Survey data of Department of Agricultural Economics, 2021

Per capita consumption of fish of the sample households

The world average annual per capita fish and seafood consumption was 19.00 kg in 2021 (Statista, 2023, para 1). The average annual per capita fish and seafood consumption of CLMV countries in 2021 were 38.31 kg in Cambodia, 25.51 kg in Laos and 28.36 kg in Vietnam (FAO, 2021). According to the data of World Fish Myanmar, Myanmar's average fish consumption was estimated as 30 kg per capita per year (World Fish, 2021, para 1).

Fish consumption was measured by the self-reported frequency of fresh fish consumption of the households. When calculating fresh fish consumption in this study, consumption of fish-based products was not included. In this section, the monthly and annual per capita consumption of fish by the selected households are presented in Table 6. The adult equivalent number of total household members (1,400 household members) was utilized to calculate the per capita consumption of fish. The average per capita monthly consumption of fish was 0.82 kg and ranged from 0.03 kg to 4.35 kg. The average annual per capita fish consumption of the respondents at the household level was 9.80 kg, and it ranged from 0.42 kg to 52.16 kg.

Table 6. Per capita fish consumption of sample households (n= 1400)

Items (kg)	Average	Minimum	Maximum	SD
Monthly consumption	0.82	0.03	4.35	0.63
Annual consumption	9.80	0.42	52.16	7.56

Source: Survey data of Department of Agricultural Economics, 2021

In this study, the income group levels of the selected households were classified to compare per capita fish consumption of the sample households (Table 7). As the adult equivalent of household members, 409 household members were found in the low income group (US\$ 28 – US\$ 141/ month). Furthermore, 491 household members in the middle income group (US\$ 142 – US\$ 245/ month) and 500 household members in the high income group (US\$ 246 – US\$ 2030/ month) were discovered according to the adult equivalent ratio.

Table 7. Household members and adult equivalent of different income groups

Income group	Range	No. Household members	Adult equivalent of household members
Low income group (n=126)	US\$ 28 – US\$ 141/month	434	409
Middle income group (n=147)	US\$ 142 – US\$ 245/month	515	491
High income group (n=117)	US\$ 246 – US\$ 2030/month	518	500

Source: Survey data of Department of Agricultural Economics, 2021

The description of monthly and annual per capita fish consumption by different income groups of sample households are described in Table 8. Among the different income groups, the sample households from the middle income group consumed the most fish per capita, averaging 0.88 kg per month and 10.50 kg annually. The per capita fish consumption rates by the low income group were 0.78 kg/month and 9.40 kg/year, and per capita consumption rates of fish by the high income group were 0.78 kg/month and 9.36 kg/year. According to this data, it was discovered that the sample households from the middle income group consumed more fish than those in the low and high income groups.

Table 8. Per capita fish consumption of different income groups of sample households

Items	Low income group (n= 409)		Middle income group (n=491)		High income group (n= 500)	
	kg/month	kg/year	kg/month	kg/year	kg/month	kg/year
Average	0.78	9.40	0.88	10.50	0.78	9.36
Minimum	0.16	1.96	0.03	0.42	0.07	0.86
Maximum	3.26	39.12	4.35	52.16	3.49	41.91
SD	0.56	6.70	0.69	8.28	0.62	7.50

Source: Survey data of Department of Agricultural Economics, 2021

Conclusion

In the study, the average household size of the sample respondents was 4 and the average age was 44 years as well as most of the sample respondents were female. Most of the sample respondents were graduates and they were working in the governmental sector. There were several items of fish that were eaten by the respondents, and mrigal, featherback, small fish, common catfish and short-headed catfish were being the most commonly consumed fish items among all sample households. The adult equivalent ratio indicated that only 1,400 household members were detected overall, despite the fact that 1,467 household members were present in the households that was chosen based on age group.

The average yearly per capita intake of fish at the household level, which was approximately 9.80 kg, was significantly less than the per capita fish consumption rate estimated by World Fish Myanmar. In this study, the consumption rate of fish-based products of households was not taken into account when calculating the fish consumption rate, but it was found that there are significant differences between the fish consumption rate reported on websites and the fish consumption rate of households in practice. Therefore, there is a need to conduct research that studies the rate of fish consumption on a national level in order to accurately know the rate of fish consumption by households in Myanmar. Myanmar is the aquatic rich country therefore the fisheries sector vital to the national economy and food security. Therefore, Myanmar fishery sector is critically important not only important for the export but also for the domestic



demand and public nutrition as fish is the healthy food item. The results of this research are useful information for policy makers who make strategies for developing the fishery sector by demand driven approaches. In addition, it would be able to assist those who are studying the country's nutritional status.

Acknowledgements

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Healthy Rice Consumption Behaviour in Nay Pyi Taw, Myanmar

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Abstract

Myanmar is still facing challenges related to nutrition, including prevalent health issues like anemia, stunting, and wasting. Anemia, specifically, is acknowledged as a public health concern in the country. Simultaneously, the incidence of non-communicable diseases such as obesity, hypertension, and diabetes is on the rise, contributing to increased morbidity and mortality. Myanmar exhibits a high per capita consumption of rice, making healthy rice a culturally adaptable solution to address its nutrition-related health challenges. Therefore, this study seeks to investigate the factors influencing the choice of healthy rice among Myanmar rice consumers. Data for this study were collected from 481 rice consumers in Nay Pyi Taw, the capital of Myanmar, between September and October 2023. Descriptive statistics, t-test, chi-square test, and binomial logit model were employed to achieve the study objectives. Only 18% of rice consumers reported choosing healthy rice. Several factors drive rice consumers to choose healthy rice, including the education level of the respondent, the presence of children or elderly household members, household monthly income, knowledge score, and habitual health-related behaviour score. While knowledge significantly influences consumption, its impact is mediated by factors such as income. Therefore, targeted knowledge-sharing programs should prioritize medium-income group consumers with vulnerable households for optimal effectiveness. The habitual health-related behaviour score showed a highly significant association with healthy rice consumption, emphasizing the need to promote good health habits, such as exercise routines, by providing facilities and creating environments conducive to physical activities, given the currently limited access in Myanmar.

Keywords: Myanmar, rice consumers' choice, healthy rice

JEL code: D12 - Consumer Economics: Empirical Analysis

SDG goal: Good Health and Well-being

Introduction

Myanmar has a high per capita rice consumption of 155.14 kg/year (425.04 g/day) (Myint et al., 2016). Being a low-income Southeast Asian country with a population of approximately 51.47 million, Myanmar faces persistent nutrition-related issues. Anemia is a significant public health concern, particularly affecting children and women. According to the Myanmar Micronutrient and Food Consumption Survey (MMFCS) 2017, around 35.6% of children aged 6-59 months, 51% of children aged 5-9 years, 30% of adolescent girls (age 10-14), and 30% of women of reproductive age (age 15 to 49) are anemic (MoHS, 2019a). Stunting, which is indicative of chronic undernutrition in children under 5 years old, is also prevalent, with Myanmar classified in the high threshold level (20-<30%) at 27%. Additionally, acute undernutrition or wasting affects 7% of children (FAOSTAT, 2018).

In addition, non-communicable diseases (NCDs) are on the rise, contributing to increased morbidity and mortality (CSO, 2021; Swe et al., 2020). Conditions such as obesity, hypertension, and diabetes are becoming more prevalent, mainly due to factors like food quality, food safety, and dietary habits. The Myanmar Demographic and Health Survey (2015–2016) reported a high prevalence of overweight (28.1%) and obesity (13.1%) among women of reproductive age (Hong et al., 2018). Hypertension rates were found to be increasing from



23.5% in 2003-2004 to 30% in 2009-2010. Diabetes prevalence in Myanmar is notably higher than in other ASEAN countries, increasing from 8.1% in 2004 to 10.5% in 2014 among residents aged 25 to 64 years (Latt et al., 2019). These health issues are more prevalent in urban areas than in rural areas (Aung et al., 2018; Thapa et al., 2021).

In this study, "healthy rice" refers to a combination of fortified rice, brown rice, rice berry rice, konjac rice, basmati rice, and parboiled rice; those that are polished white rice as alternative choices of staple food consumption considered healthy diets. These types of rice are found to be consumed in Nay Pyi Taw, the capital. Among them, fortified rice is an important choice to address anemia, one of the most significant health problems in Myanmar. It is a combination of normal rice grains with fortified grains, achieved by adding rice flour, six vitamins (vitamin A, B1, B6, B12, folic acid, and niacin) and two minerals (iron and zinc) based on the dietary patterns and nutritional status of Myanmar's population (MoHS, 2019b). Existing literature supports that fortified complementary foods are effective in preventing anemia (Csölle et al., 2022; WHO, 2018). As of 2022, nine countries globally mandate rice fortification through legislation, including Papua New Guinea, Solomon Islands, US, Costa Rica, Nicaragua, Panama, Peru, Philippines, and India. Additionally, studies indicate that other healthy rice varieties, such as brown rice, rice berry rice, and konjac rice, possess anti-obesity and anti-diabetes effects due to their high phytochemical content compared to white rice (Melini & Acquistucci, 2017; Ravichanthiran et al., 2018; Yoshizaki et al., 2014). Understanding choices of rice consumption is important to address nutrition-related health challenges in Myanmar as it is a staple food and culturally adaptable option. This study aims to explore the factors that drive Myanmar rice consumer to choose healthy rice.

Methodology

Data Collection

A total of 481 rice consumers aged 18 years and older were interviewed during September to October 2023. The survey took place in Nay Pyi Taw Council Territory, the administrative capital of Myanmar. Among the eight townships in Nay Pyi Taw, four townships, namely Zabuthiri, Pyinmana, Pobbathiri, and Zeyarthiri, were selected based on the highest urban population percentage.

The sampling procedure for this study aimed to include consumers from different income groups and households with children under 5 years old. This consideration took into account the varying affordability and purchasing behavior based on household income, as well as the prevalent use of fortified rice as a baby supplement in Myanmar. To ensure the inclusion of these household types, participants were selected from open markets, modern trade stores, and parents visiting playgrounds/preschools.

The total sample size of 481 was allocated proportionally across the four selected townships based on their total urban population. As Zabuthiri township has the highest urban population among the four townships, 41% of the total sample (197 participants) was selected from there. Approximately 136 participants (28% of the total sample) were selected from Pyinmana, 84 (17% of the total sample) from Pobbathiri, and 64 (14% of the total sample) from Zeyarthiri townships, based on their respective urban population numbers.

The selected samples from each township were evenly distributed among three locations: open markets, modern trade stores, and preschools/playgrounds as shown in Table 1.

Table 1. Sample size allocation by township and market places

Township	Urban population ^a	Percent of Population	Number of Respondents				Percent of Respondents
			Open market	Modern trade store	Preschool/ Playground	Total	
Zabuthiri	104,596	41	68	64	64	197	41
Pyinmana	72,010	28	48	44	44	136	28
Pobbathiri	44,437	17	28	28	28	84	17
Zeyarthiri	35,106	14	24	20	20	64	14
Total	256,149	100	168	156	156	481	100

^aSource: Department of Population (2015)

Data Analysis

Descriptive analysis was performed to present the socio-demographic characteristics of the respondents. A t-test and chi-square test were utilized to determine whether the difference between the healthy rice and normal rice groups is statistically significant. The contribution of selected variables to consumer choices to consume healthy rice was tested using binary logistic regression model.

The binary response variable y , was denoted as $y=1$ if a consumer chose to consume healthy rice and $y=0$ if otherwise. Assuming that the probability of $y=1$ is P , the function of y is as follows:

$$f(y) = P^y (1 - P)^{1-y}, y=0,1 \quad (1)$$

This paper employed the maximum likelihood estimation method to compute for the regression parameters. The basic form of the logit model is given by:

$$\text{Prob}(y_i = 1) = P_i = \frac{1}{1+e^{-z_i}}, \text{ where } z_i = \beta_0 + \sum_{j=1}^8 \beta_j X_{ij} + \mu_i \quad (2)$$

The probability of $y_i=0$ is given by:

$$\text{Prob}(y_i = 0) = 1 - P_i = 1 - \frac{1}{1+e^{-z_i}} = \frac{1}{1+e^{z_i}} \quad (3)$$

Here, P_i is the probability of consumer i , β_0 is the intercept, β_j is the regression parameter of influencing factor j , X_{ij} is the independent variable representing influencing factor j in sample i , μ_i is the error term.

In the case where P_i is strictly between 0 and 1, the method involves transforming P_i to obtain $\text{Logit}(y) = \ln\left(\frac{P_i}{1-P_i}\right)$. The odds ratio was calculated as:

$$\text{Odds Ratio} = \frac{P_i}{1-P_i} = \frac{1+e^{z_i}}{1+e^{-z_i}} = e^{z_i} \quad (4)$$

The logit (y) is expressed as:

$$\text{Logit}(y) = \ln\left(\frac{P_i}{1-P_i}\right) = \ln e^{Z_i} = \beta_0 + \sum_{j=1}^8 \beta_j X_{ij} + \mu_i \quad (5)$$

Logit, the log of the odds ratio, is not only linear in X, but is also, from the estimation view point, linear in the parameters. The description of dependent and independent variables used in the model are presented in Table 2.

Table 2. Description of variables used in the logit model

Symbol	Name	Description	Unit of measurement
y	Consumer's consumption behavior for healthy rice	This variable indicates whether the respondent has consumed healthy rice in the past three years (1) or has not consumed healthy rice in the past three years (0).	Binary (1 or 0)
X ₁	Respondent's age	The age of the respondent	Years
X ₂	Education of respondent	The number of schooling years completed by the respondent	Years
X ₃	Household size	The count of individuals living in the respondent's household (defined as the same housing unit for at least six months, sharing meals and expenses)	Count
X ₄	Existence of children in household	Indicates whether there are children in the respondent's household.	Dummy (1 for Yes, 0 for No)
X ₅	Existence of elderly household member	Indicates whether there is an elderly member in the respondent's household.	Dummy (1 for Yes, 0 for No)
X ₆	Household monthly income	The monthly income of the respondent's household	Million MMK (Myanmar Kyat)
X ₇	Knowledge score	A numerical score representing the respondent's knowledge about anemia, diabetes, and nutrition based on 24 questions (1 point for each correct answer)	Numeric score
X ₈	Habitual health-related behavior score	A numerical score representing the respondent's habitual health-related behaviors, including exercise routine, fruit and vegetable consumption, etc. (1 point for each healthy habit, assessed through 8 questions)	Numeric score

Results and Discussion

Healthy rice consumption

The fact that healthy rice is mainly found on the shelves of modern trade stores suggests limited healthy rice consumption, as rice trade in Myanmar typically occurs in retail or wholesale shops rather than modern trade stores. Despite efforts to include a diverse population for the purpose of comparing healthy rice consumers and non-consumers, only 88 out of 481 respondents (18% of total sample) reported consuming healthy rice. Among these, 22 respondents are current consumers, while the remaining 66 have tried healthy rice in the last three years. Fortified rice stands out as the most popular choice among healthy rice consumers, making up more than half

of the total (57%). This could be because of the efforts of various organizations like the Ministry of Health and Sports, Ministry of Social Welfare, Relief and Resettlement, LIFT, PATH, and the World Food Programme. These groups have worked together on different activities, such as providing technical assistance to fortified rice producers, incorporating fortified rice in schools' lunch program, distributing fortified rice to vulnerable populations and making effort for demand generation (Thi, 2017; WFP, 2019). Brown rice comes in as the second most consumed type, accounting for 27%. Basmati rice takes the third position in terms of consumption. Other varieties of healthy rice, such as rice berry rice, konjac rice, and parboiled rice, show negligible usage, each accounting for less than 1% as shown in Figure 1.

The reasons for consuming healthy rice include the presence of vulnerable household members such as children and elders, anemic individuals, diabetes patients, and cancer patients. It is also chosen for achieving target weight and during family weak times, such as the COVID period, or simply as an experiment. On the other hand, reasons for discontinuing consumption include a dislike for the taste, high prices, difficulty in purchasing, achieving target weight, and the necessity of preparing separate meals for patients.

Interestingly, some respondents mentioned that they are concerned about the suitability of these rice varieties for children. The rationale provided by some respondents is that they did not seem to notice the apparent benefits of consuming healthy rice. This lack of awareness may be attributed to the fact that the benefits of healthy rice may not be immediately apparent and may necessitate a more prolonged period of consumption, as opposed to the brief trial periods some respondents have undertaken. For instance, in the case of fortified rice, continuous consumption for at least six months is recommended to observe the benefits, which may not be as immediately noticeable as with certain medications.

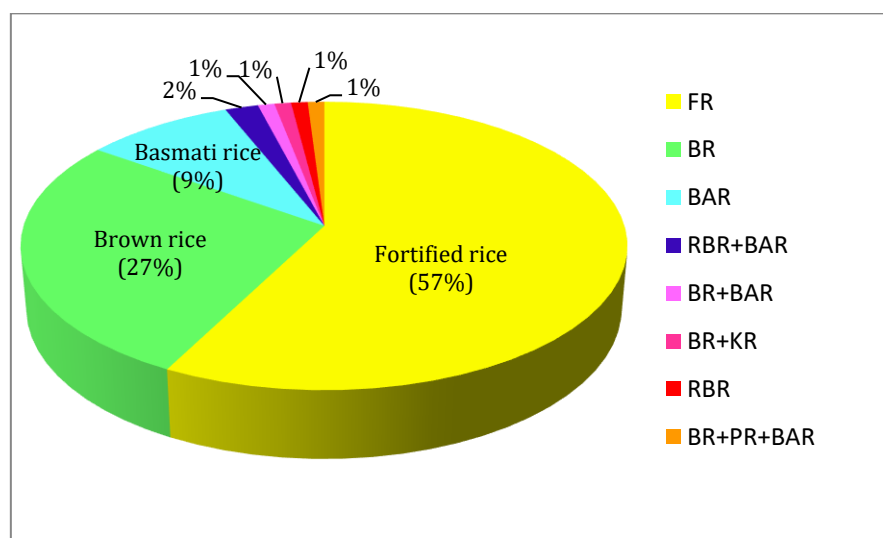


Figure 1. Type of healthy rice consumed by the respondents (n=88)

Note: FR=Fortified rice, BR=Brown rice, BAR=Basmati rice, RBR=Rice berry rice, KR= Konjac rice, PR=Parboiled rice

Socio-demographic profile of the respondents

The socio-demographic characteristics of respondents are presented in the Table 3, divided into two groups: (a) those who had consumed any healthy rice in the past three years (healthy rice group: 88 respondents, i.e., 18%); and (b) those who had never consumed any healthy rice in the past three years (normal rice group: 393 respondents, i.e., 82%). The share of women consuming healthy rice is much higher than that of men, possibly because women often play a major role in household purchase decisions. The gender proportion is nearly identical in both the healthy rice and normal rice groups.

For respondents who chose normal rice, the ages skewed towards an older group (above 35 years old), while for respondents who chose healthy rice, the ages varied between 26 and 35 years old.

Half of the respondents have a bachelor's degree or above, and half have a high school education or below. While respondents who chose healthy rice show a higher educational level, with more than 70% having completed a bachelor's degree and above, only above 40% is in the normal rice group. The results of chi-square tests revealed a significant difference in education levels between the normal and healthy rice-consuming respondent groups ($\chi^2 = 25.764$, $p\text{-value} = 0.000$).

Income sources also significantly differ between the healthy rice group and normal rice group. Unskilled workers make up a large part of the normal rice group at 36%, while the healthy rice group is dominated by government staff, self-employed enterprises, and skilled workers.

Income groups of normal and healthy rice consumers are also differ significantly. More than 70% of healthy rice consumers are in medium and high income groups, however, nearly half of normal rice consumers (47%) are in low income group.

About half of the respondents (52%) have three or four family members and 39% have more than 5 household members and 9% have less than 2. The number of household members is not different between healthy rice and normal rice groups. Interestingly, healthy rice groups have more vulnerable household members of children and elder members, and the significant difference is supported by chi-square results. The existence of anemic and diabetic household members is also different between healthy rice and normal rice groups, showing significant results with chi-squared tests. About 31% of the healthy rice group and 17% of the normal rice group has a diabetic member.



Table 3 Socio-demographic characteristics of the respondents and type of rice consumed

Characteristics	Mean and Std. Dev	Number of Sample and (%)	Respondent Group (%)		Chi-Square	Sig.
			Healthy Rice	Normal Rice		
Number of respondents		481 (100%)	88 (18%)	393 (82%)		
Gender	-				0.024	0.876
Male		57 (12)	11	12		
Female		424 (88)	89	88		
Age (years)	38.84 (10.77)				7.245	0.064*
18-25		33 (7)	5	7		
26-35		177 (37)	49	34		
35-50		201 (42)	36	43		
51 ⁺		70 (15)	10	16		
Education level	11 (4)				25.764	0.000***
Did not complete primary		16 (3)	-	4		
Completed primary school		39 (8)	1	10		
Completed middle school		105 (22)	11	24		
Completed high school		72 (15)	14	15		
Completed bachelor degree		213 (44)	64	40		
Completed master degree and above		36 (7)	10	7		
Household Monthly income in million MMK ^a	6.9 (7.9)				30.819	0.000***
<0.5		202 (42)	22	47		
0.5-1		185 (38)	40	38		
>1		94 (20)	39	15		



Characteristics	Number of Sample and (%)	Respondent Group (%)		Chi-Square	Sig.
		Healthy rice	Normal rice		
Main occupation of household				32.899	0.000***
Government staff	176 (37)	47	34		
Self-employed enterprise	96 (20)	26	19		
Skilled worker	46 (10)	17	8		
Unskilled worker	146 (30)	7	36		
Other	17 (3)	3	3		
Household size (number)				2.440	0.295
≤2	42 (9)	6	9		
3-4	252 (52)	59	51		
≥5	187 (39)	35	40		
Children household member below 5				8.524	0.004***
Yes	233 (48)	63	45		
No	248 (52)	38	55		
Elder household member above 60				4.9679	0.026**
Yes	190 (40)	50	37		
No	291 (61)	50	63		
Anemic household member				2.8385	0.092*
Yes	85 (18)	24	16		
No	396 (82)	76	84		
Diabetes household member				8.4995	0.004***
Yes	94 (20)	31	17		
No	387 (80)	69	83		

Note: Figure in the parentheses represents percentage; ***, ** and * are significant at 1%, 5% and 10%; ^a1USD=2,100 MMK as of September, 2023



Nutritional knowledge

Nutritional knowledge among respondents was assessed in four categories: anemia, diabetes, nutrient sources, and food sources. Given the association between the consumption of healthy rice and non-communicable diseases like anemia and diabetes, the respondents' understanding of the causes, symptoms, preventions, treatments, and complications related to these health conditions was examined. To measure nutrition-related knowledge, questions were posed regarding the roles of essential nutrients in various aspects of health and their food sources.

The questions were structured with predefined choices in a closed-ended format. Each correct response received a score of 1, while incorrect or "Do not know" answers had a score of 0. The assessment was for a total of 24 questions, with 5 questions each for anemia and diabetes knowledge, 6 questions on nutrient sources, and 8 questions on food sources. As a result, the knowledge score for the 24 questions ranged from 0 to 24. Knowledge scores were classified into three levels using Bloom's cut-off points (Abeje et al., 2016; Thandar et al., 2019): low level (59% or below), moderate level (60-80%), and high level (81-100%).

The results are presented in Table 4. Almost all respondents exhibited a low to moderate level of knowledge, with a mean knowledge score of 10.87 and a standard deviation of 4.03. However, healthy rice consumers had a higher mean knowledge score (12.27) compared to normal rice consumers (10.56). Nearly half of healthy rice consumers (43%) had a moderate level of knowledge, while only 25% had a moderate level among normal rice consumers.

The knowledge score varied among different income groups (Table 5). The low-income group had the lowest knowledge score among the three income groups, with a mean value of 10.45. The medium-income group consumers had the highest knowledge score at 12.65, while high-income group consumers had a slightly lower knowledge score (11.66) than the medium-income group. These results align with (Thandar et al., 2019), which found that pregnant women in Myanmar belonging to the second, middle, and fourth quintiles of the wealth index had higher knowledge scores compared to those in the lowest and highest quintiles. This is attributed to the risky health behaviours such as stress, unbalanced diet, and physical inactivity observed among the poorest and richest groups.

Knowledge scores were statistically significant between healthy and normal rice consumers in the medium-income group, although no significant effect was found in the low and high-income groups. For low-income consumers, despite having sufficient knowledge, price barriers may pose a significant obstacle to consumption. For middle-income consumers, having enough knowledge influences their decision to move towards consumption.



Table 4. Distribution by level of knowledge and average knowledge score by type of rice consumed

Knowledge Level	Respondent Group					
	Healthy Rice (n=88)		Normal Rice (n=393)		Total (n=481)	
	No.	%	No.	%	No.	%
Low (0-13 scores)	48	55	296	75	344	72
Moderate (14-19 scores)	38	43	94	24	132	27
High (20-24 scores)	2	2	3	1	5	1
Average knowledge score (standard deviation)	12.27 (3.98)		10.56 (3.98)		10.87 (4.03)	
t value	-3.711					
Sig.	0.000***					

Note: *** denotes significance at 1%

Table 5. Knowledge scores of respondents by income group and type of rice consumed

Knowledge Level	Low Income						Medium Income						High Income					
	Healthy Rice (n=19)		Normal Rice (n=183)		Total (n=202)		Healthy Rice (n=35)		Normal Rice (n=150)		Total (n=185)		Healthy Rice (n=34)		Normal Rice (n=60)		Total (n=94)	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Low	13	68	148	81	161	80	14	40	104	69	118	64	21	62	44	73	65	69
Moderate	6	32	34	19	40	20	20	57	44	29	64	34	12	35	16	27	28	30
High	-	-	1	1	1	0.5	1	1	2	2	3	2	1	3	-	-	1	1
Average score	11		9.89		10.45		13.80		11.49		12.65		12.00		11.32		11.66	
t value	-1.117						-3.086						-0.854					
Sig.	0.265						0.002***						0.395					

Note: *** denotes significance at 1%



Habitual health related behaviour

Habits are a valuable construct in social psychology, significantly influence eating behaviour (van't Riet et al., 2011; Verplanken et al., 2018). Therefore, this study aimed to include habitual health-related behaviours such as exercise routines, weekly exercise hours, fruit consumption, and vegetable consumption, limiting sugary or processed foods, and reading nutritional information labels, to understand the behaviour of consumers choosing healthy rice. A total of eight questions were used to obtain a self-reported healthy habit score. A score of one was assigned for each healthy habit in response to each question, resulting in a total of eight scores for individuals with fully established healthy habits. The average score of all respondents is 4.69, but for healthy rice consumers, it is 5.44, which is higher than for normal rice consumers at 4.27. The difference between the healthy and normal rice groups is statistically significant under the t-test.

Table 6. Distribution by level of habitual health-related behaviour score and average knowledge score by type of rice consumed

		Respondent Group				
Level	Healthy Rice (n=88)		Normal Rice (n=393)		Total (n=481)	
	No.	%	No.	%	No.	%
Low (0-3 scores)	19	22	148	38	167	35
Moderate (4-6 scores)	48	55	191	49	239	50
High (7-8 scores)	21	24	54	14	75	16
Average score (out of 8)	5.44		4.27		4.69	
t value	-2.4627					
Sig.	0.0156**					

Note: ** denotes significance at 5%

Determinants influencing healthy rice consumption

The binary logistic model was employed to determine the factors influencing healthy rice consumption. The estimates in Table 7 reveal that education level of the respondent, existence of children in the household, presence of elderly household members, household monthly income, knowledge score, and habitual health-related behaviour score significantly contribute to the likelihood of consuming healthy rice. Conversely, the age of the respondent and household size do not exert a significant impact on consumption behaviour.

The educational background of respondents exhibits a highly significant association with the probability of consuming healthy rice. This finding is consistent with studies (Fard et al., 2021; McIsaac et al., 2015), which observed that individuals with higher educational attainment are more likely to maintain a healthier diet. Specifically, women with higher educational attainment exhibit greater control over their dietary choices, have more supportive partners, place value on the long-term health benefits of healthy eating for the entire family, experience fewer concerns regarding cost and waste, and draw upon more positive food-related experiences (Lawrence et al., 2009). The presence of vulnerable household members, such as children or the elderly, is also highly associated with the consumption of healthy rice.

Unsurprisingly, income demonstrates a highly significant association with the consumption of healthy rice, potentially due to affordability concerns. Currently, the prices of healthy rice variants, such as rice berry rice and basmati rice, are nearly double that of normal high-quality rice, while Konjac rice is considerably more expensive. Even brown rice and fortified rice, though beneficial, come at a moderately higher cost than normal medium-quality rice.



The coefficient for the knowledge score is statistically significant and positive suggesting that consumers with good nutritional knowledge are more likely to consume healthy rice. This finding supports the empirical evidence of several studies (Jayne et al., 2018; Wardle et al., 2000) indicating that knowledge is an important factor in explaining variations in food choices. Knowledge was significantly associated with healthy eating, and the effect persisted after controlling for demographic variables (Wardle et al., 2000) and barriers such as availability and price (Amore et al., 2019).

The habitual health-related behaviour score is also highly significant in relation to the consumption of healthy rice. This result aligns with the findings of (Jayne et al., 2018) that fostering a healthy eating identity is more effective in promoting healthy food choice behaviours than nutrition education alone among U.S. Army Soldiers.

Table 7 Estimated logit model for consumers' healthy rice consumption

Variables	Coefficient	Std. err.	z	P>z	Marginal effect	P>z
Age of respondent (years)	-0.019	0.014	-1.310	0.192	-0.002	0.190
Education of respondent (years)	0.139	0.043	3.240	0.001***	0.018	0.001
Household size (number)	-0.018	0.080	-0.220	0.825	-0.002	0.825
Existence of children household member (Dummy)	0.738	0.282	2.620	0.009***	0.094	0.008
Existence of elder household member (number)	0.592	0.291	2.030	0.042**	0.076	0.040
Household monthly income (million MMK)	0.045	0.017	2.730	0.006***	0.006	0.005
Knowledge score	0.060	0.035	1.720	0.086*	0.008	0.084
Habitual health related behaviour score	0.219	0.070	3.120	0.002***	0.028	0.001
Constant	-5.096	0.948	-5.370	0.000		
Number of observations = 481		Pseudo R2 =0.149				
LR chi2 (13) = 68.06		Log likelihood = -194.848				
Prob>Chi2 = 0.000						

Note: ***, **, * denotes significance at 1%, 5% and 10%, respectively

Conclusion

The adoption of healthy rice in Myanmar remains limited. The level of education of respondents and the presence of vulnerable household members significantly influence healthy rice consumption. Income emerges as a crucial factor determining the consumption of healthy rice, with accessibility skewed towards wealthier households. Currently, the prices of healthy rice variants such as rice berry rice and basmati rice are nearly double that of normal high-quality rice, while Konjac rice is considerably more expensive. Even brown rice and fortified rice, though beneficial, come at a moderately higher cost than normal medium-quality rice.

Nutritional knowledge exhibits a significant positive correlation with consumption, with a majority of individuals falling within the moderate knowledge range or below. However, other factors, notably income, play a mediating role in the relationship between knowledge and consumption. For the medium-income group, knowledge significantly influences consumption as they possess some affordability, and their decision-making is more influenced by knowledge. Conversely, for low-income groups, despite having knowledge, affordability becomes a limiting factor. Therefore, targeted nutritional programs should prioritize the medium-income group with vulnerable households to achieve effectiveness.



Examining the reasons for discontinuing the consumption of healthy rice reveals that even some healthy rice consumers are unaware of its benefits. Therefore, nutrition education programs should address this gap in awareness. Additionally, habitual health-related behaviours show a strong correlation with consumption. Individuals with good health behaviours are more likely to be aware of the benefits of consuming healthy rice, making them regular consumers. To promote healthier behaviours, it is essential to provide facilities and create environments conducive to exercise and physical activities, given the current limited access in Myanmar.

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Ethical approval and consent to participate

Ethical approval was given by Kasetsart University Research Ethics Committee, Thailand (Serial number COA66/042).

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Track 6

Agribusiness and sustainable management



SWOT Analysis of Myanmar Indigenous Chicken (MIC) Enterprises in Nay Pyi Taw, Myanmar

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Abstract

Myanmar Indigenous Chicken (MIC) production is a one of the rural household income sources, food security and poverty alleviation for the resource-poor rural households and also contributes their job opportunities. Preference for MIC products becomes higher as well as its demands are increasing due to changes in consumer's perception of health and nutritional preferences. However, potential of the MIC enterprises in Myanmar is constrained by low productivity and marketing bottlenecks. Hence, comprehensive research on Strengths, Weaknesses, Opportunities and Threats (SWOT) analysis of MIC enterprises is critically important to identify the real situation of MIC enterprises. Main objective of the study was to determine SWOT elements of MIC enterprises in Lewe, Pyinmana, Tatkon, Pobbathiri Townships in Nay Pyi Taw. The study areas were purposively selected because most of the MIC enterprises are located. Stratified random sampling was used to collect SWOT elements data from a total of 105 MIC enterprises using structured questionnaire through personal interview during May-June 2023. The collected data were analysed by using SWOT matrix to identify and suggest possible intervention areas. The results show that easiness to raise, income generation, self-employment, potential of market demand and price were contribution factors. Meanwhile, limited access to veterinary services, technical training, financial support, seasonal diseases and low productivity were affecting negatively. Suggestions for intervention areas from that study were technical training, livestock loan, vaccine and veterinary services, hatcheries and pure breed, and entrepreneurial transition which could improve for future development of MIC enterprises in Nay Pyi Taw.

Keywords: MIC enterprise, Nay Pyi Taw, Productivity, SWOT analysis

JEL code: Q1, Q13, Q18

SDG goals: No Poverty, Zero Hunger, Gender Equality

Introduction

Agriculture plays an important role in the Myanmar economy, and it includes crops, livestock, fisheries, and agro-forestry production. The agricultural sector has a substantial contribution to Gross Domestic Product (GDP), employment, and export earnings. The livestock production sector includes cattle, buffalo, sheep, goats, pigs and poultry. Poultry production is the largest livestock production activity in the country and most of the agricultural households in Myanmar engage in poultry production. Poultry species include indigenous/native chicken, broiler chicken, semi-broiler chicken, layer chicken, duck, turkey, geese and quail (LBVD, 2019). The indigenous chicken species account for the very large proportion among the total chicken population (MOALI & JICA, 2018). According to the national livestock baseline survey conducted in 2021, there were about 66.8 million chickens in Myanmar. Among the total chicken population, indigenous chicken were 39.7 million and accounted for 59.4% in the



country. In Nay Pyi Taw, indigenous chicken population is accounted for 60%, 62%, 39% and 62% in 2018, 2019, 2020 and 2021 respectively (LBVD, 2021).

According to IFC (2016), Myanmar Indigenous Chicken (MIC) production in Myanmar is identified as one of the potential sectors for investment as it could bring economic and social development. Moreover, preference for indigenous chicken products became higher due to changes in consumer's perception of health and environmental issues. Therefore, indigenous chicken production becomes more important than ever to meet the meat requirement of the country Fang et al. (2020). Although it has great potential, there are some production and marketing challenges such as limited skills and knowledge, limited access to finance of the producers, inadequate marketing infrastructures and market price fluctuations (Burgos & Roland-Holst 2009; Henning & Pym 2019). The supply of quality and affordable feeds remains production challenge in MIC production Belton et al. (2020). Therefore, comprehensive study of strengths, weaknesses, opportunities and threats (SWOT) analysis on supply and demand situation, marketing aspects and business potential of MIC enterprises is very important for the future development of the MIC enterprises.

There are a lot of studies on indigenous chicken production sector internationally (Mapiye 2007; Moges et al., 2010; Unakitan & Abdikoglu 2016; Birhanu et al., 2021 and Macharia 2023). In these studies, indigenous chicken production and marketing systems, production constraints and opportunities and SWOT analysis of this sector has been examined.

Although there are some studies conducted on genetic characterization, improved feed, health and management options, they are not comprehensive enough and did not relate production, productivity, marketing and constraints of MIC enterprises in Myanmar (Henning & Pym, 2019). For successful and sustainable transformation of the sector, improved production practices for indigenous chicken, marketing strategies, building capacity of farmers, improved networking between all stakeholders along with MIC enterprises are identified as potential research areas. However, this paper focused on current constraints and potentials of small-scale MIC enterprises through SWOT analysis in Nay Pyi Taw.

The study was conducted with the objective of determining the strengths, weaknesses, opportunities and threats of the MIC enterprises in the study area, Nay Pyi Taw. The study on SWOT analysis of MIC enterprises in Nay Pyi Taw will expose all possible constraints and solutions to enhance the productivity of MIC enterprises. This study also can provide understanding to policymakers for policy formulation that can support the livelihood of chicken farmers and the development and potential of small-scale MIC farming enterprises. A sound and good policy implementations for MIC farming sector would directly contribute to the MIC farmers to increase household income, household food security, promote poverty alleviation and women empowerment.

Methodology

The research area was selected purposively, namely Lewe, Pyinmana, Tatkon and Pobbathiri Township in Nay Pyi Taw because MIC farms are located the most in these Townships. Stratified random sampling was used to select 105 MIC farms in which producers or farmers keep 50 to 1000 indigenous chickens in confined house. This research was conducted in collaboration with Livestock Breeding and Veterinary Department (LBVD) and Department of Livestock and Aquaculture Research (DLAR). The primary data from a total of 105

respondents of MIC enterprises were collected through personal interview using structured questionnaire during 16 May to 30 June, 2023.

In MIC production, availability of Day Old Chicks (DOCs), managerial skills of the farmers, incidence of diseases and predators, marketing aspects and financial status of enterprises are the most important areas for the future development of MIC enterprises. Therefore, all areas would be required to identify internal contexts (strengths and weaknesses) and also external contexts (opportunities and threats) to explore the current situations, to suggest the possible policy formulation and to find out critical intervention areas by SWOT analysis in Nay Pyi Taw. SWOT analysis is a simple framework for generating strategic alternatives from a situation analysis. Thompson et al. (2007) stated that SWOT analysis is a simple but powerful tool for sizing up an organization's resource capabilities and deficiencies, its market opportunities, and the external threats to its future. SWOT matrix provides a framework for identifying and formulating strategies by matching key internal and external factors. SWOT matrix helps managers or policy makers in developing four types of strategies, namely strengths-opportunities (S-O) strategies, weaknesses-opportunities (W-O) strategies, strengths-threats (S-T) strategies, and weaknesses-threats (W-T) strategies (Wehrich, 1982).

The survey data were analysed by SWOT analysis to point out current situation of MIC enterprises by investigated internal strengths and weaknesses as well as external opportunities and threats. Then, using SWOT matrix to develop the possible specific policy options from an external-internal analysis and identify the critical intervention areas in the production sectors of the MIC enterprises for future development.

Results and discussion

Demographic characteristics of the selected respondents in the study areas

The demographic characteristics of the selected respondents are presented in Table 1. The average household size was 4.5 and average adult household member was 3.9 in the study area. It was also found that average livestock farming experience was nearly 22 years and maximum livestock farming experience was 60 years. The average MIC farming experience was 11 years and maximum MIC farming experience was found 51 years. The average women participation in MIC farming was 0.86 with the maximum participation was 3 women in a household of selected respondents. Average land ownership was 1.17 hector of the sample households.

The information about age group and education level of sample farms household heads were described in Table 2. The eldest age of household heads was 77 years old and the youngest age was 23 years while the average age of household heads was 50.2 years. The household heads education levels were grouping into illiterate, primary, secondary, high school and graduate level. Majority of household heads had secondary school level (40.00%) followed by primary level (35.24%). Only one household head was found illiterate (0.95%) and 3 household heads were found graduate level (2.86%) among selected respondents.

Table 1. Demographic characteristics of the selected respondents in the study areas (n=105)

Items	Unit	Average	Range	SD
Household size	Number	4.5	1 – 8	1.23
Adult household member (18 year and above)	Number	3.9	1 – 8	1.35
Farm household labor in MIC farming	Number	2.1	1 – 5	0.69
Livestock farming experience	Year	21.67	2 - 60	12.32
MIC farming experience	Year	11.01	1 - 51	10.97
Women participation in MIC farming	Number	0.86	0 – 3	0.68



Items	Unit	Average	Range	SD
Land ownership	Ha	1.17	0 - 5.7	4.01

Source: Own survey, 2023

Table 2. Age group and education level of sample farm household heads in the study areas (n=105)

Items	Frequency	Percent	SD
Age group (year)			
21 – 30	3	2.86	
31 – 40	15	14.29	
41 – 50	33	31.43	
51 – 60	36	34.28	
Over 60	18	17.14	
Average	50.2		10.6
Range	23 - 77		
Education Level			
Illiterate	1	0.95	
Primary	37	35.24	
Secondary	42	40.00	
High school	22	20.95	
Graduate	3	2.86	

Source: Own survey, 2023

According to results of SWOT analysis in MIC enterprises, it had a number of internal strengths and external opportunities that help to achieve the development and internal weaknesses and external possible threats that destructive for further development of MIC enterprises as shown in Table 3.

The key strength factors of MIC enterprises were less initial cost, self-employment and household food security. Moreover, jobs opportunities in the MIC production sector create a stable income for the family labour and it also had a chance to promote women empowerment. This finding of the study are consistent with those of Henning & Pym (2019) which reported that indigenous breeds-based semi-intensive production can create business opportunities for women to generate income that supports households' livelihood.

On the other hand, weakness factors of MIC enterprises were insufficient farming knowledge and technical training, limitation of land, hire labour, limited supply of Day Old Chicks (DOCs) for replacement stock and incidence of predators. These results are in consistent with those (Henning et al., 2009; IFC 2016; MOALI & JICA 2018) which reveal that smallholder poultry production farmers are facing different bottlenecks and these include inadequate management practices, high disease prevalence, predatory attack and unfavourable environmental conditions. Additionally, farmers were limited to capital investment and financial sources. This results are in lined with those of (Burgos et al., 2009; Win 2012; Raitzer et al., 2015; Pym 2017; Henning & Pym 2019; Sherman et al., 2019; Belton et al., 2020) which reported that limited skills and knowledge of producers and limited access to finance are the other main constraints under the smallholder production system in Myanmar. Moges (2010) also stated that capacity building and extending credit facilities could encourage landless or small land owning farmers and unemployed youth and women to engage in chicken production and improve their livelihoods.



However, there were opportunities for the MIC production sectors such as increase in consumer preferences leading to the opportunity of market demand, good market price for MIC meat and presence of the potential of the MIC business. These results are in consistent with the report of Unakitan & Abdikoglu (2016) which stated that increasing in consumers' healthy nutrition knowledge and rapid population will cause increase in production, is one of the sector opportunities. This finding also agreed with the report of (EU 2019) which stated that an increase in population growth, urbanisation, middle-income population and change in consumer preferences from red meat to the white meat have led to increasing demands for poultry products globally.

Conversely, the incidence of seasonal diseases impact on MIC production, unable to access to veterinary services and vaccine, poor growth rate and mortality of chickens were threatened to development of MIC production sector according to the study results. This result was in consistent with Henning et al. (2006) which showed that disease prevention and treatment measure are minimal due to a lack of producer's knowledge and skills in poultry health and inadequate access to veterinary services.

According to the data analysis of the 105 respondents of MIC enterprises, Figure 1 indicates that the majority of respondents (49.5%) response that easiness to raise as a strength factor in MIC production followed by income generation (32.4%) of the respondents. Figure 2 shows about the weaknesses, there are 6 weaknesses facing commonly in MIC production. According to the responses of samples, insufficient farming knowledge and technical training (35.2%) and limited knowledge to vaccines and drugs (29.5%) were identified as major weaknesses.

With regard to the opportunities of MIC production, as shown in Figure 3, the most important factor that supports the opportunities is market demand (65.7%) according to the respondents. This result is in line with the reports of Birhanu et al. (2021) who noted that households in the country have a higher preference and significant increase in the consumption of poultry meat compared to the other livestock meat and fish. According to this paper, it was assumed that higher preference and increase in the consumption of poultry meat can lead to the increase in market demand of poultry production. The study results as shown in Figure 4 stated that most of the respondents (45.7%) are experiencing the incidence of seasonal diseases in MIC production as a threat factor. The results are in line with Unakitan & Abdikoglu (2016) which stated that the most important threat in the sector is diseases in chickens such as bird flu and Newcastle diseases in Turkey. Serkalem et al. (2005) also reported that Newcastle disease was the major infectious diseases affecting productivity and survival of village chicken in the central highlands of Ethiopia. The study also shows livestock loans and veterinary services were critical threat factors in the study areas. This result was agreed with the report of Wagacha et al. (2020) which revealed that due to the small scale of production, most farmers have limited access to financial and credit services. Lack of financial facilitation hindered the expansion of indigenous poultry enterprises. Some of the hindrances to credit acquisition included lack of information, high loan interest, absence of banking facilities in rural areas, and low literacy levels among farmers.

Table 3. Internal and external contexts of the MIC enterprises in Nay Pyi Taw

Internal Contexts		External Contexts	
Strengths	Weaknesses	Opportunities	Threats
1. Easiness to raise	1. Insufficient farming knowledge and technical training	1. Good opportunity of market demand	1. Seasonal diseases
2. Income generation	2. Limited knowledge to vaccines and drugs	2. Good opportunity of market price	2. Access and knowledge of vaccine and drugs
3. Less initial cost	3. Limitation of capital investment	3. Good potential of the business	3. Livestock loans and veterinary services
4. Self-employment	4. Predators		4. Poor growth rate and mortality
5. Household food security	5. Lack of supply of DOC and pure breed		
	6. Limitation of land and hire labor		

Source: Own survey, 2023

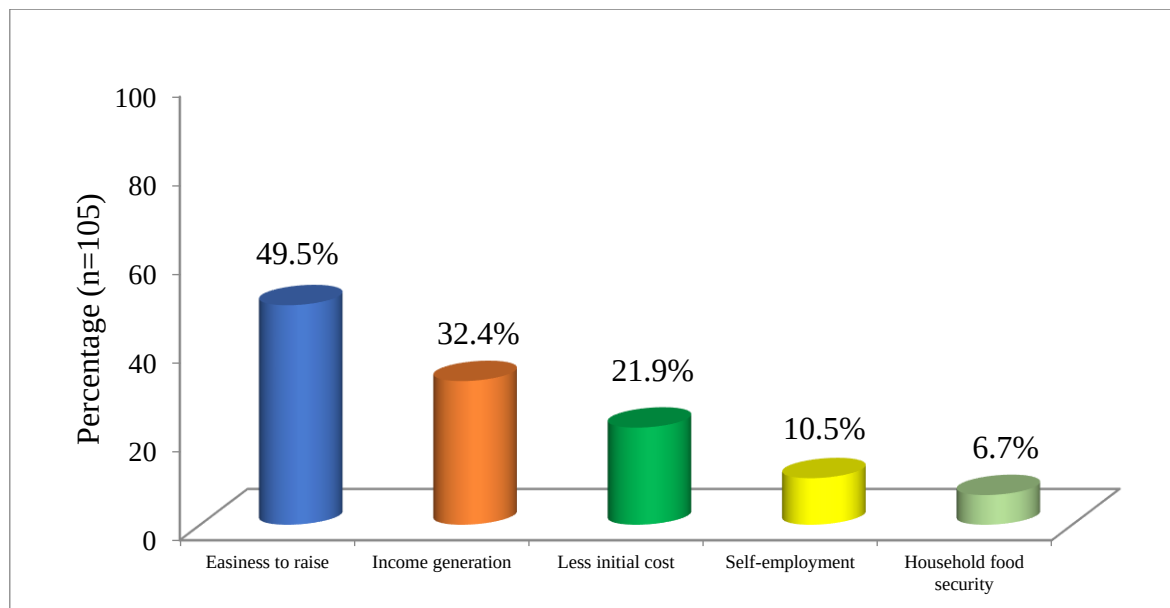


Figure 1. Strengths of MIC enterprises in Nay Pyi Taw (n=105)

Source: Own survey, 2023

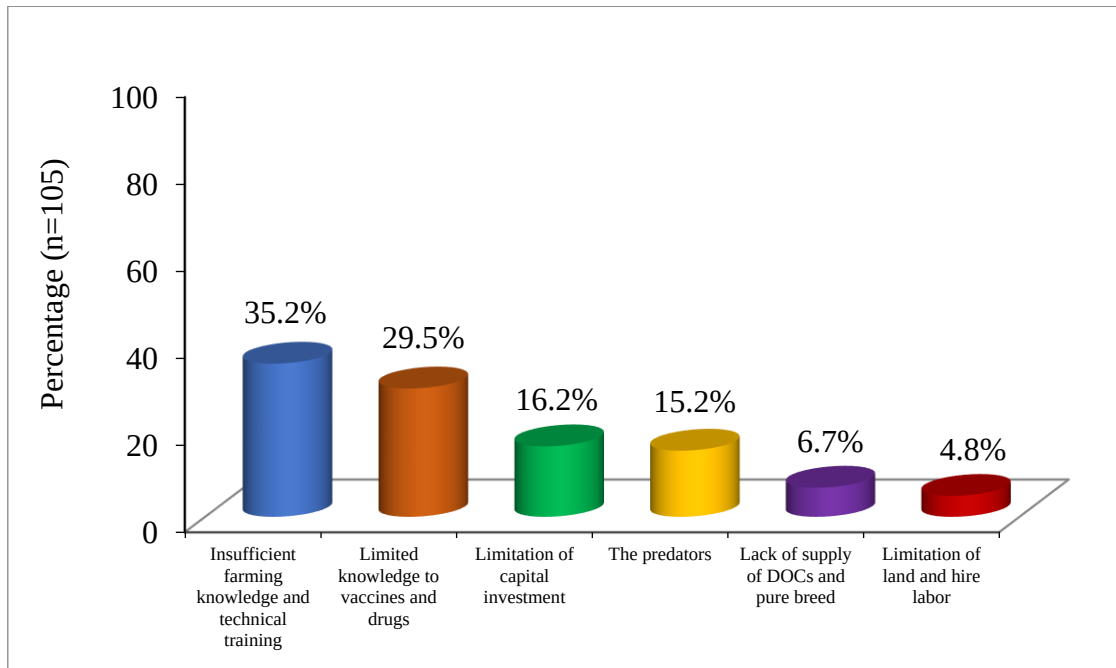


Figure 2. Weaknesses of MIC enterprises in Nay Pyi Taw (n=105)
Source: Own survey, 2023

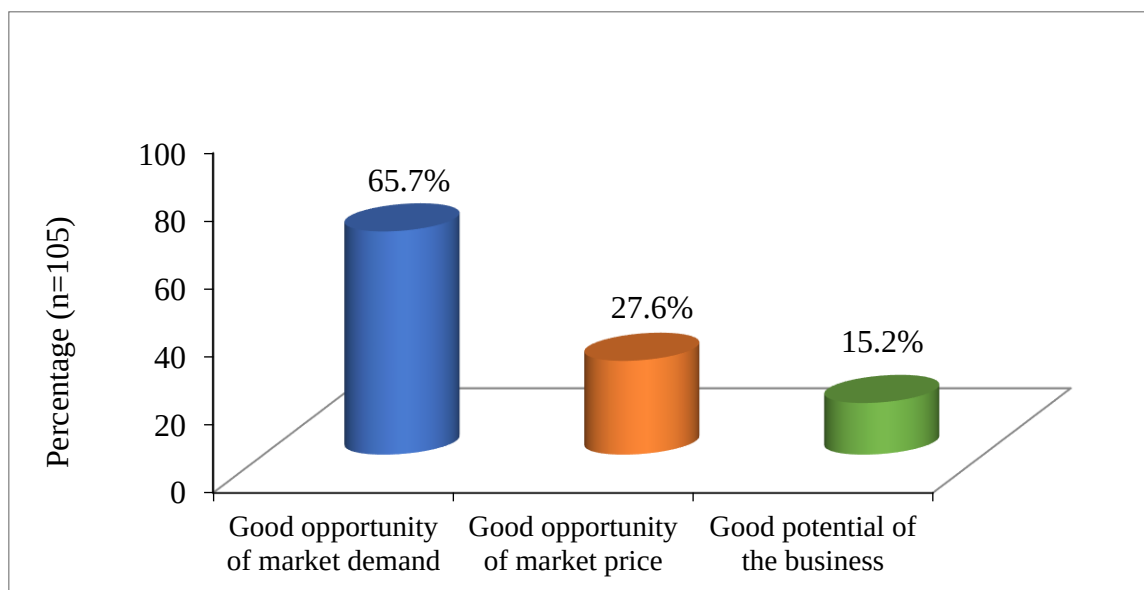


Figure 3. Opportunities of MIC enterprises in Nay Pyi Taw (n=105)
Source: Own survey, 2023

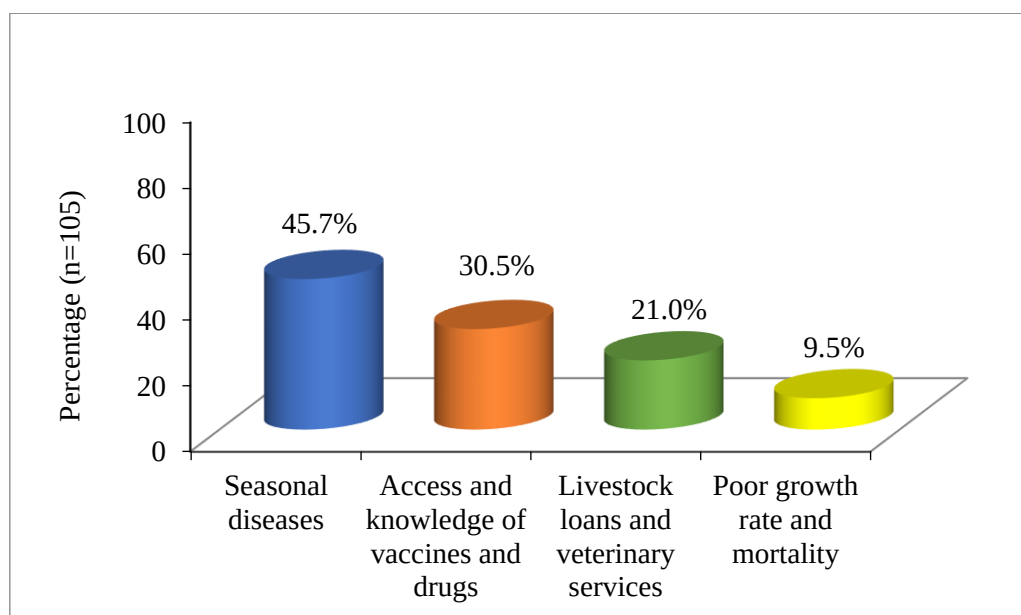


Figure 4. Threats of MIC enterprises in Nay Pyi Taw (n=105)

Source: Own survey, 2023

According to the methodology, possible specific strategies of MIC production sector were formulated by a combination of SWOT factors using strategies matrix. S-O strategies identified the ways to use strengths factors to maximize the opportunities of organization or company. S-T strategies identified the way to use strengths factors to minimize the possible threats factors of organization or company. W-O strategies that identified the opportunities to develop strategies that would be minimized the weaknesses of organization or company. W-T strategies identified the opportunities to develop strategies that would be avoided or escaped from threats of organization or company. Figure 5 presents possible strategies matrix for the MIC enterprises.

Internal factors External factors	STRENGTHS (S)	WEAKNESSES (W)
	S1. Easiness to raise S2. Income generation S3. Less initial cost S4. Self-employment S5. Household food security	W1. Insufficient farming knowledge and technical training W2. Limited knowledge to vaccines and drugs W3. Limitation of capital investment W4. Predators W5. Lack of supply of DOCs and pure breed W6. Limitation of land and hire labor
OPPORTUNITIES (O)	↓ ↓	
	S-O Strategies (Using internal strength to take advantage of external opportunities)	W-O Strategies (Taking advantages of opportunities to offset internal weaknesses)
O1. Good opportunity of market demand O2. Good opportunity of market price Good potential of the business	S1O3- Promote the livelihoods of rural households by raising MIC S3O3- Encourage farmer to start the business by creating job opportunities within household level S4O3- Promote awareness and management practices to get maximum profit S5O1- Increase household food security due to higher market demand	W1O3- Support technical training on MIC farming W2O3- Support vaccines and veterinary services on MIC farming W3O3- Facilitate loans and financial programs on MIC farming W5O3- Support local hatcheries to fill the gap of DOCs and pure breed W6O3- Facilitate to the better tenure system and management practices for lower labor cost
THREATS (T)	↓ ↓	
	S-T Strategies (Using internal strength to mitigate or minimize external threats)	W-T Strategies (Strategies that minimize both internal weakness and external threats)
T1. Seasonal diseases T2. Access and knowledge of vaccines and drugs T3. Livestock loans and veterinary services T4. Poor growth rate and mortality	S1T1- Improve the farmer's awareness and knowledge on seasonal diseases S1234 Encourage to form T1234 farmer association on MIC production to share knowledge and market information	W1T1- Provide technical training on seasonal disease W2T2- Provide training to enhance farmer's knowledge on vaccines and drugs W3T3- Facilitate loans and veterinary services programs for MIC farmers W4T4- Find ways to prevent the predators for solving the poor growth rate and mortality problems W5T3- Establish local hatcheries to support DOCs gap and pure indigenous breed

Figure 5. Possible specific strategies for MIC enterprises
Source: Author's compilation based on own survey



Conclusion and suggestions for critical intervention areas

Poultry production is an essential part of livestock production system and poultry is the most common livestock species kept by the majority of the agricultural households in Myanmar. Among the total chicken population, about 62.3% accounted for indigenous chicken in Nay Pyi Taw according to the national livestock baseline survey (LBVD, 2023). MIC production plays important role in the livelihood of the rural households and almost every rural household raise MIC for many reasons. MIC production systems can be classified into backyard production and small-scale production system and are characterized by low-input and low-output systems.

The present study deals with SWOT analysis of MIC enterprises in Nay Pyi Taw and suggesting a critical intervention area through strategies matrix. According to the results of the study, a number of SWOT elements such as easiness to rise, income generation, less initial cost, self-employment, household food security, good opportunity of demand and market price are main contribution points. Meanwhile, limited technical training, veterinary services and vaccine, livestock loans and financial support, incidence of seasonal diseases and predators, lack of supply of DOCs and pure breed are major constraints to MIC production in the study area.

The study can take a responsibility for the evidence based policy formulation for livestock sector and MIC enterprise in specific. The strategies in order to exploit the strengths and opportunities and to elucidate the weaknesses and threats will help to improve the productivity of MIC enterprises. Therefore, the findings of the study provide policy options in terms of critical intervention areas for the development MIC enterprise of livestock sector in Myanmar.

Critical intervention areas of MIC enterprises in Nay Pyi Taw

Technical training

Technical training to improve farming practices and building capacity of farmers were needed. It would be provided by the government official Livestock Breeding and Veterinary Department (LBVD), Department of Livestock and Aquaculture Research (DLAR) and public and private sectors to produce better performance, economic and social returns of MIC enterprises.

Livestock loans, vaccines and veterinary services

Almost all MIC enterprises ask for livestock loans specifically for small scale indigenous chicken farming and needing financial support. These enterprises also critically need the contribution of vaccines and supportive veterinary services to enhance the productivity and profitability of chicken production.

Local hatcheries and pure breed

MIC enterprises in Nay Pyi Taw area are producing their own replacement stocks as there are no local commercial hatcheries. There also should support for pure indigenous breed for better performance of the enterprises as they are disease-resistance, well adapted to tropical climates and better growth rate.

Promoting entrepreneurial transition in MIC farming

Indigenous chicken farming in rural area has the potential to provide small-scale farmers with additional business opportunities. Promoting indigenous chicken farming in rural area in Myanmar can provide a major source of subsidiary income for the rural poor and marginalized



sections of the population and nutritious chicken eggs and meat for their own consumption. It is important to educate entrepreneurs on the benefits of indigenous chicken farming and provide them with the necessary resources to start their own businesses.

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Factors Influencing Access to Formal Credit by Pottery Households: Case Study in Bat Trang Village, Hanoi, Vietnam

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Abstract

Diversification of rural livelihood through the development of non-farm activities is one of important policies for holistic rural development in Vietnam. However, non-farm households in general and pottery households in particular have faced with capital shortage in production process. One of reasons for their capital limitation is difficulties in formal credit access. This paper aimed to identify factors that influence pottery households' access to formal credit in Bat Trang village, Hanoi city. By using Yamane's formula, sample size of 167 households was determined. Descriptive statistics and Probit regression model were applied in quantitative data analysis. The results showed that households' credit access was influenced by factors including age, educational level, collateral value asset, and return from ceramic production after tax. This study recommended that policy makers should implement a specific credit support for non-farm households in rural areas. In addition, commercial banks should loose credit requirements on collateral value assets in order to help rural non-farm households to access to formal credit, particularly banking loan.

Keywords: Factors, Influence, Formal, Credit access, Pottery households.

JEL code: R51, G51.

SDG goals: No Poverty, Decent Work and Economic Growth

Introduction

According to Benedikter et al. (2013), non-farm business has been considered as a significant livelihood strategy in rural areas, especially in the context of severe climate change and unstable economic conditions (Duong et al., 2020). Ellis (1998) supposed that growth in agriculture is considered as prerequisite for the emergence of new rural service and commodity markets. Empirical studies in the world have shown that non-farm activities really help rural households to create new on-farm business, employment and income opportunities, therefore enhancing food security and reducing poverty (Hieu & Thanh, 2018; Mishra & Khanal, 2017; Owusu et al., 2011).

Non-farm activities are all income generating strategies that do not based on production of raw agricultural commodities, but include manufacture, commerce, construction and government services, among others (Losch et al., 2012; Haggblade et al., 2010; Barrett et al., 2001). Some previous have shown that migration from rural to urban areas and to industrial zones is a vital non-farm livelihood strategy. However, the shock caused by Covid-19 has witnessed that migrant labors' life is vulnerable. A number of migrant workers had to return to their hometown during the time of lock-downs in urban centres and industrial zones because of their job loss (Waibel et al., 2020). In this context, non-farm economic activities such as wage-employment and self-employment in rural areas play important roles in income generation and living standard improvement (Do et al., 2022).



The participation of rural labors in non-farm activities depends on either “push” factors (land limitation and risk reduction) or “pull” factors (complementarities with existing income sources, better job-opportunities and higher profitability), or both. Several factors including education, skills, household size, and access to formal credit affect labors’ participation in a particular non-farm activity (Jatav & Sen 2013).

In Vietnam, rural transformation began in the late 1980s. In the economic reform process, the share of households who have been engaging in non-farm activities dramatically increased. In 2020, the whole country had over 8.58 million non-farm households, accounting for 50.89% of the total rural households (an increase of 4.55 percentage points compared to 2016 and 13.04 percentage points compared to 2011). At the same time, the proportion of households whose the largest source of income came non-farm activities is 59.22% in the total rural households, increased from 42.49% in 2011 and 52.08% in 2016 (GSO, 2020). Mulia et al. (2019) indicated that income and consumption per capita of households who conduct non-farm activities has significantly higher than those that do not.

Among a number of policies supporting the diversification of rural livelihood and the development of non-farm activities, the program of preserving and developing craft villages play a crucial role. In terms of production growth, employment capacity of a plentiful underemployed workforce in rural areas and of the resilience of livelihood strategy during the formal industrial crises, the craft villages have proved their worth (Fanchette, 2012). Vietnam has nearly 5,400 craft villages of which one-third (about 1,350 craft villages) are located in Hanoi. The production value of the craft villages is about 22,000 billion VND (equivalent to one billion USD) and the export turnover value is about 200 million USD in Hanoi (Minh Son, 2022). The craft villages have created job opportunities for one million local workers. These villages produce articles designed for daily life of local people (processed food, religious objects, furniture, commercial and transport services) and for export (clothing, art objects, and furniture).

Bat Trang is a traditional craft village with a long history of pottery production. It is situated in the peri-urban area, about 20 km from the center of Hanoi. Bat Trang ceramics have been exported to many countries such as Japan, the Republic of Korea, the US and EU members. In the village more than 1,000 out of 2,300 households produce pottery and the rest are engaged in trading and services (The People committee of Bat Trang, 2022). Annually, production value reached to 1,200 billion VND and created jobs for more than 4,000 villagers and 10 thousands migrant workers from surrounding communities.

Despite of the success and positive socio-contributions, pottery households in Bat Trang village have been facing a variety of difficulties, particularly lack of financial resource in order to invest in new equipment and expand production scale. Low access to formal credit is one of the most important constraints as only 12 percent of pottery households can access to formal credit.

It is very important to understand the meaning of formal credit and credit access. Formal credit can be defined as what are provided by institutions regulated by the government’s regulations (Campero & Karen, 2013). The formal credit sources include commercial banks, government credit programs, and other institutions (e.g. People Credit Fund in Vietnam). The concepts of access is frequently used by property analysts and other social theorists (Ribot & Peluso, 2003). For health care services, access refers to “entry into or use of the health care system”



(Penchansky & Thomas, 1981). Ribot & Peluso (2003) have gone beyond the specific concepts of “access” by saying that “access is about all possible means by which a person is able to benefit from things”. In financial sector, credit access was defined as whether a person can or cannot get a loan when he/she needs (Khoa, 2018). According to Tesfaye & Worku (2019), access to credit is a crucial condition for rural households to acquire necessary inputs and technologies in their production and to approach to better market opportunities. By doing so, their return is improved.

However, rural households’ formal credit access are affected by a number of factors. A varieties of empirical studies found that household characteristics strongly influence their credit access, such as sex, age, education and marital status of household head, production scale, value of assets (Kiros & Meshesha, 2022; Waje, 2020; Ayele & Goshu, 2018; Asifaw & Adebaba, 2016; Khoa, 2017; Nguyen & Pham, 2015; Anang et al., 2015). In addition, credit institutional characteristics also influence household’s credit accessibility. Duy (2016) and Selamawit & Nigus (2014) indicated that credit terms (conditions under which credit is granted) considerably influence borrowers’ access, particularly interest rate, credit limit, loan period, distance from households to credit institution, and document procedure. Most of previous studies concentrated on the credit access of farm and poor households or small and medium enterprises, not so many papers analyzed factors influencing formal credit access of households who do on-farm activities in rural areas.

Under such condition, an attempt that has made in this paper is to examine the factors affecting on household’s access to formal credit mainly using the direct interview in traditional pottery village in Hanoi city. The paper’s structure is: (i) to show how pottery households in Bat Trang village access to formal credit sources; and (ii) to analyze which factors and how they influence pottery households’ accessibility to formal credit.

Methodology

Study area

Located in the suburb of Hanoi, Bat Trang pottery village has a long history with 700 years of ceramic production. In Bat Trang village, 1015 households of 2373 have been conducting ceramic production, the remains provide relating services such as material inputs, final product marketing and other activities. Total population of the village is about 9,000 people. In the modernization process and reducing environmental pollution, all ceramic producers have been encouraged to change from charcoal to gas kilns.

The first gas kilns were imported from Japan in 1997 at the price of USD 20-25 thousand (rate of exchange at that time) in Bat Trang village (Ha & Huong, 2015). Nowadays, about 100 percent of producers have applied gas kilns imported from Japan, Thailand, and Germany. As high requirement of capital for investment in gas kilns, more than 80 percent of producers need to borrow money from formal credit institutions such as banks and People Credit Fund (PCF) at commune level.

Data collection

Secondary data relating to general information of the village has been collected from statistical and formal credit institutions at commune and district levels. Involving information that was collected from secondary sources include numbers of formal credit institutions, procedures of getting loan, difficulties in accessing formal credit by pottery households.

Primary data: Multi-staged sampling procedure was applied in this research. Firstly, pottery households were categorized based on their accessibility to credit (i.e. accessed credit users or borrowers and non-accessed credit users or non-borrowers) through the list provided by formal credit institutions at the commune and district levels (commercial banks and People Credit Fund). Among 1015 households conducting ceramic production, 667 households have accessed to credit and 348 households have not. Then, the pottery households were randomly selected by Yamane's formula (1967) to make up the determined proportion of each category.

$$n = \frac{N}{(1 + N \cdot e^2)}$$

In which: n is the sample size; N is the population size; and e is the level of precision. If, n₁ denotes for sample size of households accessed to formal credit, n₂ denotes for sample size of households could not access to formal credit, and e equals to 0.1 (10%), total sample size (n₁ + n₂) in this research is 167:

$$n_1 = \frac{667}{(1 + 667 \cdot 0.1^2)} = 89$$

$$n_2 = \frac{348}{(1 + 348 \cdot 0.1^2)} = 78$$

$$n = n_1 + n_2 = 89 + 78 = 167$$

In order to get primary data, structured questionnaires consisting of closed and open-ended questions were applied to 167 random selected respondents (89 credit accessed household heads and 78 credit non-accessed household heads) in Bat Trang village. The survey covered aspects such as the socio-economic characteristics of households, their sources of credit, conditions for accessing formal credit, and reasons for not accessing formal credit. Questions were carefully prepared, pre-tested, and refined before carrying out a formal survey.

Apart from the survey, in-depth interviews were also carried out with local leaders (2 persons), formal credit institutions' representatives (01 from Bank for Agriculture and Rural Development, 01 from Bank for Social Policy, and 01 from People Credit Fund) in order to get in-depth knowledge about credit facilities and mode of access.

Data analysis and Modelling

The descriptive statistics and econometric models are applied in this study. The descriptive statistics were applied in calculating and analysing real situation of credit accessibility by pottery households and their characteristics. In order to explore determinant factors that affect pottery households' access to formal credit for ceramic production, a model of binary choice decision was applied in analysis. The reason is the fact that the binary choice model can be written in terms of the odds and log of odds which enables one to understand the interpretation of the coefficients. The odds ratio implies the probability (P_i) that a household head chooses an alternative to the probability (1-P_i) that he/she does not choose it (Waje, 2020). The theoretical model is presented as in equation (1).

$$Ui = \ln \left(\frac{P_i}{1-P_i} \right) = \alpha + \beta_1 X_1 + \beta_2 X_2 + \beta_m X_m \quad (1)$$

Based on the literature review of factors influencing households' accessibility to formal credit (Duong et al., 2020; Waje, 2020; Khoa, 2018), this study tried to find out how (i) demographic (age, sex and family size) and (ii) socioeconomic conditions (education status, asset value, land area) by a function as equation (2):

$$Y(1/0) = \beta_0 + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \beta_4X_4 + \beta_5X_5 + \beta_6X_6 + \beta_7X_7 + \beta_8X_8 + e_i \quad (2)$$

Where, Y is dependent variable (Access to credit), β_0 is a constant term; X_1 is sex of household head, X_2 is age of the household head, X_3 is educational level, X_4 is family size, X_5 is number of hired labor, X_6 is land area for ceramic production, X_7 is value of collateral assets, X_8 is return from ceramic production after tax (Table 1); and e_i is error term were explanatory variables; and $\beta_1 - \beta_8$ are the coefficients associated with each independent variables which measure the change in the mean value of access to formal credit.

Table 1. Description of the variables used in the model

Variables	Type	Description
<i>Dependent variable</i>		
Access to credit	Dummy: 1 if yes, 0 otherwise	Whether a household head has access to credit or not
<i>Independent variables</i>		
Sex (X_1)	Dummy: 1 if household head is male, 0 if household head is female	Sex of the household head
Age (X_2)	Continuous (Years)	Age of the Household head
Education (X_3)	Categories: Primary school equals to 1; Secondary school equals to 2; High school equals to 3; College equals to 4; University and above equals to 5	Education of Household head
Family size (X_4)	Continuous (Persons)	Number of people live in the household
Hired labor (X_5)	Countinuous (Persons)	Number of hired labor working in the pottery workshop
Workshop size (X_6)	Countinuous (m ²)	Land area for ceramic production measured in m ²
Collateral (X_7)	Countinuous (million VND)	Value of assets which can be used for collateral
Return (X_8)	Countinuous (million VND)	Return from ceramic production after tax

Results and Discussion

Overview of formal credit institutions in rural area of Vietnam

Before the year 2000, the Vietnam Bank for Agriculture and Rural Development (VBARD) and the Vietnam Bank for Social Policies (VBSP) were two main providers of formal credit to individuals and households in rural areas in Vietnam. As a representative of the state-owned commercial bank, VBARD has been responsible for directed lending to agricultural and rural sectors (Duy et al., 2012). Nowadays, commercial bank system is very diverse, including state-owned and private banks in Vietnam. Pottery producers are defined as non-farm households in rural area. Therefore, they cannot access to VBSP through representation of social organizations such as Women's Union, Farmers' Union, and Youth Union. They must borrow from VBARD and other commercial banks based on collateral. In Bat Trang, formal credit sources for ceramic producers include VBARD, Bank for Investment and Development of

Vietnam (BIDV), Vietnam Industry Bank (VietinBank), and People Credit Fund. Procedure for getting loan from state-owned commercial banks are quite similar as presented in Figure 1. Figure 1 shows the operational procedures of VBARD – a formal credit provider in rural Vietnam (Duy et al., 2012). The operational procedures include: (1) Borrower sent application forms (including loan application, production and business project, documents related to collateral) to the bank staff; (2) Bank staff report to the credit department after receiving loan application forms; (3) The assigned bank staff examines the loan application forms if they are proper; (4) The assigned bank staff appraises how the applicant meet the bank's requirements, particularly collateral; (5) The head of the credit department gets the report from the assigned bank staff; (6) The head of the credit department re-assesses the loan application conditions and reports to the bank's director; (7) The bank's director makes decision on the loan and informs to the head of credit department; (8) The assigned bank staff is informed by the head of credit department; (9) The loan applicant is informed about the decision by the bank staff; (10), (11), (12) Internal information circulation among the bank's specialized departments; (13) If the application forms are accepted, the treasury department disbursed loans to the borrower. Previous studies indicated that not all households who need capital can be accepted as clients of formal credit institutions because three reasons as follows: (i) They cannot fill proper application forms, particularly households' business strategy; (ii) Households fail to provide a proof of sufficient collateral; (iii) The short terms and small amount of loan cannot meet long investments like ceramic production. All these requirements may cause burden for rural households, including small-scale ceramic producers.

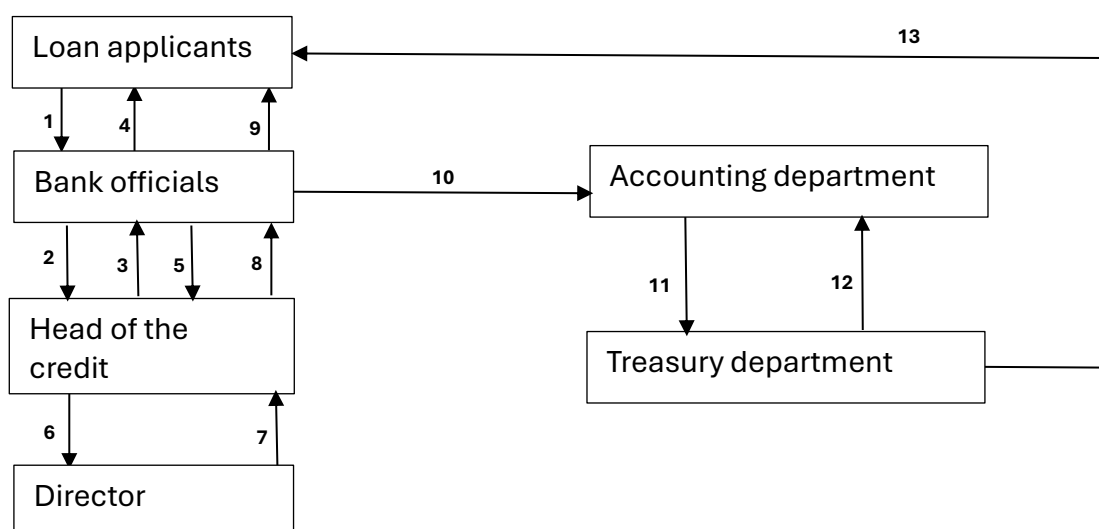


Figure 1. Lending procedure by public commercial banks in Vietnam (Modified from Ninh, 2003)

Table 2 shows average loan amount of pottery household is 3,050 million VND. The primary purposes for borrowing are new kiln construction (29.21%), expanding the workshops (29.21%) and purchasing raw materials (20.22%). High collateral requirement, complex borrowing procedure, high interest rate, and short loan term are reasons for which almost half of pottery households did not access to formal credit. Many respondents supposed that formal credit institutions have simple procedures will attract more clients. Although People Credit Fund lends at higher interest rate and smaller amount, households tended to borrow from this source because it has the simplest fastest procedure among formal credit institutions around Bat Trang village.

Table 2. Situation of credit accessibility by pottery households

Criteria	Borrowed (from formal credit) household	Non-borrowed (from formal credit) household
<i>Numbers of household</i>	89	78
<i>Average loan amount (million VND)</i>	3,050	-
<i>Reasons for not borrowing</i>		
Short loan term (%)	-	20.37
High interest rate (%)	-	25.93
Complex borrowing procedure (%)	-	20.37
High collateral requirement (%)	-	33.33
<i>Understanding of formal credit sources</i>		
Never heard about (%)	0	17.95
Partly awareness (%)	29.21	14.10
Fully awareness (%)	23.50	17.95
Careless (%)	0	32.05
Well understanding (%)	47.19	17.95
<i>Purposes of loan investment</i>		
Constructing a new kiln (%)	29.21	-
Purchasing raw materials (%)	20.22	-
Expanding the workshop (%)	29.21	-
Buying a truck (%)	3.37	-
Investing in new production technology (%)	17.97	-

Source: Surveyed data, 2023

Another reason for that households could not access to formal credit sources is lack of information. Up to 17.95% of non-borrowed households have never known information about the formal credit institutions even they live in the suburb of Hanoi city. The descriptive analysis also shows that 32.05% non-borrowed households did not care about formal credit sources because their production scale is so small that they can effort to invest themselves. Borrowed households knew formal credit sources better than non-borrowed ones. However, only 47.19% of them knew fully loan procedure.

Household characteristics of borrowers and non-borrowers

Table 3 shows the differences of characteristics between borrowed and non-borrowed households. Household heads with access to formal credit were slightly older but not significantly different than those without. In terms of educational level, ratio of non-borrowed household heads graduated from colleges and university is bigger than the borrowed ones, but it is not statistical significance.

Table 3. Household characteristics (continuous, categorical and dummy variables)

Criteria	Borrowed household (n=89)	Non-borrowed household (n=78)	T-test
Age of household head (years)	47.83	47.27	0.39
Level of education (% completed college and university)	56.30	61.00	0.12
Family size (persons)	3.67	3.27	0.02***
Hired labor size (person)	44.96	26.64	0.00***
Residential land (m ²)	141.91	114.00	0.002***
Ceramic production workshop area (m ²)	2,194.20	548	0.00***
Value of collateral assets (million VND)	22,305.56	10,088.16	0.00***

Criteria	Borrowed household (n=89)	Non-borrowed household (n=78)	T-test
Return after tax per year (million VND)	532.85	330.52	0.00***
Gender of household head (% male)	70.00	75.00	0.25
Production scale (% large scale)	54.00	10.00	0.00***

Source: Surveyed data, 2023

*: Significant at 10%; **: Significant at 5%; ***: Significant at 1%.

The difference in average family size is not much, but the number of hired labors are largely varied between two groups. The size of hired labor correspond to the production scale as the borrowed households have a higher proportion of large-scale production than the non-borrowed households.

Total landholding, especially land area of ceramic workshop, has been considered as a crucial determinant of formal credit access. The previous findings (Duy et al., 2012; Okurut, 2006) as well as practical requirements of banking system in Vietnam witnessed that households with more land can use land certificate as collateral for the loan. In the survey, production workshop areas and production scale of borrowed households are significantly higher than non - borrowed households. While the borrowed households possessed over 2,000 m² averagely, the average area of non-borrowers is only 548 m² with statistically significance at 1%.

Another important determinant is the value of assets used for collateral. The results show statistical differences in asset values between borrowers and non-borrowers. Both asset value and return from ceramic production (after tax) of borrowers were statistically higher than non-borrowers’.

Factors influencing pottery access to formal credit – The Probit model result

The Probit regression model result indicated that among 8 hypothesized explanatory variables, four variables (X₂, X₃, X₇, and X₈) significantly influenced pottery households’ formal credit access at 5% and 10% levels. It could be seen that credit access was determined 56.36% by the above-mentioned factors (Table 4). The likelihood ratio Chi-square of 46.84 with a p-value of 0.0000 shows that the model was statistically significant.

Table 4. Probit regression model output of factors influencing formal credit accessibility of pottery households

Variables	Coef.	Std. Err.	Z	P> z	Marginal effect
X ₁	-.161441	.595575	-0.27	0.786	-.0395661
X ₂	-.0581663	.0339561	-1.71	0.087*	-.0142554
X ₃	-.9651909	.4325277	-2.23	0.026**	-.2365497
X ₄	.0105469	.3113988	0.03	0.973	.0025848
X ₅	.024277	.024256	1.00	0.317	.0059498
X ₆	-4.66e-06	.0003167	-0.01	0.988	-1.14e-06
X ₇	.0000951	.0000497	1.91	0.056*	.0000233
X ₈	.0041466	.0018192	2.28	0.023**	.0010162
-cons	2.852865	3.290952	0.87	0.386	
Diagnostic statistics					
Number of obs	167				
LR chi2 (8)	46.84				
Prob > chi2	0.0000				
Log likelihood	-40.442616				



Variables	Coef.	Std. Err.	Z	P> z	Marginal effect
Pseudo R2	0.5636				

Source: Computed from the surveyed data, 2023

*** Significant at 1%, ** significant at 5% and * significant at 10% level.

The variables with positive effects on pottery households' access to formal credit include value of collateral asset (X_7) and return from ceramic production after tax (X_8). The value of collateral asset variable was found as a positive and statistically significant influential factor which affect pottery households' access to formal credit ($p=0.056$) at 10% of the probability level. The marginal effect of estimation result showed that if the pottery household's collateral asset value increases one million VND, the probability for them to access to formal credit increases by 0.002%. This reflected a fact that the pottery households only can get loan when they prove their relative collateral value assets. It also coincides with the descriptive analysis when 33.3% non-borrowers responded that they could not access formal credit because of collateral limitation. This finding is consistent with the conclusions of Waje (2020), Assogba et al. (2017), Dzadze et al. (2012), Duy et al. (2012), and Pham and Lensink (2007).

Households' return from ceramic production after tax was positively correlated with their access to formal credit with statistically significance ($p=0.023$) at 5% of the probability level. The positive marginal effect means that the higher return after tax, the more loan pottery households could get from formal credit institutions. In this case, if the household's return after tax increases one million VND, the probability for them to access to formal credit increases by 0.1%. Households' income or return after tax is a critical factor that formal credit institutions in Vietnam considered as repayment guarantee for loans. The result also reflects the fact that operating ceramic production in the context of commercialization and globalization is not relevant to the old household head. This research findings are supported by several previous ones, particularly Waje (2020), Khoa (2018), Argaw (2017), and Muhongayire et al. (2013). However, the finding is opposite to E. Saqip et al. (2018) when they found out that monthly income had a negative significant effect on access to agricultural credit in Pakistan.

Age (X_2) and educational level (X_3) have negatively effects on pottery household's access to formal credit. The negative relationship of household head's age and the accessibility to formal credit can be explained by less motivation of the older. It seems that the old aged household head were not expected to recovered credit that they borrowed. As indicated in Table 4, every one year increases in household head leads to a 1.42% decrease in the probability of access to formal credit. This study result is similar to the findings of Waje (2020) and Assogba (2017). The model found out that education level (X_3) has a negative and statistically significant (at 5%) relationship with the probability of farmers accessing to formal credit. The marginal effect indicated that a one-level increase in the pottery household head's education resulted in a 23.6% decrease in their likelihood of obtaining credit from formal sources. The reason for the finding was that higher educated pottery household heads diversified their household livelihood strategy. These households could earn income from various sources such as civil servant, farming, grocery shop keeping, and service providing, instead of ceramic production only. The descriptive statistical analysis also indicated that the higher household heads educated, the smaller ceramic production scales were. This finding is quite similar to the works of Gebeyehu et al. (2019), Ray & Das (2020), and Muhammed (2013) as they also found a negative relationship between the education level of farmers and the probability of accessing to credit. Even though, many others recognized a positive relationship between the educational level of household heads (mostly farmers) and the probability of formal credit access (Waje,



2020; Mulatu et al., 2020; Ayele & Goshu, 2018; E.Saqib et al., 2018; Khoa, 2018; Argaw 2017; Asante-Addo et al., 2017).

The research results also found out the positive relationship between three other factors including family size, labor size, and workshop scale. However, it does not have statistical significance in this case.

Conclusion and Policy Implication

The paper investigated the determinants of access to formal credit among pottery households in Bat Trang village, Hanoi city applying descriptive statistics and Probit regression model. The statistical data pointed out that 65.7% of pottery households in the village could access to formal credit institutions, including commercial banks and People Credit Fund while the remain had to get loan from informal credit sources. The Probit model showed that households' formal credit accessibility was determined 56.36% by the above mentioned factors, whereas the remaining 43.67% was determined by the others. In addition, the likelihood ratio Chi-square of 46.84 with a p-value of 0.000 tells that the model is statistically significant. From the results of Probit regression model, it was revealed that the main factors influencing pottery households' accessibility to formal credit in the study area were value of collateral asset, return from ceramic production after tax (positively influenced with statistical significance), age and educational level of household heads (negatively influenced with statistical significance).

Recognizing the importance of collateral asset value and return from ceramic production after tax of household in getting larger loan amount from formal credit institutions, it is implied that commercial banks and other formal credit institutions in Vietnam paid much attention to their safety through borrowers' repayment. By doing so, it limited the accessibility of pottery households, particularly whose production scale was small. It is recommended that commercial banks should loose credit requirements, particularly on collateral value assets, in order to help rural non-farm households to access to banking loan.

As mentioned above, pottery households' identities stand in-between small enterprises and livelihood-oriented businesses. These actors are different from each other in the official definition, then support mechanism. As a result, both policies and promotional activities for SME sector and for farm households tend to ignore the different strategies and constraints of the different types of enterprises. State interventions and support schemes therefore need to be designed in a more target-group specific way. In close connection to this, the policies supporting non-farm households to access to formal credit need to recognize their specific characteristics and roles in employment creation, poverty reduction, and economic growth in rural areas.

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Bio-fertilizers from Food Wastes for Sustainable Agriculture in Brunei Darussalam

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Abstract

This paper aims to review recent literature on bio-fertilizer production in Brunei and identifies different types of food wastes to be utilized for bio-fertilizer production and their benefits to Brunei Darussalam's agricultural industry. The Systematic Literature Review was carried out through the use of electronic search engines, specifically the Scopus database and Google Scholar for non-Scopus databases. A combination of carefully chosen keywords was done in order to enhance the efficacy of the search. Initially, a total of 19 papers were retrieved on the subject of bio-fertilizer production in Brunei, and 2,647 papers on organic bio-fertilizer made from food waste. However, after a rigorous screening process, only 2 papers were found to be relevant to bio-fertilizer production in Brunei and 26 papers concerning organic bio-fertilizer made from food waste were deemed eligible for inclusion in this review. Current research indicates that there is a dearth of information about Brunei Darussalam's use and production of biofertilizer, especially organic biofertilizer made from food waste. As a result, there is a need for extensive studies and field research in Brunei Darussalam. Hence, the presented review creates awareness on the need for adopting or introducing bio-fertilizers from food wastes for improving the soil and crop productivity without degrading the quality of the environment in Brunei Darussalam.

Keywords: Food wastes; bio-fertilizers; wastes management; biological farming; nature inspired solutions

JEL code: Q01; Q10; Q16

SDG goals: Goal 2 (Zero hunger); Goal 12 (Responsible consumption and production)

Introduction

Sustainable agriculture is one of the most effective methods to consistently fulfill the Sustainable Development Goals (SDGs) such as poverty and hunger eradication, good nutrition and health, quality education, economic, and social progress, peace and security, and environmental preservation. Bio-fertilizers are substances rich in living microorganisms which when applied to soils, seeds, or plant surfaces, they are able to colonize the rhizosphere or plant internal tissues to stimulate plant growth and development. Unlike chemical fertilizers, bio-fertilizers sustain soil and crop productivity (Arjjumend, Koutouki & Donets, 2020) because their microorganisms such as bacteria and fungi promote soil and plant health. The bacteria or fungi in bio-fertilizers often fix nitrogen, solubilize phosphate, oxidize sulfur, produce plant hormones, or decompose organic substances (Pirttilä et al., 2021). Moreover, bio-fertilizers do not only increase crop productivity, nutrients availability, and soil organic matter abundance but they also neutralize the harmful effects caused by chemical fertilizers because of the compatibility of their microorganisms with organic wastes (Areeshi, 2022).

Food wastes the food loss or unconsumed food which represents the part of food which is not eaten. Food wastes could be managed by through transforming them into bio-fertilizers because these wastes are bio-degradable and may efficiently accelerate the activities of microbial metabolism (Areeshi, 2022). Approximately 30% to 40% of food are wasted along the food



chain (Kang et al., 2021). Food wastes have the worst effect on the environment and the agricultural industry particularly if composting them is not carried out properly. Annually, 1.3 billion tons of food which is equivalent approximately 50% of the world's annual cereal crop production (Kang et al., 2021) are wasted (Paritosh et al., 2017). In Asia, developing countries dispose 11 kg of food per person, whereas developed nations waste up to 80 kg of food per person (Food and Agriculture Organization of the United Nations, 2013). In the Association of Southeast Asian Nations (ASEAN) countries, the ASEAN population produces food wastes which is approximately 83 kg per capita per year (UNEP, 2017). Approximately 32% of the total food waste is produced in Brunei Darussalam (Kon, 2019). The food waste is one of the major issues in ASEAN including Brunei Darussalam.

This review is significant because it focuses on recent studies on organic bio-fertilizers which are likely to benefit Brunei Darussalam's agricultural industry and elsewhere. This could also serve as an alternative of chemical fertilizers. Currently, composts which are produced from organic wastes are the most common type organic amendments used in Brunei Darussalam. Although, composting wastes increases agricultural output, its impact is inferior to bio-fertilizers which rice in beneficial microorganisms capable of improving soil and crop health. Bio-fertilizers produced from food wastes should be implemented in Brunei Darussalam especially by the local farmers in the Agricultural sector. Recently, Bio-fields Solutions, a Brunei-based company has successfully transformed food waste into organic compost fertilizer as their main product which is high in organic matter and beneficial microorganisms (Faisal, 2023). This can also be referred to as "Bio-fertilizer". Research studies on bio-fertilizers has shown many positive results.

According to a recent study by Arjjumend et al. (2020), implementing microbial bio-fertilizers can enhance crop resilience to various diseases and climate changes, while also promoting the growth of humus and enzymatic activities. Additionally, the microorganisms found in bio-fertilizers can help convert atmospheric nitrogen for crop utilization and reduce soil salinity. Another study by Pandey & Singh (2019) highlights the importance of using bio-fertilizers to remediate polluted areas, as it is a crucial step towards promoting environmental sustainability. However, there is a research gap in the scientific research publications on utilization of bio-fertilizers made of food wastes in Brunei Darussalam. Further research is needed to examine the potential of bio-fertilizers in Brunei and to develop specific formulations, especially using food wastes, that can enhance the overall soil health, crop yield, and agricultural productivity in Brunei Darussalam. Thus, the gap this review fills could facilitate the introduction of and adoption bio-fertilizers use in soil and soilless agriculture. This paper aims to review literature on identifying food waste types that are prevalent in Brunei Darussalam and evaluate their feasibility and effectiveness for the production of bio-fertilizers. It also assesses the effect of bio-fertilizers from food waste on soil health and crop productivity and recommends strategies to reduce food waste and promote bio-fertilizer use in agriculture in Brunei.

1. Food wastes in Brunei Darussalam

Municipal solid waste has become a major concern because the amount of this type waste generation has increased significantly partly because of the rapid urbanization, industrialization, population growth, and improved lifestyle. Among the ASEAN (Association of Southeast Asian Nations) countries, Brunei Darussalam is the second country (followed by Singapore) which generates more solid wastes per capita. The six percent of the total wastes generated is used to produce compost and the 70% of the solid wastes goes directly to Brunei Darussalam's six landfills and the remaining of the wastes are disposed in other standard



methods (Shams, Juani & Guo, 2014). Daily, between 400 tonnes to 500 tonnes wastes are transported to Sungai Paku landfill, Mukim Telisai in Tutong district, Brunei Darussalam (Wong, 2020). A growing concern for effective waste management and utilization is the Gross Domestic Product (GDP) growth of 2.3% which occurred between 1999 and 2007 and the continued increase in the number of businesses registered, for example, 2,577 businesses in 1998 to 7,240 a decade later (Shams et al., 2014). From a 2005 survey in Brunei Darussalam, the most prevalent composition of solid waste discovered was derived from food scraps (36%), followed by plastic wastes (18%) (Shams et al., 2014). This suggests that food waste is becoming a challenge in Brunei Darussalam. This write-up provides a review on some of recent studies on organic bio-fertilizers produced from selected food wastes and their benefits to Brunei Darussalam's agricultural industry *vis a vis* chemical fertilizers.

2. The Sustainability Development Goals

In 2015, the United Nations adopted the Sustainable Development Goals (SDGs) as a universal call to end poverty, protect the planet, and ensure that the world enjoys peace and prosperity by 2030. The 17 SDGs are linked because they acknowledge that actions in one area have an impact on outcomes in others and that development must balance social, economic, and environmental sustainability (United Nations Development Programme, 2022). Brunei Darussalam seeks to improve on its Millennium Development Goal accomplishments in effort to enable more progress towards the 2030 Agenda for Sustainable Development and SDGs. The 2030 Agenda supplements Brunei Darussalam's national goal, Wawasan (Vision) Brunei 2035, which aspires to develop a high-quality of life population and a dynamic and sustainable economy with knowledgeable, highly skilled, and competent workforce by 2035 (United Nations, 2020). There are total of nine focused goals in Brunei Darussalam out of which the two main goals on progress and development are discussed in this review.

2.1 Zero hunger (Goal two of the SDGs)

Zero hunger is the goal two of the SDGs. To contribute to achieving this goal, sustainable food system in Brunei Darussalam is being pursued. Achieving food sustainable security in Brunei Darussalam has been challenge. For example, only 0.54 % of the country's GDP is contributed by the agricultural sector (Department of Agriculture and Agrifood, 2022). To feed approximately 445,440 Bruneians (Ministry of Finance and Economy, 2022), the government of Brunei Darussalam has made efforts to become self-sufficient in food production. An example being the improvement in the agricultural sector because of the expansion of farmland and more resource support. Brunei Darussalam's self-sufficiency in the poultry business, in particular, was 89.5 % in 2018, or an output of 2538 thousand tonnes. The local output for 2019 was estimated to be 24.58 thousand tonnes, an increase in poultry output of approximately 1.4%. The country's fruits and vegetables self-sufficiency levels are 37% and 47%, respectively (Pehin Dato Musa & Basir, 2021).

2.2 Responsible consumption and production (Goal 12 of the SDGs)

The government of Brunei Darussalam utilizes a national strategy to improve consumption and production behaviour to protect the environment, an example being the efforts of Green Brunei, a social enterprise which supports environmental sustainability. Their support to the Plastic Bottle Free Initiative run by the Department of Environment, Parks, and Recreation (JASTRe) and the Green Protocol initiated by the Brunei Darussalam National Council on Climate Change (BDNCCC) (Prime Minister's Office, 2021). Although Brunei Darussalam's efforts on wastes recycling is commendable, food wastes continue to be a significant issue because they are disposed conventional in landfills, a practice which is not environmental friendly because

it could increase the greenhouse emissions. Given that food wastes account for the bulk of the waste produced in Brunei Darussalam, it is more practical to recycle them by producing soil amendments/conditioners or organic fertilizers which are rich in nutrients and organic matter for farming systems which are organic. To achieve this, there is a need to address Brunei Darussalam's food waste issues in addition to educating farmers and the general populace on how to recycle food wastes into organic fertilizers and related farm inputs for achieving sustainable agriculture through regenerative agriculture or climate smart agriculture. With these efforts, there could be significant curtailment in the food waste issues in Brunei Darussalam besides contributing to achieving the goal 12 (Responsible consumption and production) of the SDGs before year 2035.

Methodology

For this review study, Systematic Review and Meta-Analysis (PRISMA) methodology modified by Moher et al. (2010) was utilized, which is a thorough and reliable standard for evidence-based reporting. The literature search was carried out using the Scopus database and Google Scholar (non-Scopus database), with a focus on recent publications ranging from year 2010 to 2023. To ensure accuracy, a combination of automated and manual de-duplication techniques, as outlined by Gallagher et al. (2016), were utilized. All relevant materials, including articles, abstracts, conference proceedings, and books, were included in the analysis, while any records that were not relevant to the review topic were excluded.

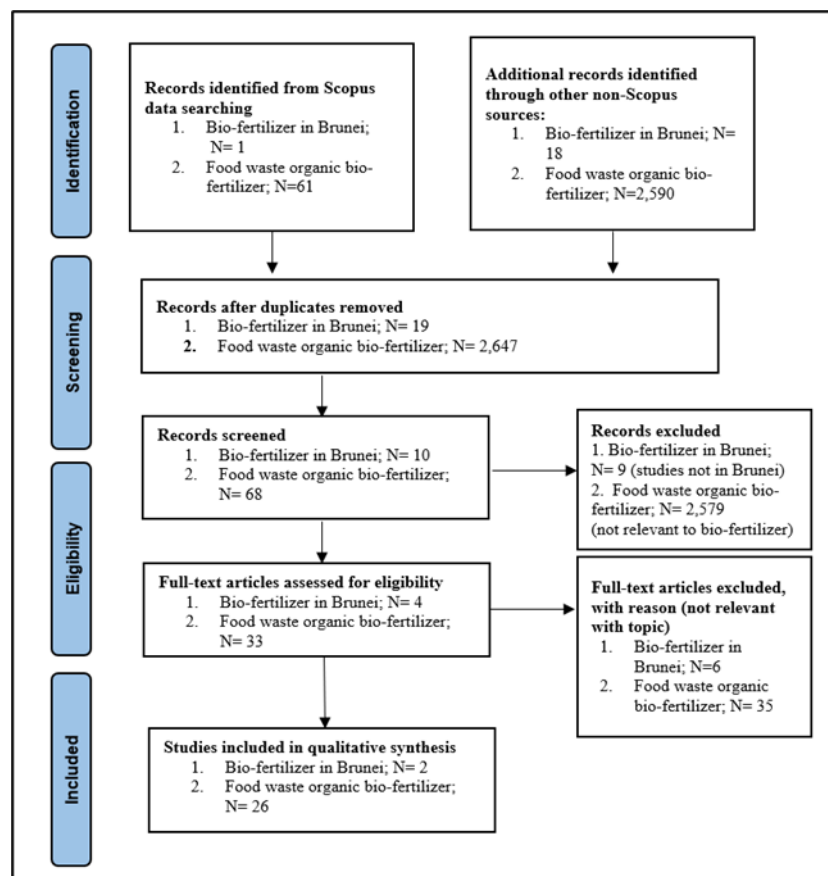


Figure 1. A modified version of Moher et al. (2010) Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flowchart was utilized in this study

Based on a search conducted on 24 February 2024, Figure 1 reveals that only one publication title was found that included the keywords 'Bio-fertilizer' and 'Brunei' using the Scopus database. However, a Google Scholar database search using the combined keywords 'Bio-fertilizer', 'food waste', and 'Brunei' yielded 18 records. Since there were limited publications on bio-fertilizers in Brunei, a further review was conducted using the combined search terms 'Food wastes', 'Organic', and 'Bio-fertilizer' to extract recent literature findings on bio-fertilizers made from food waste in general. The Scopus database identified 61 papers, while the non-Scopus database recorded 2,590 papers on the search for food waste organic bio-fertilizers. After a thorough screening process based on eligibility criteria, only two papers related to bio-fertilizers in Brunei (Table 1), while 26 papers were included regarding food waste organic bio-fertilizers (Table 2).

Table 1. Title of publications in the included studies for database searches with keywords on Bio-fertilizer in Brunei (N=2)

No.	Title	Publication year	Author	Type of paper
1	Performance of a selected <i>Trichoderma</i> strain as plant pathogen inhibitor and biofertilizer	2022	Abdul-Halim, Shivanand & Taha, 2022	Article
2	Conversion of kitchen food waste to halal organic fertilizers	2023	Sulaiman et al., 2023	Article

Table 2. Title of publications in the included studies for database searches with keywords on Food waste organic bio-fertilizer (N=26)

No.	Title	Publication year	Author	Type of paper
1	Identification of phenolic compounds from banana peel (<i>Musa paradaisica</i> L.) as antioxidant and antimicrobial agents.	2016	Aboul-Enein et al., 2016	Article
2	Advantages of Using the Biofertilizers in Ukrainian Agroecosystems.	2020	Arjjumend et al., 2020	Article
3	Benefits and limitations of biofertilization in agricultural practices	2012	Carvajal-Muñoz & Carmona García, 2012	Review Article
4	Valorization of fruit and vegetable waste for biofertilizer and biogas	2020	Chakravarty & Mandavgane., 2020	Article
5	Effects of Mixing Garlic Skin on Fermentation Quality, Microbial Community of High-Moisture <i>Pennisetum hybridum</i> Silage	2021	Chen et al., 2021	Article
6	Effect of Different Fruit Peel Powders as Natural Fertilizers on Growth of Okra (<i>Abelmoschus esculentus</i> L.)	2021	Dayarathna & Karunarathna, 2021	Article
7	Exploiting the use of agro-industrial residues from fruit and vegetables as alternative microalgae culture medium.	2020	de Medeiros et al., 2020	Article
8	The Effects of Organic Liquid Fertilizer (Vegetable Waste) on Moisture Retention, Soil Physical Properties and Yield of Lettuce (<i>Lactuca Sativa</i> L.) Grown in the Malkerns Area, a Region in the Kingdom of Eswatini.	2021	Dlamini, Mukabwe & Sibandze, 2021	Article
9	Valorization of food waste into biofertiliser and its field application.	2018	Du et al., 2018	Article



No.	Title	Publication year	Author	Type of paper
10	Characterizing the variability of food waste quality: A need for efficient valorisation through anaerobic digestion.	2016	Fisgativa, Tremier & Dabert, 2016	Article
11	Local Fruit Wastes as a Potential Source of Natural Antioxidant: An Overview.	2016	Ibrahim et al., 2016	Conference
12	Study on Use of Fruit Peels Powder as a Fertilizer.	2016	Jariwala and Syed, 2016	Conference
13	Effects of Organic Fertilizer Mixed with Food Waste Dry Powder on the Growth of Chinese Cabbage Seedlings.	2021	Kang et al., 2021	Article
14	Food waste as a valuable resource for the production of chemicals, materials and fuels. Current situation and global perspective.	2013	Lin et al., 2013	Article
15	The Effect of Bio-fertilizer on Soil Chemical Properties of Sugarcane in Purwadadi Subang.	2017	Mulyani et al., 2017	Conference
16	Chemical and Microbial Characterization of Washed Rice Water Waste to Assess Its Potential as Plant Fertilizer and for Increasing Soil Health.	2021	Nabayi et al., 2021a	Article
17	Fermentation of Washed Rice Water Increases Beneficial Plant Bacterial Population and Nutrient Concentrations.	2021	Nabayi et al., 2021b	Article
18	Valorization of Fruit Waste for Bioactive Compounds and Their Applications in the Food Industry.	2023	Nirmal et al., 2023	Review article
19	Aplikasi Pupuk Organik Cair Limbah Kulit Nenas Terhadap Pertumbuhan Tanaman Kacang Panjang.	2020	Nurcholis et al., 2020	Article
20	A review on the valorisation of food waste as a nutrient source and soil amendment.	2020	O'Connor et al., 2020	Review article
21	Role of biofertilizers and biopesticides in organic farming.	2021	Parewa et al., 2021	Book
22	Utilization of vegetable dumplings waste from industrial production by anaerobic digestion.	2017	Pilarska et al., 2017	Article
23	An Effect of Onion Peel Water on Various Plant Disease and Plant Growth.	2022	Rajput et al., 2022	Article
24	Preparation of biofertilizer blend from banana peels along with its application in agriculture and plant microbial fuel cell.	2023	Sogani, 2023	Conference
25	Characteristics of Pineapple Waste as Liquid Organic Fertilizer and Its Effect on Ultisol Soil Fertility	2023	Sutikarini et al., 2023	Article
26	Evaluation of Eggshell as Organic Fertilizer on Sweet Basil	2019	Wijaya & Teo, 2019	Article

Results and Discussion

Inadequate information on Bio-fertilizer production in Brunei Darussalam

There were total of 2 papers included and eligible for this review study which was on bio-fertilizer in Brunei (Table 1). According to study by Sulaiman et al. (2023), found that the plants treated with compost-based fertilizer (CBF) derived from halal organic fertilizers obtained from kitchen food waste (including leftover green vegetables, eggshell wastes and banana peels) showed better growth and nutrient levels than those grown using clay-based soil (CBS) alone. This finding suggests that using halal organic fertilizers from food waste (also known as Bio-fertilizer) can have positive effects on plant development and nutrient content. Another study by Abdul-Halim et al. (2022), found that rice plants treated with *Trichoderma* strains showed increase in shoot length, fresh shoot weight, and dry shoot weight. The findings suggest

the potential of *Trichoderma* sp. UBDFM01 as a bio-fertilizer for improving rice plant growth and controlling *Rhizoctonia* sp. in rice cultivation in Brunei Darussalam. The production of microbial bio-fertilizer in Brunei may pose certain challenges due to limited accessibility of strains. Conversely, organic bio-fertilizer derived from food waste represents a more viable and sustainable option for production in Brunei Darussalam. The findings suggest a dearth of information and research on the application and production of bio-fertilizers in Brunei Darussalam, particularly those made from food wastes. Therefore, another review was performed to identify different types of food wastes which are potential for production of bio-fertilizer and application in Brunei.

Selected food wastes transformation into bio-fertilizers in Brunei Darussalam

In Table 2, there were total of 21 papers retrieved which were related to effects of different types of food wastes used for bio-fertilizer. Eggshell is a rich source of macronutrients (Example, potassium, nitrogen, calcium, magnesium, and phosphorus) and micronutrients (Example, copper and zinc), both of which are needed for plant growth and development (Wijaya & Teo, 2019). According to Wazir et al. (2018), red clover plants which were planted on eggshell with soil grew 10 mm larger than the plants grown on non-eggshell fertilized soil and this relates to the fact that eggshell is rich in calcium. Calcium does not only neutralize soil's acidity but it is also a component of cell wall in plants. It is needed for enzyme formation, nitrate uptake, and root development.

In 2022, it was estimated that total consumption of rice per capita in Brunei Darussalam was 27,627 mt and 62.03 kg per year (Department of Agriculture and Agrifood, 2022). Because of the ongoing population growth, it is anticipated that the quantity would increase. Based on a conservative calculation by Nabayi et al. (2021b), three billion L of wastewater from washed rice would be produced annually if every 1 kg of rice grains is washed with at least 1 L of water. It must be noted that washing rice can significantly reduce the number of water-soluble nutrients in rice (Nabayi et al., 2021a). Washed rice water is considered wastewater, hence as part of water governance, it must be recycled like other wastewater. In particular, municipal water demand accounts for 11% of the world's freshwater withdrawal, yet only 3% of this is used, with the other 8% discarded as wastewater. Thus, reusing WRW can significantly reduce water and fertilizer consumption in agriculture (Nabayi et al., 2021b).

The fruit and vegetable industries produce more trash than other food-processing industries do, with peelings contributing between 25 to 30% of that waste, followed by seeds, skins, shells, pods, cores, pulp, pomace, etc (Nirmal et al., 2023). Because of their high biodegradability and fermentability, fruit wastes cause significant problems to the environment, including water and soil pollution, the greenhouse effect, eutrophication, global warming, and other health issues (de Medeiros et al., 2020). It is a crucial issue that needs to be properly controlled to keep the environment free of pollutants, particularly at the industrial level (Jariwala and Syed, 2016). Fruit peels are high in plant essential macro and micronutrients (Ibrahim et al., 2016). Considering the fact that fruit scraps have minerals which are vital for plant growth, they are used as fertilizers and soil amends to improve soil fertility in addition to enhancing soil microbiota (Dayarathna & Karunarathna, 2021).

Banana fruits are ranked first for the major type of local fruits production in Brunei Darussalam with a quantity production of 1,673,424 kg in 2022 (Department of Agriculture and Agrifood, 2022). This suggests that banana consumption in Brunei Darussalam is such that it could contribute to high banana peel wastes disposal in this country. Banana peels are commonly



discarded as waste because they form the integral part of the fruit. However, banana peels have several beneficial properties for transformation into bio-fertilizer as soil amendment. Banana peels are not only rich in macronutrients such as nitrogen, phosphorus, and potassium but they are also rich micronutrients (iron, manganese, zinc and copper) (Aboul-Enein et al., 2016) promote growth of plants from seed germination, flowering, and fruiting. With these nutrients, banana peels improves plants' resistance to diseases (Wazir et al., 2018). The high quantities of K, growth-stimulants, and amino acids such as L-tryptophan of banana peels have significant effects several biological characteristics of plants, including a greater rate of seed germination (Sogani, 2023).

Pineapple fruit is one of the major types of local fruits production in 2022 in Brunei Darussalam with estimated total quantity of 223,443 kg (Department of Agriculture and Agrifood, 2022). The disposal of pineapple peel wastes is on the increased. The use of pineapple wastes as a liquid organic fertilizer is essential. The pineapple peel is rich in sugars and carbohydrates. Approximately 81.72% of the pineapple peel is made up of water, followed by 20.87% crude fiber, 17.53% carbs, 4.41% protein, and 13.65% reducing sugar (Sutikarini et al., 2023). According to study by Nurcholis et al. (2020), ultisol soils which are characterized as marginal areas with low organic matter content, may benefit from the application of this liquid organic fertilizer. The best outcomes for the growth and production of long bean plants were obtained using a liquid organic fertilizer at a concentration of 450 ml/L.

According to the Food and Agriculture Organization of the United Nations (FAO), losses and wastes in fruits and vegetables are the largest of all food kinds and could be up to 60% (Sagar et al., 2018). Industrial vegetable wastes (VWs) can be used as bio-fertilizers through anaerobic digestion (Pilarska et al., 2017). With the participation of microorganisms including bacteria and archaea to decompose organic matter in anoxic circumstances, anaerobic digestion (AD) breaks down complex organic materials in VWs to produce bio-gas as a substitute for biofuel. Bio-fertilizers can be developed from the final effluent from anaerobic digesters (Chakravarty & Mandavgane, 2020).

According to Rajput et al. (2022), a fungal infection on the stem area of the Tulsi plant (*Ocimum Tenuiflorum*) prevented plant growth because the growth of the plant was halted. The infection was later reduced after applying onion peel water to the diseased areas of plants for 21 days to 25 days. New green leaves were also produced at the plant's tip, indicating that the plant's regrowth process had begun. The onion peel water had the potency of reducing the severity of plant infection, increasing plant growth, flowering, and commencing plant regeneration which have several chemical constituents such as flavonoids, phenols, tannins, and others that are good to plants (Rajput et al., 2022). Thus, onion peels can serve as one of the organic fertilizers which could be used in farming systems to improve soil and crop productivity.

Garlic peels and straw are the examples of garlic wastes, which constitutes approximately 25% to 30% of the weight of the raw material, are usually dumped or incinerated. This improper disposal pollutes the environment (Chen et al., 2021). Garlic peels provide essential nutrients for plant growth and development because they are rich in vitamins, antioxidants, and nutrients such as fiber, calcium, calories, iron, potassium, and magnesium (Patil, Jana & Murumkar, 2021). In fact, the newest findings indicate that garlic peel may have an impact on bacterial communities. Garlic peels enhance the fermentation quality of high-moisture silages by boosting *Lactobacillus* abundance and reducing the relative abundance of *Clostridium* (Chen



et al., 2021). Therefore, garlic peels have proved to be another source for producing organic fertilizers to improve soil and crop productivity.

Benefits of utilizing food wastes for organic bio-fertilizer production in Brunei Darussalam

In Table 2, there were total of 8 out of 27 papers recorded which addressed on benefits of utilization of food wastes for bio-fertilizer production. To effectively manage compostable wastes, organic fertilization using food waste should be taken into consideration because it improves crop yield and soil fertility. Food waste fertilizers can be used as an alternative to chemical fertilizers to boost vegetables yield in addition to enhancing the physical properties of soil (Dlamini, Mukabwe & Sibandze, 2021). It has been proven that continuous applications of organic fertilizer made from food waste enhances soil quality, increase crop yield, and it even promotes the growth of soil bacteria. Additionally, it was reported that applying food waste to soil enhances its physical, chemical, and biological characteristics and also the growth and development of a variety of crops, including rice, tomato, pakchoi, and common bean (Kang et al., 2021). Food waste cannot be used directly as a fertilizer because it contains salt, which is the major deterrent to fertilization using food waste. As a result, the production of organic bio-fertilizers from food waste is a more sustainable and efficient approach than using conventional chemical fertilizers in agriculture (Kang et al., 2021). Moreover, increased soil and crop productivity guarantees achieving sustainable food security.

Food waste disposal in landfills is associated with several negative environmental effects. For example, anaerobic degradation of food waste in landfills causes emission of methane, ammonia, and volatile fatty acids, and a high chemical oxygen demand (Fisgativa, Tremier & Dabert, 2016). In addition, landfill leachates have a high potential to polluting the surrounding surface waters and groundwater (Bolan et al., 2014). There has been promising research outcomes on converting food waste into value-added products including bio-fertilizers, bio-fuels, and new and existing chemicals (Lin et al., 2013). Compared with chemical fertilizers, digested food waste fertilizer ought to have several environmental merits because high-quality energy is gained in the production process and the nutrients are preserved within the effluent, that is, the digestate (O'Connor et al., 2020). When food wastes are used to produce organic bio-fertilizers, the approach decreases food wastes issues, consequently reducing the harmful greenhouse emissions and pollutants.

Given that food waste is posing a challenge in Brunei Darussalam, utilizing food wastes as the primary components of organic bio-fertilizers will undoubtedly benefit the country. The more food wastes are utilized to produce bio-fertilizers, there will be a reduction in costs for the importation of chemical fertilizers. Due to their effectiveness and low-cost, organic bio-fertilizers made from food waste can boost agricultural production, which in turn increases the country's income and GDP and encourages the development of a sustainable economy. Additionally, excess food wastes can be transformed into biofuels and several bio-products aside from transforming them into organic fertilizers. This can further contribute to Brunei Darussalam's economic sustainability improvement. The value of producing bio-fertilizer from food waste has been underestimated in contrast to biofuel and biochemical production. Fertilizer has a promising market outlook, with a projected value of more than $\$150 \times 10^9$ per year by 2020. By reducing the demand for synthetic chemical fertilizers and replacing them with bio-fertilizer derived from food wastes, the environmental impact of food wastes will significantly decrease and directly enhancing food production (Du et al., 2018).

Limitations of using bio-fertilizer in Brunei Darussalam

In regards to cost-benefit analysis, however, there may be challenges when utilizing food waste for bio-fertilizer production in Brunei Darussalam. According to results in Table 2, there were 2 papers recorded (Mulani et al., 2017; Carvajal-Muñoz & Carmona García, 2012) which addressed on limitations of bio-fertilizer. Bio-fertilizers have naturally lower macronutrients concentration of NPK compared with commercialize chemical fertilizer (Mulyani et al., 2017). Therefore, larger volumes of bio-fertilizer are required in agriculture (Carvajal-Muñoz & Carmona García, 2012). This implies that there will be an increase in production costs because of the requirement for additional workforce, transportation and facilities to maximize the effectiveness of bio-fertilizers to the soil and crops in field application.

Conclusion and recommendation

In summary, a total of 19 papers on bio-fertilizer production in Brunei and 2,647 papers on food waste organic bio-fertilizer were initially recorded using both Scopus database and Google Scholar (non-Scopus database). After a thorough screening, only 2 papers on bio-fertilizer in Brunei and 26 papers on food waste organic bio-fertilizer were deemed eligible for the review study. According to literature findings on different types of food wastes, it was observed that the use of bio-fertilizers made from food wastes have a positive impact and benefits on overall soil and crop productivity. These observations highlight the potential of utilizing food waste to produce bio-fertilizers as a sustainable approach towards agriculture and waste management in Brunei Darussalam. However, using bio-fertilizer has a few limitations such as lower NPK content (compared to chemical fertilizers) and higher production costs for large-scale application. To conclude, it is evident that there is a lack of information or data regarding Brunei Darussalam's production and application of biofertilizer, particularly derived from food wastes. The implications of organic bio-fertilizer appear a new concept in agriculture sector in Brunei Darussalam which might be because of less awareness and confidence in bio-fertilizer's practices. Additionally, an effective strategy for food waste disposal by recycling or valorization into value-added products will significantly enable to further improvement of wastes management matters in the country. To address the research gaps of application of organic bio-fertilizers production to soils, field studies in Brunei Darussalam need to be pursued.

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Social Return on Investment of Chiang Mai's Urban Pesticide-free Vegetable Production System Development Project

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Abstract

The Center for Agricultural Resource Systems Research at the Faculty of Agriculture, Chiang Mai University initiated a project for producing pesticide-free vegetable in the urban agro-ecosystem of Chiang Mai, aiming to serve as a model for promoting pesticide-free vegetable production in urban areas, aligned with Sustainable Development Goals 12 (Responsible Consumption and Production). The project funded by the Program Management Unit on Area Based Development (PMU A) for a one-year duration starting from May 2021 and ended in April 2022. This study investigates the Social Return on Investment (SROI) of the project. The analysis aims to elucidate the project's multifaceted outcomes and offer valuable insights for policymakers to encourage investments in safe vegetable production within urban domains. The SROI evaluation demonstrated the project's success in achieving economic, social, and environmental objectives, particularly in establishing a sustainable source of safe food through a community of pesticide-free vegetable producers in urban areas. This initiative fostered community interaction, economic development, and improved health through pesticide-free vegetable consumption, showcasing a potential model for green urban communities. Despite challenges posed by the COVID-19 pandemic, the project yielded significant benefits over ten years period, with a net present value of \$66,831 and an SROI of 2.99, indicating that every \$1 invested generated a social return of \$2.99 – a favorable rate for agricultural projects. The project's success underscores the importance of continued support from the Faculty of Agriculture, Chiang Mai University, or relevant research funding agencies to sustain such impactful endeavors.

Keywords: Sustainable production, urban farming development, social impact, community empowerment

JEL code: H43 Project Evaluation; Social Discount Rate

SDG goal: Responsible Consumption and Production

Introduction

The consumption of vegetables within urban communities predominantly relies on produce sourced from local fresh markets, often originating from peri-urban areas characterized by intensive chemical usage to mitigate pest, and weed pressures, thereby posing potential health risks to urban consumers. However, promoting organic vegetable cultivation within urban settings encounters spatial constraints alongside knowledge and skill deficiencies in production practices, encompassing effective planning and marketing strategies. Furthermore, consumer confidence and comprehension regarding market mechanisms remain inadequate, impeding the adoption of pesticide-free alternatives and the recognition of associated benefits.

Consequently, the Centre for Agricultural Resource Systems Research at the Faculty of Agriculture, Chiang Mai University (CMU), has initiated a prototype project aimed at fostering pesticide-free vegetable production within urban environments. This endeavor entails the development and validation of an ecologically aligned system for cultivating pesticide-free



vegetables, complemented by the establishment of a supportive market infrastructure facilitating the distribution and consumption of project-produced produce. Spanning a one-year duration, commencing in May 2021, and concluding in April 2022, the prototype project seeks to illuminate the transformative impacts ensured by its implementation (Norsuwan et al., 2022).

To elucidate the project's outcomes, the project had been evaluated for social return on investment (SROI). This evaluation endeavors to provide significant insights for stakeholders, urban vegetable producers, and entrepreneurs, aiding in informed decision-making and resource allocation. Additionally, the findings can serve as a foundational resource for governmental entities in devising policies conducive to fostering investments in safe vegetable production within urban domains, thereby facilitating project monitoring, evaluation, and future iterations.

Methodology

This study applied SROI method to monetize the economic and social values of the project using financial proxies based on cost-benefit analysis. The methodology of this study can be divided into 3 parts as follows.

1. Procedures and Methods for Assessing SROI

The SROI assessment process has different phases as follows (modified from Thailand Development Research Institute Foundation, 2020):

- 1.1 Initial investigation of project activity, budget allocation, outputs alignment with objectives through performance reports and interviews.
- 1.2 Define the analysis scope, identify stakeholders, and outline their roles. Stakeholders' involvement drives changes and is identified through reports and discussions.
- 1.3 Gather data and create outcome maps illustrating the relationship among resources, activities, outputs, and outcomes. Stakeholders engage in outcome delineation through meetings or interviews.
- 1.4 Develop indicators linked to measurable outputs for each activity, adjusting them as needed. Anticipated for evaluating changes resulting from the planned implementation of each activity. Use a questionnaire to systematically collect information from stakeholders, excluding spontaneous changes.

After examining the final report of the urban pesticide-free vegetable production project, basic financial indicators and representative values anticipated for use in the study are classified by stakeholder groups as outlined in Table 1.

Table 1. Classification of stakeholders, outcomes, indicators, and financial proxies

Stakeholders	Outcomes	Indicators	Financial proxies
Pesticide-free vegetable producers engaged in the project	Enhanced income	Increased income of pesticide-free vegetables	Market value of pesticide-free vegetables
	Decreased production expenses	Reduced production costs due to the project recommendation	Market value of reduced resources



Stakeholders	Outcomes	Indicators	Financial proxies
	Knowledge gained from the workshop training	Number of producers attending workshops	Workshop training costs
	Better health from pesticide-free production and consumption	Decrease of visit frequency and costs for medical care from chemical-related diseases	Cost of medical care and the opportunity cost of time lost due to medical care.
	Strengthened community unity from enhanced relationships among vegetable producers	Number of participated members and frequency of exchange activities	Cost and time value spending for exchange activities
Municipality in the study areas	Decreased promoting cost for safe agriculture	Reduction of expenses due to the existing project	Decreased agricultural promotion expenditure
	Knowledge gain from the workshop training	Number of officials attending workshops	Reduced costs for officials' training
Community consumers	Enhanced health outcomes from consuming pesticide-free vegetable	Number of consumers affected by agricultural chemicals and reduced costs of medical care	Expenses for medical care related to chemical-induced diseases
	Diminished expenses for safe vegetables	Decreased expenses for safe vegetables from external sources	Time value spent traveling to purchase safe vegetables and associated travel expenses
Faculty of Agriculture, CMU	Enhancing Goodwill's corporate image	Number of individuals accessing various media disseminating information about the project and project published medias	Reduced expenses in public relations

In this context, production has shifted from chemical to safe methods, reducing reliance on pesticides. Expected environmental outcomes include decreased greenhouse gas emissions from reduced chemical use. However, due to the project's small scale and focus on household consumption, assessing the environmental impact presents challenges not addressed in this study.

This study employs the following methodologies:

- 1) Utilizing the Net Present Value (NPV) approach, this study assessed the project's monetary impact by examining evidence collected over the project's duration, delineating the benefit period and drop-off rate. The NPV calculation entails evaluating cash flows derived from project benefits, predicated on data amassed from stakeholder groups throughout the project's duration, to ascertain societal benefits.



- 2) The study calculates the SROI, representing the present value of all social benefits relative to the investment unit, providing a comprehensive measure of the project's societal impact.

2. Identifying the stakeholders' economic and social goals

After clearly identifying the project stakeholders, the identification of economic and social goals is based on input from stakeholders to reflect the changes that have occurred due to the project. Data collection involves two primary channels:

2.1 In-depth interviews with representatives from the Suthep and Mae Hia Subdistrict municipalities, active members of two vegetable producer groups, and a sample of pesticide-free vegetable consumers (47 participants).

2.2 Focus group discussions with local stakeholders, including community members engaged in vegetable production in both subdistricts and municipal representatives, and officials involved in the project.

3. Steps of creating a theory of change, Impact Value Chain, and Base Case Scenario

It is imperative to demonstrate changes in both outputs and outcomes within the evaluation period. This may encompass aspects such as the augmented income and enhanced health of vegetable producers arising from the production and consumption of pesticide-free vegetables. This study processes the theory of change derived from the project activities and the project outcomes arising from these transformative initiatives.

The Impact Value Chain is the distribution of activities and outputs crucial for actualizing the defined theory of change. In developing an impact value chain, it is essential to ascertain the inputs that lead to the projected output. When composing the impact value chain, the various activities conducted must be specified. Outputs stemming from these activities should possess concreteness and measurability and reflect that social results have transpired. Examples include the quantifiable increase in income for vegetable producers and the count of households gaining access to the consumption of pesticide-free vegetables.

In this step, data were collected from small group meetings. Each stakeholder group delineated their roles and specified project activities, detailing the inputs expended, such as financial resources, time, and labor. Additionally, stakeholders will articulate the outcomes or changes, specifying their magnitude and corresponding measurement metrics.

The base case scenario is the evaluation result based on principles, reflecting outcomes directly resulting from the project's activities. It excludes results arising from the actions of other organizations (attribution), outcomes that might occur even without any organization's performance (deadweight), and results that are not additive but rather substitute for other outcomes (displacement). This includes estimating future results that decrease (drop-off) after the project has concluded. Information in this section is derived from the second subgroup meeting, conducted after the initial meeting. The steps for the second meeting are as follows:

3.1 Provide stakeholders with comprehensive feedback regarding the changes and outcomes that have transpired within each stakeholder group.

3.2 The meeting participants collaboratively analyzed whether, in the absence of project implementation, outcomes or changes would have occurred and specified the weight (percentage) of changes that have already taken place even without project implementation (deadweight).



3.3 The meeting participants expressed their opinions and analyzed the role of various agencies or organizations in causing change, including specifying the proportion of changes that occur as a result of the project (attribution).

3.4 The meeting participants collaboratively conducted an analysis of the sustainability of the benefits arising from the project, specified the period during which benefits will be received from the project (benefit period), and shared opinions about the rate of reduction of benefits (drop-off).

Results and discussion

Summarizing project's activities and implementing expenses

The project comprised six components: 1) Community capital and potential exploration, enhancing understanding of urban agroecology; 2) Establishing pesticide-free vegetable demonstration plots; 3) Conducting practical study tours and training sessions; 4) Providing production support and community follow-up; 5) Facilitating knowledge exchange through community participation; and 6) Implementing market management and production standards. Amid the COVID-19 pandemic, the project adapted certain activities to online formats, including training sessions and study tours. Nevertheless, field visits for contextual learning with community leaders persisted, alongside LINE communication for interaction. Demonstration plots included a 0.12 hectare open-field and 5 greenhouses for pesticide-free vegetable production. Two online study tours attracted up to 46 participants initially, with extensive engagement through comments and shares. Post-event follow-ups reached a maximum of 3,751 viewers and engaged 1,806 participants. Subsequent events garnered 43 live viewers, with active participation and extensive post-event engagement. Members were encouraged to visit demonstration sites in person after online study tours, enhancing overall engagement.

Two rounds of budget support totalling \$7,569 were allocated for agricultural materials to project participants. In Suthep Municipality, 16 recipients received a total support of \$3,848, while in Mae Hia Municipality, 23 recipients received a total support of \$3,721. Researchers conducted on-site evaluations of member activities, gathering data on production areas, labor usage, and production methods, identifying challenges from 26 participants. Two focus group meetings in December 2021 addressed cultivation challenges, with 29 attendees introduced to quality inspection through the Agricultural Product Traceability Unit (AGtrace CMU) of the Faculty of Agriculture, Chiang Mai University. Techmorrow developed the "Nearby Vegetable Sales" LINE Application to distribute member produce, although its usage was limited due to low member participation. Instead, "Suthep CMU Green&Clean for Life" and "Mae-Hia Green Road" Facebook pages were created. Furthermore, project activities were promoted through various networks and online media channels such as Chiang Mai News, Chiang Mai CM108, and Northern Region News NBT Chiang Mai.

Value of benefits incurred to stakeholder (Base case)

The values of benefits arising from project implementation are classified according to four stakeholder groups: the group of vegetable producers involved in the project (15 producers in two subdistricts), community consumers, *Suthep* subdistrict municipality and *Mae Hia* subdistrict municipality, and the Faculty of Agriculture, Chiang Mai University which is the organization that carries out the project. Based on the producers' expectation to continue growing vegetables, the projects' benefits will be evaluated for another ten years or from 2022-2032. The benefit value results of each stakeholder group are listed in Table 2 and can be summarised as follows.



- 1) *Additional benefits of the pesticide-free vegetable producer group participating in the project.* The benefits of pesticide-free vegetable producers can be divided into 5 parts: 1) additional income from increased production of pesticide-free vegetables considered for both household consumption and sale (\$10,221 per year) 2) the value of knowledge gained from participating in project training (\$460 per year) 3) the value of benefits arising from improved health from producing and consuming their own pesticide-free vegetables (\$28 per year) and 4) the value of benefits arising from better relationships among pesticide-free vegetable producers, fostering unity within the community (\$2,718 per year). The total benefit of the pesticide-free vegetable producer group participating in the project was \$13,399 per year.
- 2) *Marginal benefits of community consumers.* These benefits can be divided into 2 parts: 1) total benefit value from improved health of consumers from the consumption of pesticide-free vegetables (\$5,827 per year) and 2) value of benefits from cost savings in purchasing pesticide-free vegetables (\$241 per year). The total benefit for community consumers was \$6,068 per year.
- 3) *Additional benefits of the municipalities.* The municipality is a local agency that helps coordinate the project implementation. The result showed that there was no additional benefit for both municipalities due to two reasons. First, the municipality's officials did not gain more knowledge because they did not participate in the training, they performed only coordination duties and went to the communities to follow up on operations. Second, the municipality official reported there was no budget saving related to promoting safe vegetable production in their areas because they did not set up a similar project.
- 4) *Benefits from a better image of the Faculty of Agriculture.* The project implementation is considered to be the way to publicize and make people in the area recognize the Faculty of Agriculture, Chiang Mai University. In terms of estimating the value of benefits in monetary terms, it can be assessed from budget savings in public relations for the Faculty of Agriculture. The Faculty of Agriculture's public relations budget is approximately \$4,766 per year. Therefore, it is considered that the benefits obtained from having the project in terms of a better image of the Faculty of Agriculture, is equal to \$4,766 per year.

Table 2. The benefit value of Chiang Mai's Urban Pesticide-free Vegetable Production System Development Project

Benefit value	Benefit value per year (US\$)*			Present value of project (11 years)		
	Suthep	Mea Hia	Total	Suthep	Mea Hia	Total
1. Total benefits of the pesticide-free vegetable producer groups participating in the project	5,666	7,733	13,399	43,919	62,728	106,646
a. additional income from increased production of pesticide-free vegetables	3,601	6,620	10,221	29,489	54,210	83,700
b. the value of knowledge gained from participating in project training	345	115	460	345	115	460



Benefit value	Benefit value per year (US\$)*			Present value of project (11 years)		
	Suthep	Mea Hia	Total	Suthep	Mea Hia	Total
c. the value of benefits arising from improved health from producing and consuming pesticide-free vegetables	-	28	28	0	230	230
d. the value of benefits arising from better relationships among pesticide-free vegetable producers	1,720	998	2,718	14,084	8,173	22,257
2. Total benefit for consumers in the community	2,976	3,092	6,068	24,370	25,319	49,689
a. total benefit value from improved health of consumers from the consumption of pesticide- free vegetables	2,900	2,927	5,827	23,748	23,965	47,713
b. value of benefits from cost savings in purchasing pesticide-free vegetables	76	165	241	622	1,354	1,976
3) Additional benefits for the municipality	0	0	0	0	0	0
4) Benefits from a better image of the Faculty of Agriculture	N/A	N/A	4,766	N/A	N/A	4,766
Total benefit	8,642	10,825	24,233	68,289	88,047	161,101

Source: Author's calculation

*The exchange rate used in this study was from Bank of Thailand (29 Jan 2023): 1 US\$ = 35.67 baht

*The exchange rate used in this study was from Bank of Thailand (29 Jan 2023): 1 US\$ = 35.67 baht



Table 3. Sensitivity analysis

Stakeholders	Outcomes	Study area	NPV (US\$)	deadweight	Displacement rate	Attribution	drop off	NPV of total benefits (US\$)
1. the pesticide-free vegetable producer group participating in the project	additional income from increased production of pesticide-free vegetables	Suthep	29,489	38%	0%	40%	47%	5,814
		Mea Hia	54,210	23%	0%	40%	0%	25,045
	the value of knowledge gained from participating in project training	Suthep	345	0%	0%	0%	0%	345
		Mea Hia	115	0%	0%	0%	0%	115
	the value of benefits arising from improved health	Mea Hia	230	26%	0%	40%	0%	102
	the value of benefits arising from better relationships among pesticide-free vegetable producers	Suthep	14,084	7%	0%	0%	0%	13,098
		Mea Hia	8,173	21%	0%	0%	0%	6,456
2. consumers in the community	benefits value from cost savings in purchasing pesticide-free vegetables	Suthep	23,748	0%	0%	0%	0%	23,748
		Mea Hia	23,965	0%	0%	0%	0%	23,965
	Benefits value from improved health	Suthep	622	50%	0%	40%	0%	187
		Mea Hia	1,354	50%	0%	40%	0%	406
3. Faculty of Agriculture	Benefits from a better image of the Faculty of Agriculture		4,766	50%	0%	50%	0%	1,191
The net present value of total benefit (US\$)						100,473		
The present value of investment cost (US\$)						33,642		
The net present value of the total benefit subtracted with the present value of the operation cost (US\$)						66,831		
The social return on investment (SROI)						2.99		

Source: Author's calculation



Social Return on Investment of the project

The project's initial investment amounted to 33,642 US\$, yielding net present value of benefits totalling \$100,473 over a 10-year period (2022 - 2032). Deducting the project's expenses from its benefits yields a net present value of \$ 66,831. With an SROI of 2.99 meaning that investing \$1 in the Chiang Mai's Urban pesticide-free vegetable production system development project generate a social return of \$2.99. The findings align with those of Basset (2023), who conducted a comprehensive review of SROI applications in social farming. Basset's analysis revealed that the SROI of similar projects generally falls within the range of approximately 2 to 3.

Sensitivity analysis of social return on investment

Sensitivity analysis was conducted to assess the viability of the project under different implementation scenarios. This analysis examines how change in various factors, such as costs and benefits, impact the project's overall worthiness for investment in situations where implementation deviates from expectations.

In the first scenario, if there are changes in attribution due to the stakeholder group receiving support from other agencies or research projects while other factors remain constant, the attribution ratio can increase to be 72 percent. Even with this increase, the project still maintains a social return rate of 1, suggesting that if support or participation from another entity in the area accounts for 72 percent, the project can still yield social return equivalent to its investment cost. In the second scenario, if the drop-off rate is reduced by up to 68 percent, the project's social impact is brought closer to its investment, maintaining a social return rate of 1.

Conclusion

The Chiang Mai's urban pesticide-free production system development project initiated by the Faculty of Agriculture, Chiang Mai University focused on six key components: community exploration, pesticide-free vegetable demonstration, practical training, production support, knowledge exchange and market management. Adaptation was made during the pandemic, shifting some activities online while maintaining field visits and LINE communication. Demonstration plots included an open field and greenhouses. Online study tours reaching thousands of viewers. Evaluation through Social Return on Investment (SROI) demonstrated the project's success in achieving economic, social, and environmental objectives, notably in establishing a sustainable source of safe food through a community of pesticide-free vegetable producers in urban areas. This initiative fostered community interaction, economic development, and improved health through pesticide-free vegetable consumption, showcasing a potential model for green urban communities. Despite challenges posed by the COVID-19 pandemic, the project yielded significant benefits, with a net present value of \$66,831 and an SROI of 2.99, indicating that every \$1 invested generated a social return of \$2.99 – a favorable rate for agricultural projects. The project's success underscores the importance of continued support from the Faculty of Agriculture, Chiang Mai University, or relevant research funding agencies to sustain such impactful endeavors.

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Track 7

Food and nutrition security



Food and Nutrition Security Vulnerability to the Don Sahong Hydropower Dam

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Abstract

This study examines the impact of the Don Sahong Hydropower Dam on food and nutrition security in the Mekong River Basin. This study uses the Household Food Insecurity Access Score (HFIAS) and Household Dietary Diversity Score (HDDS) to measure food insecurity and dietary diversity among households affected by the dam's construction. Preliminary results indicate higher levels of food insecurity and lower dietary diversity among these households. The study underscores the need for comprehensive impact assessments and sustainable planning practices in infrastructure development. It also calls for interventions to improve food security and dietary diversity among households affected by such projects. The findings from this study will contribute to a better understanding of the intricate interplay between infrastructure development, ecological preservation, and food security, providing valuable insights for policy-making and sustainable development practices.

Keywords: food security, natural resource, energy, environmental and development

JEL code: Q25, Q18, Q56, Q13

Introduction

Dams and reservoirs are the most common types of man-made infrastructure on the planet (Wang et al., 2022). Long before comprehensive understanding on hydrology and hydromechanics existed, humanity began constructing dams as a major method of utilizing water resources and avoiding natural challenges (Tahmiscioğlu & Anul, 2007). More than two-thirds of the world's renewable electricity is generated by hydropower dams, which facilitates multiple water resources development benefits such as mitigating the adverse effects of climate change on flood and drought (by paving the way for sustainable agriculture and increasing agricultural production), stabilizing the energy mix, and increasing access to fairly cheap electricity. It suggests that the growth of water bodies (especially dam construction), food security, and energy production have been intertwined for a long time, with a change in one implying a change in the other two. (Salam, Shrestha, Vishnu, & Anal, 2017) provided a summary of the water-energy-food security nexus. Hydropower energy can be exploited for water pumps, drainage, water treatment, and distribution, all of which have a direct impact on the water supply. The same electrical energy produced by the hydropower stations can be used to power irrigated agriculture. Water is used as an input in irrigation and for various kinds of food production. Aside from feeding households, the food produced can also be sold to generate income. The relationships described here indicate that food production, water resources, and energy needs are highly interrelated.

Mekong river is the world's 12th longest river, and one of the 35 global hotspots (Dugan et al., 2010). The Mekong River Basin is known for having the most fish species diversity of any river in Asia. The Mekong River is home to around 1200 species, with 18% of the total diversity being indigenous to the system (Pin et al., 2020). Inland fisheries in the Mekong are considered to be among the world's most productive, and their contribution to food security and nutrition is critical (Hortle, Hawkins, Bioscience, & Phommanivong, 2014). According to one of the



latest comprehensive estimates, the harvest from wild capture fisheries in Laos¹ amounts to 64,600 tons, which accounted 78% of the country's total fish caught (Eric Baran & Ratner, 2013). Estimates the direct value in the domestic economy are between USD 66 million and USD 100 million per year (STEA, 2003). In addition, 80% of the animal protein consumed by rural populations, particularly who living above and below the Khone Fall comes from wild-caught fish and other aquatic animals (Hortle, 2007). The Mekong River Basin is unique globally in that the annual variations between low water and high water volumes in the mainstream river are greater than for any other large river in the world. The peak water levels with approximately 30 times as much as dry season water level. The hydrological conditions that exist in the Mekong Basin have contributed to the creation of a variety of aquatic habitats and ecological conditions. The broad difference in ecological and hydrological condition in difference part of the Mekong Basin at the time of the year, cause fish and other aquatic need to move to difference location to be survived (Baird, 2014). The distance of migration could be hundreds of kilometers up to the upper Mekong River in each year (Hogan et al, 2007). As the results, a high proportion of wild fish caught from large rivers in the Lower and Middle Mekong Basin during their journey. More than 78% of the fish caught in the Sesan river in Ratanakiri Province (Cambodia) migrate from the Mekong River (Baird, 2009). Fish migration are such an important aspect of the ecological of the Mekong Basin, which provides food and nutrition for the people along the Mekong River Basin.

Although, the lower mainstream of Mekong River consist of a several channels separated by many large and small islands and natural rock structures. However, some of this channels that are part of the Khone Falls area have high waterfalls (i.e. Khone Phrapheng Falls, Tham I Deng Falls, Somphamit Falls) which are considered as biogeographical barriers to fish migration, specifically for upriver movement. In the other case, fish are able to migrate past a small water fall and turbulent water under the particular condition, and during certain time of year. There is one channel in the Khone Fall area, which fish can easily pass upriver year round: the Hou Sahong Channel (Roberts and Baird 1995). The channel is approximately seven kilometers long, without high waterfalls and geographical barrier located along its length for the fish movement. As a result, any blockage on the Hou Sahong Channel might have significant consequences for the ecological system. This might also effectively block dry-season fish flows between the lower Mekong plains and the Mekong basin upstream, leading to decreased fish catches, consumption, and nutrition for both those living below and above the Khone Falls.

Since 2014, the Hou Sahong Channel has been considered for hydropower construction, and the construction has been started from 2016 to 2019. Despite the fact that it is a true run-of-river scheme with storage in the project's reservoir for only 2 to 4 hours and no water abstraction (Hortle & Phommanivong, 2016), the Don Sahong Hydropower Dam will also have a significant impact on the hydrological flow of water and be a significant barrier for fish migration in the mainstream Mekong River. Changing the flow regime of the Mekong River has profound effects on ecological system in the river (Sabo et al., 2017), leading to decreased fish catches and decreased food security for local people. In addition, changing hydrological and ecological system in the river increased the demand for other resources to replace lost protein and calories. Therefore, this study aims to examine the impact of the Don Sahong Hydropower Project on food and nutrition security vulnerability of the local communities, and provide relevant stakeholders with policy recommendations to mitigate the effects of Don Sahong Hydropower Project on food and nutrition security vulnerability.

¹ including catch in rice fields



Literature Review

The body of knowledge regarding the advantages and disadvantages of developing and constructing hydropower dams is growing. Hydropower dam projects, according to Ecological Modernization Theory (EMT), on the one hand, promote the development of new technologies. The argument is that technology undertakings, such as the development of large hydroelectric dams, can encourage economic growth and provide a sustainable improvement in human welfare. Dams are considered a means to promote worldwide economic development, provide flood control, enhance irrigation, generate hydropower, and prevent ecological damage resulting from flooding and sedimentation downstream (Fujikura, Nakayama, & Takesada, 2009). On the other hand, there are some argument content that building of hydroelectric dam alters the social, physical, and economic context of the dam site and drives locals out of their homes, farms, and other productive assets (Burrier, 2016). In addition, (Kebede, 2009) found that building dam leads to loss of common pool resource, and food deficiency among surrounding communities. Wolde, Wei, Kunpeng, and Ketema (2020) found that food is the center of nexus resources for the community in the study area.

The recent study by (Jima et al., 2022) investigated the effect of the Amerti and Neshe hydroelectric dam reservoirs on the food insecurity of the adjacent rural households in Ethiopia. This study applied a probability proportional to the size sampling technique, where data were gathered from 485 houses using a cross-sectional method (268 affected and 217 non-affected households). In order to assess the level of food insecurity among households in the research area, the households' food insecurity access scale (HFIAS) and households' dietary diversity score (HDDS) were utilized. The effect of the dam building on household food insecurity was determined using the Endogenous Switching Regression model. The findings showed that the research area's average HDDS and HFIAS were 5.1 and 10.29, respectively. The study also showed that the impacted household's HDDS and HFIAS averages were 4.48 and 10.98, respectively. The study's findings also showed that while HDDS decreased by 24%, HFIAS of displaced households grew dramatically by 14.6% as a result of the construction of dams. Even though dam development is supposed to promote food security by improving access to water, this study demonstrated a negative link between food security and dam construction.

Mekong River has been emphasize as the virtual source of food and nutrition for the people living along the Mekong River (Baran et al., 2001; Kurien et al., 2006). The Mekong Basin is primarily a wetlands ecosystem, with three main influences on productivity: hydrology, floodplain environment quality, and fish movement patterns. This fluctuation is mostly due to the river's yearly flood pulse, which occurs from May to November and inundates approximately 84,000 km² of floodplains. The Mekong River is one of the largest tropical river systems, supporting a unique mega-diverse fish community. Fish provide a significant amount of calcium, protein, and necessary elements to the local diet, as well as a significant source of revenue for rural households. The population's dietary demands are dependent on the basin's fisheries. In Cambodia, and Laos, the fish harvest accounts for 3 times pig output, 20 times chicken production, and up to 75% of animal protein requirements (Kurien et al., 2006).

Changing the flow regime of the Mekong River has effect on ecological system in the river. The dam construction in the Lower Mekong Basin will significantly effect on fish catches. E. Baran & Myschowoda, (2009) states that although, dams benefit the region's economies, but they will have a negative impact on other sector that depend on river flows, such as fishing. Dugan et al., (2010) examined the specific case of fish migration and dams on the Mekong river. Dugan found that Dam construction leads to major losses of fisheries and other



anticipated benefits. Millions of people in the basin, particularly in low-income populations in Cambodia, Laos, and Vietnam will lose their livelihoods, nutrition, and social stability as a result of this. Dams will impair upstream spawning movement of ecologically and biologically important species Dugan (2008). Dams in the lower Mekong basin's middle and lower reaches, including major tributaries, will prevent the longest migrations and disrupt recruitment to the river's lower reaches. In addition, the recent study by and Intralawan et al., (2019) point to decreased food security and loss of local livelihoods for millions of people as major concerns related to dam development. Golden et al., (2019) found that Hydropower development in the Lower Mekong Basin could restrict access to subsistence fish from the Mekong River Basin and lead to increased risk of nutritional deficiencies in Cambodia and the lower Mekong basin. The lower Mekong basin population at risk of nutritional deficiencies could rise from 0.21 to 2.23 million people in 2010 to 0.41 to 1.58 million people in 2030. Those at risk are in addition to the malnourished. Fish is the principal animal source diet and micronutrient source in the lower Mekong basin. Reductions in fishing output could worsen severe nutritional deficits, heightening the risk of widespread nutritional insecurity

Methodology

Data and model specification

Description of the study area

This study was conducted in the wetland area of the Khong district of Champasak province. The present study focused on the surrounding communities living along the Mekong river closes to the Don Sahong hydropower dam. The Don Sahong Hydropower Company, which has the ability to produce 260 MW, completed construction and began operations in mid-2019, generating 260 MW (Baird, 2014). This project is located at the Khone Fall in the southern (downstream) end. The Don Sahong Hydropower Station blocks approximately 13% of the total average Mekong flow at the site, with the remaining 83 percent flowing down the existing natural channels (Falls & Hawkins, 2018) as show in Figure 1.



Figure 1 Location of the study area
 Source: Google map

Measuring food insecurity

This study uses the Household Food Insecurity Access Score (HFIAS), and Household Dietary Diversity Score (HDDS) to measure food insecurity following methodologies proposed by Abafita & Kim, (2014); Fraval et al., (2019); and Jima et al., (2022). HFIAS and HDDS measure households' food insecurity differently, in which a high value of HFIAS indicates a given household is more food insecure while a high value of HDDS suggests a household is more food secure. The study will be using both of these measures to make sure that the results are consistent and reliable across households.

To generate the HFIAS, a standard questionnaire with nine questions capturing dimensions of household food insecurity is used. In the questionnaire, a household is asked to describe how often it experiences food insecurity for each question as rarely, sometimes, or often. The numerical value of HFIAS can range from a minimum of 0 indicating no food insecurity in the household to 27 indicating the most extreme case of food insecurity (Coates et al., 2007). Similarly, the household dietary diversity score (HDDS) measures how many different foods a given household consumed over the past 24 hours (FAO, 2010). This study used fifteen (15) food items that are commonly consumed in the study area to produce the HDDS. A household is asked to indicate its consumption of each food item as 1 for "Yes" or 0 for "No". This leaves the maximum and minimum value of HDDS to 15 and 1, respectively. In this measure, a household that scores 15 on HDDS has the highest dietary diversity.

To analyze the impact of the Don Sahong Hydropower Project on food and nutrition security, this study has followed the model introduced by (Jima, Diriba, Senbeta, & Simane, 2022), which includes dependent and independent variables as Table 1:

Table 1. Definition of variables

Variable	Definition	Measurement	Expected Effect	Source
Dependent variable: being affected by dam construction (first stage)	Household who live, and used to fishing along Sahong channel, and Sadam channel.	Dummy, assumes 1 if household affected, 0 otherwise		Household survey
HFIAS (second stage)	Household food insecurity status as define in (Coates et al., 2007)	The continuous index measure between 0 and 27		Household survey
(HDDS) (second stage)	Households Dietary Diversity score (Abafita & Kim, 2014)	The continuous index measure between 1 and 15		Household survey
Gender	Gender of the household head	dummy variable: 1 if the head is male and otherwise	+	Household survey
Status	Marital status of household head	dummy variable: 1 if the head is married and otherwise	+	Household survey
Edu	Education of the household head	Measure in year	-	Household survey
Age	Age of the household head	Measure in year	-	Household survey
Source of income	Number of income source, a given household has	Continuous	+	Household survey
Credit	Credit status of a household	dummy variable: 1 if family loan form financial institution and otherwise	+	Household survey
Income	Land owned by household, both agriculture and non-agriculture	hectares	+	Household survey

Sampling technique and sample size

Sample Size Determination is calculated based on the formula of Yamane, when population is known. Population is households living along the Khone fall area in Khong district. There are 1,240 household in total.

The multi-stage sampling procedure will be followed to select 303 sample (both affected and non-affected households). In the first stage, the Khong district was selected because of the Don Sahong dam prevalence. In the second stage, 9 villages (both affected and non-affected) were randomly selected from the district following simple random sampling as show in Table 2. Then, after proportionally allocating the required sample size to each village, sample households were selected using a simple random sampling procedure. The study sample size was determined following (Wogu et al., 2019), a minimum required sample size for any population size at a 5% level of precision is 303.

Table 2. Sample selection

No	Description	Number of questionnaires
Non-Affected Villages		119
1	Hinsew Village	29
2	Muangsene Village	30
3	Haoy Village	30
5	Na Village	30
Affected Villages		163
6	Done Khone Village	39
7	Done Det Village	39
8	Done Sahong Village	45
9	Done Sadam Village	40
Total		285

Estimation Strategy

In order to evaluate the effect of the Don Sahong Hydropower Dam on the vulnerability of food and nutrition security, which was prone to endogeneity from both known and unknown sources, an Endogenous Switching Regression (ESR) model was employed. This method was selected because it successfully takes into account biases originating from both known and unknown sources (Lokshin & Sajaia, 2004). To this effect, the sampled households were split into two regimes: those that were affected by the construction of the dam and those that were not. In this study, a given household has been identified as affected if they used to fishing or lived along the Sahong channel, whereas a given household was identified as non-affected if they never fish or live along the Sahong channel.

The endogenous switching regression approach to estimate the impact of the Don Sahong Hydropower Dam on Food and Nutrition Security Vulnerability involves a two-step procedure (Lokshin & Sajaia, 2004). In the first step, based on Wooldridge (2012), the binomial probit regression was used to estimate the probability of a given household being affected by the construction of the Don Sahong Hydropower dams in the study area. In the second stage, the Ordinary least square estimation was employed on major outcome variables of the study by inserting the inverse mills ratio as one of the independent variables in the model.

$$SD_i^* = \alpha Z_i + \mu_i \quad (1)$$

$$SD_i^* = \begin{cases} 1 & \text{if } SD_i^* > 0 \\ 0 & \text{if } SD_i^* \leq 0 \end{cases} \quad (2)$$

Whereas, SD_i^* is an unobserved latent variable, its value is dependent on whether a particular family is affected or not as a result of the dam building. If a specific household has been affected, it is assigned a value of 1; otherwise, it is assigned a value of 0. The vector Z_i is an array of factors that impact the classification of households into affected and non-affected groups as a result of dam construction; represents the unknown coefficient parameters; and i is a stochastic term.

In the second stage, distinct food insecurity regressions were derived for affected and non-affected households. These regression functions are listed below.

$$\text{For affected : } FI_{1i} = \beta_{1i}X_{1i} + \theta_1\widehat{\lambda}_{1i} + \varepsilon_{1i}, \text{ if } SD_i = 1 \quad (3)$$

$$\text{For non-affected : } FI_{2i} = \beta_{2i}X_{2i} + \theta_2\widehat{\lambda}_{2i} + \varepsilon_{2i}, \text{ if } SD_i = 0 \quad (4)$$

According to the household food insecurity access score (HFIAS) and the households dietary diversity score (HDDS), FI_{1i} and FI_{2i} (Equations 3 and 4) refer to the food insecurity status of impacted and non-affected groups of households, respectively. The vectors X_{1i} and X_{2i} reflect diverse socioeconomic characteristics of homes that determine household food insecurity status; β_{1i} and β_{2i} are unknown coefficient parameters; $\widehat{\lambda}_{1i}$ and $\widehat{\lambda}_{2i}$ are inverse mills ratios derived from the first stage estimate; and ε_{1i} and ε_{2i} are stochastic terms.

The result equation must be identified in the ESR. Selection tools are required to identify the endogenous switching regression outcome equation. In order to achieve this criteria, at least one significant variable in the selection equation should be excluded from the outcome equation during the second stage of estimate. Following this logic, the size of the family was utilized as a selection tool in this study.

The endogenous switching regression model is based on the assumption of trivariate joint normality of the stochastic factors ε_{1i} , ε_{2i} , and μ_i . This is provided as follows:

$$\text{cov}(\varepsilon_{1i}, \varepsilon_{2i}, \mu_i) = \begin{bmatrix} \sigma_u^2 & \sigma_{\varepsilon 1u} & \sigma_{\varepsilon 2u} \\ \sigma_{\varepsilon 1u} & \sigma_{\varepsilon 1}^2 & \sigma_{\varepsilon 1\varepsilon 2} \\ \sigma_{\varepsilon 2u} & \sigma_{\varepsilon 1\varepsilon 2} & \sigma_{\varepsilon 2}^2 \end{bmatrix}$$

Where σ_u^2 is the variance of the selection equation's disturbance term in the first stage of estimation; $\sigma_{\varepsilon 1}^2$ and $\sigma_{\varepsilon 2}^2$ are the variances of the two outcome equations' disturbance terms in the second step of regression; and $\sigma_{\varepsilon 1\varepsilon 2}$ is the covariance between the disturbance terms of the two outcome equations. These deviations cannot be identified since the two outcomes being affected and being unaffected—cannot occur for the same household at the same time. In each of the two regimes, $\sigma_{\varepsilon 1u}$ and $\sigma_{\varepsilon 2u}$ calculate the covariance between the selection and outcome equations. If this covariance, or, to be more precise, the correlation coefficients calculated thereof, are statistically different from zero, it may be due to an endogeneity problem.

After the second-stage endogenous switching regression, the average treatment effect on the treated (ATT) and the average treatment effect on the untreated (ATU) should be computed to determine how dam building affects family food security (Lokshin & Sajaia, 2004). In order to do this, the predicted values of the outcome variables for impacted and non-affected households were calculated in both actual and counterfactual circumstances (Abdullah et al., 2019; Teklewold, Kassie et al., 2013b; Aseres et al., 2019). The actual anticipated value of food insecurity outcomes for those affected was estimated as follows:

$$E(FI_{1i} | SD_i^{\square} = 1) = E(\beta_{1i}X_{1i} | D_i^{\square} = 1) \quad (5)$$

The counterfactual expected value of food insecurity outcomes for impacted families is assessed using the same approach as:

$$E(FI_{2i} | SD_i^{\square} = 0) = E(\beta_{2i}X_{2i} | D_i^{\square} = 0) \quad (6)$$

Results and discussion

Sample Characteristic

Tables 3 and 4 offer a thorough statistical analysis of the sample, which is divided into two primary categories: continuous and categorical variables. Table 3 provides a statistical summary of the sample, which is divided into affected and non-affected households, with 163 and 119 households in each category respectively.

The average age of the sample is 48.61 years, with a standard deviation of 13.95 years. The mean age is slightly higher in the affected group (49.26 years) compared to the non-affected group (47.72 years). Education, measured in years, has an average of 6.49 years across the sample with a standard deviation of 3.67 years. The affected group has a lower average education level (5.36 years) compared to the non-affected group (8.03 years).

The average number of income sources per household is 2.62, with a standard deviation of 1.24. The affected group has fewer sources of income on average (2.43) than the non-affected group (2.88). The average landholding size across the sample is 17176.17 square metre with a large standard deviation of 18967.32, indicating significant variation in landholding size within the sample. The affected group holds less land on average (11895.36) compared to the non-affected group (22520.60).

Income is represented in logarithmic form, with an average of 17.644 and a standard deviation of 0.864 across the sample. The mean income is slightly lower in the affected group (17.495) compared to the non-affected group (17.849).

Table 3. Characteristics of sample household (continuous variables)

Variables	Mean	Std.dev	Affected household (n=163) Mean	Not-affected (n=119) Mean
Age (years)	48.61	13.95	49.26	47.72
Edu (years)	6.49	3.67	5.36	8.03
Souceofincome	2.62	1.24	2.43	2.88
Income (log)	17.644	0.864	17.495	17.849

Table 4 presents a breakdown of the sample into affected and non-affected households, with 163 and 119 households in each category respectively. In terms of gender of household head, the sample is predominantly male, making up 90.07% of the total sample. The affected group has a slightly higher percentage of males (90.76%) compared to the non-affected group (89.57%). Females represent a smaller portion of the sample, with 9.93% overall, and are slightly more represented in the non-affected group (10.43%) than the affected group (9.24%).

The marital status of the sample is overwhelmingly married, accounting for 85.11% of the total sample, with a slightly higher percentage in the affected group (87.39%) than the non-affected group (83.44%). Single individuals make up 12.41% of the total sample, with a slightly higher representation in the non-affected group (12.88%) than in the affected group (11.76%). Widows represent a small portion of the sample, at 2.47%, with a higher representation in the non-affected group (3.68%) than in the affected group (0.84%).

Finally, in terms of credit, 65.6% of the total sample does not have credit, with a higher percentage in the non-affected group (69.94%) than in the affected group (59.66%). Those with credit make up 34.4% of the total sample, with a higher representation in the affected group (40%) than in the non-affected group (30%).

Table 4. Characteristics of sample household (categorical variables)

Variables	Frequency		Percentage	Affected household (n=163)		Not-affected (n=119)	
				Frequency	%	Frequency	Percentage
Gender	Female	28	9.93	17	10.43	11	9.24
	Male	254	90.07	146	89.57	108	90.76
Status	Single	35.00	12.41	21	12.88	14	11.76
	Married	240.00	85.11	136	83.44	104	87.39
Windows	7.00	2.47	7	3.68	1.00	0.84	
Credit	No	185.00	65.6	114	69.94	71	59.66
	Yes	97	34.4	49	30	48	40

According to the data presented in the table 5, the average HFIAS score for non-affected households is 5.59, with a standard deviation of 7.31. The scores range from a minimum of 0 to a maximum of 27. On the other hand, affected households have a higher average HFIAS score of 7.76, with a standard deviation of 6.52 suggesting that food insecurity is more prevalent in affected households.

In terms of HDDS, non-affected households have an average score of 6.06, with a standard deviation of 1.63, and scores ranging from a minimum of 3 to a maximum of 11. Affected households have a slightly lower average HDDS score of 5.76, with a standard deviation of 1.43, and scores ranging from 3 to 9. This suggests that dietary diversity is slightly lower in affected households.

Overall, these results indicate that food insecurity and lower dietary diversity are more prevalent in households affected by the unspecified factor being studied. These findings highlight the importance of interventions aimed at improving food security and dietary diversity, particularly in affected households

Table 5. Household Food Security Indicator

Food security indicator	Non-affected				Affected			
	Mean	Std. Dev.	Min	Max	Mean	Std. Dev.	Min	Max
HFIAS	5.59	7.31	0	27	7.76	6.52	0	27
HDDS	6.06	1.63	3	11	5.76	1.43	3	9

Note: HFIAS is household's food insecurity access scale and HDDS is the household dietary diversity score

Factors influencing food security

The Wald test results are highly significant, indicating a good fit for the endogenous switching regression model used in this study. The endogenous switching regression model is a statistical method used to correct for potential endogeneity where an independent variable is correlated with an unobserved error term, hence justifying the use of this specific regression model. In addition to the Wald test, the likelihood ratio test of independence was used to examine the correlation between the selection and outcome equations. The results indicate that we can reject the null hypothesis of no correlation of HFIAS, and HDDS, and being affected by dam construction. In other words, this suggests that there is a statistically significant positive correlation between dam construction and both food insecurity and dietary diversity. This



means that households affected by dam construction are likely to experience higher levels of food insecurity (as measured by HFIAS) and have a lower dietary diversity (as measured by HDDS). These findings suggest that dam construction could have substantial implications for food security and dietary diversity.

Table 6 presents some significant determinants of food insecurity, including marital status, education, age, and income. Each of these factors has a unique influence on the level of food insecurity experienced by households, particularly those affected by dam construction.

The marital status has a highly significant positive coefficient of 4.681. This suggests that being married increases the likelihood of food insecurity among affected households. This could be due to the increased number of dependents or other factors related to marital status such as shared financial responsibilities, the potential for single-income households, and the economic pressures associated with supporting a larger family unit. .

The level of education is also a significant and negative determinant of food insecurity. This suggests that households headed by individuals with higher levels of education are less likely to experience food insecurity. Education often correlates with better job opportunities and higher income, which can improve access to food. Additionally, education can enhance knowledge about nutrition and efficient resource management, further reducing the risk of food insecurity. The log income has a negative and statistically significant coefficient, indicating that while higher income levels might be expected to decrease food insecurity, this relationship is statistically significant among not-affected households.

The age variable in the regression analysis shows a significant negative coefficient of -0.0568 for non-affected households. This suggests that an increase in the age of the household head is associated with a decrease in food insecurity for non-affected households. In other words, older household heads in non-affected areas are less likely to experience food insecurity. This could be due to various reasons such as more stable sources of income, accumulated savings, or the presence of grown-up children who contribute to household income.

As expected, income is a negative and significant determinant of food insecurity. Households with higher income levels are less likely to experience food insecurity. More income generally means better access to food and other necessities, reducing the risk of food insecurity.

Table 6. Parameter estimates of the endogenous switching regression model (HFIAS)

Variables	Affected household (n=163)		Not-affected (n=119)	
	Coef.	z	Coef.	z
Gender	-0.0904	1.756929	-1.918282	-1.58
Status	4.681***	1.034158	1.593891	1.5
Edu	-0.2916**	0.1602374	-0.1401862	-1.26
Age	0.0210678	0.034759	-0.0568**	-1.89
Source of income	-0.2876243	0.4683377	0.0087718	0.03
Credit	0.4116839	1.18343	0.5176607	0.68
Income (log)	-0.2052152	0.6740731	-2.717**	-5.43
Intercept	12.2298	11.22278	57.415**	6.62
/lns0	1.334172			



Variables	Affected household (n=163)		Not-affected (n=119)	
	Coef.	z	Coef.	z
/lns1	1.978854			
/r0	-0.2010602			
/r1	-0.7132133			
sigma0	3.796849			
sigma1	7.234448			
rho0	-0.198394			
rho1	-0.6126878			
Log likelihood = -	994.03955			
Wald test $\chi^2(7)$ =	41.99			
LR test of indep. eqns. : $\chi^2(2)$	10.42***			

*** 1% level of significance; **5% level of significance; *10% level of significance

Table 7 show the results of the endogenous switching regression resression when Household Dietary Diversity Score (HDDS) is employed to measure food security for those household affected and not-affected by the dam construction.

Table 7. Parameter estimates of the endogenous switching regression model (HDDS)

Variables	Affected household (n=163)		Not-affected (n=119)	
	Coef.	z	Coef.	z
gender	-0.1168	-0.3500	0.3037	0.6900
status	-0.41268**	-2.1800	0.3731	0.9700
edu	0.0517*	1.7100	0.0227	0.5500
age	-0.0113*	-1.7400	0.0092	0.8500
sourceofincome	-0.0318	-0.3600	-0.0874	-0.7700
credit	0.1668	0.7600	0.0213	0.0800
lgincom	0.8203***	6.5900	-1.108***	6.1400
_cons	-7.343***	-3.5400	-14.45***	-4.6400
/lns0	0.3248			
/lns1	0.2640			
/r0	0.2793			
/r1	-0.6261			
sigma0	1.3837			
sigma1	1.3022			
rho0	0.2722			
rho1	-0.5554			
Log likelihood = -	-610.88			
Wald test $\chi^2(7)$ =	49.61			
LR test of indep. eqns. : $\chi^2(2)$	3.93***			

*** 1% level of significance; **5% level of significance; *10% level of significance

The marital status has a significant negative coefficient of -0.41268, indicating that being married decreases the likelihood of food diversity among affected households. This could be due to the combined resources and shared responsibilities within married households, which may enable better access to food and resources.

The level of education has a significant positive impact on household dietary diversity. This means that households with a more educated head tend to have a more varied diet. The reasons for this include increased knowledge and awareness about nutrition, higher income potential due to better job opportunities, better access to diverse food information, and improved decision-making skills. All these factors contribute to making more strategic and diverse food choices, thus enhancing the dietary diversity within the household.

The income variable has a significant positive coefficient, indicating that higher income levels increase the diversity of food intake in both affected, and non-affected households. Higher income provides households with greater purchasing power, allowing them to afford a wider variety of foods and access diverse food sources. Additionally, higher income can enhance knowledge about dietary diversity and reduce food insecurity, leading to better quality of food intake. Therefore, income plays a crucial role in enhancing food security and dietary diversity, highlighting the importance of strategies aimed at improving income levels in non-affected households.

Impact of dam construction on food security

In order to determine the effects of the dam construction on food security of the household, expected gross margin for the affected household ($E(FI_{1i} | SD_i^{\square} = 1)$) are compared with what they would have been if the household has been non-affected ($E(FI_{2i} | SD_i^{\square} = 1)$). The difference in gross margin on affected household are presented in Table 8. Theoretically, it is possible to calculate the counterfactual hypothetical effect for non-members, but as there is no selection effect for non-affected, that is, non-affected do not differ from random sample, we do not consider this effect.

The expected gross margins of food insecurity index for an affected household $E(FI_{2i} | SD_i^{\square} = 1)$ is 11.35 while the counterfactual hypothetical gross margins $E(FI_{1i} | SD_i^{\square} = 1)$ is 5.79. Therefore, the return on the affected group ATT is 5.56. When we look at Household Dietary Diversity Score (HDDS), The expected gross margins of HDDS for an affected household $E(FI_{2i} | SD_i^{\square} = 1)$ is 6.39 while the counterfactual hypothetical gross margins $E(FI_{1i} | SD_i^{\square} = 1)$ is 6.08. Therefore, the return on the affected group ATT is 0.315. These reveals that the dam construction affects on food security of the household. However, it is expected that the returns to an affected vary across sample which may be due to household personal characteristics

Table 8 Marginal effect of the dam construction on food security

Food Insecurity Index	Mean	Std.Dev
$E(FI_{2i} SD_i^{\square} = 1)$	11.35576	3.6875
$E(FI_{1i} SD_i^{\square} = 1)$	5.793765	2.671962
ATT	5.56***	
HDDS	Mean	Std.Dev
$E(FI_{2i} SD_i^{\square} = 1)$	6.396129	3.6875



HDDS	Mean	Std.Dev
$E(FI_{1i} SD_i^{\square} = 1)$	6.080827	2.671962
ATT	0.315***	

*** 1% level of significance; **5% level of significance; *10% level of significance

Conclusion

This research on the food and nutrition security vulnerability to the Don Sahong Hydropower Dam highlights the potential negative impact of the dam's construction on households in the Mekong River Basin. The study utilized the Household Food Insecurity Access Score (HFIAS) and Household Dietary Diversity Score (HDDS) as measures of food insecurity and dietary diversity among affected households.

Preliminary results from the study indicate higher levels of food insecurity and lower dietary diversity among households affected by the dam's construction. This suggests that the dam has had a detrimental effect on the availability and accessibility of food for these households. These findings underscore the need for comprehensive impact assessments and sustainable planning practices in infrastructure development projects, particularly those that may have significant implications for food security.

Furthermore, the research calls for interventions to improve food security and dietary diversity among households affected by such projects. It highlights the importance of considering the intricate interplay between infrastructure development, ecological preservation, and food security. By understanding these relationships, policymakers and stakeholders can make informed decisions and implement sustainable development practices that prioritize both infrastructure needs and the well-being of local communities.

The findings from this research contribute to a better understanding of the potential consequences of hydropower dam construction on food and nutrition security. They provide valuable insights for policy-making and sustainable development practices in the Mekong River Basin and beyond. It is crucial to prioritize the preservation of ecological systems, such as fish migration routes, to ensure the continued availability of food resources for local communities.

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Household Food Security, Diet Diversity, and Nutritional Status of Preschool Children (36 to 59 Months) of Fishing Households from the Seven Lakes in San Pablo City, Laguna, Philippines

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Abstract

Food insecurity, linked to poor diet quality and diversity, heightens vulnerability to malnutrition, particularly in fishing households due to poverty, income seasonality, and environmental shifts. This study investigates food security, dietary diversity, and nutritional status of children (36 to 59 months) from fishing households in San Pablo City, Laguna, Philippines. Purposive sampling yielded eighty-six (86) households with a 100% participation rate. Food security and dietary diversity were assessed using Household Food Insecurity Access Scale (HFIAS) and Food Consumption Score (FCS) while the nutritional status of the children was derived from the Oplan Timbang Plus (OPT+) data in March 2023. Mean, frequency, percentage calculations, and Kendall's rank correlation test ($\alpha=0.05$) were used for data analysis. Results indicated that majority of the household heads earn less than Php 10,000 (44.2%) and spend less than Php 7,000 (75.6%) on food every month. Only (5.8%) were food-secure while the rest were food insecure, classified as moderate (45.3%), mild (39.5%), and severe (9.3%). Most households have acceptable food consumption (70.9%) with a mean FCS of 55.6 ± 20.6 . Stunting (45.3%), underweight (36.1%), and wasting (19.8%) were observed among the preschool children. Kendall's rank tau tests demonstrated a positive moderate correlation between household food security status and dietary diversity (CI:95%, $p=0.0040$, $\tau=0.2902$) and monthly income (CI:95%, $p=0.0141$, $\tau=0.2332$). Stunting and underweight were also strongly and moderately correlated to household food insecurity (CI:95%, $p=2.11e-05$, $\tau=0.4152$; CI:95%, $p=0.0027$, $\tau=0.2969$) and poor dietary diversity (CI:95%, $p=0.0474$, $\tau=0.2004$). The persistence of food insecurity and malnutrition necessitates effective interventions and policies targeting children and vulnerable groups in fishing communities.

Keywords: fishing households, household dietary diversity, household food security, nutritional status, preschool children

JEL code: Q18 Agricultural Policy; Food Policy; Animal Welfare Policy

SDG goals: Zero Hunger, Decent Work and Economic Growth

Introduction

According to the state of food security and nutrition in the World, an estimated 2.4 billion people experienced moderate to severe food insecurity worldwide in 2022 (FAO, 2023). Meanwhile, in the Philippines, 5.3 million Filipinos were found to be severely food insecure, while an additional 48 million experienced moderate to severe food insecurity (PIDS, 2022). Additionally, the food security monitoring conducted by the World Food Programme (WFP) Philippines in 2022 revealed that one in ten households in the country is food insecure, affecting those from the poorest regions (BARMM, Region VIII, and Region XII) and those who rely on agricultural livelihoods (WFP, 2022).

Experiencing food insecurity puts individuals at a higher risk of various forms of malnutrition, such as stunting and growth retardation among children and micronutrient deficiencies and obesity among adults (FAO, 2021a). Preschool age is one of the most crucial life stages for an individual because it encompasses the period where many foundational skills start to develop.



However, this is also the period when individuals are most vulnerable to the dangers brought about by malnutrition (Minaie et al., 2019). Undernutrition is associated with 45% of deaths among children aged five and below, most of which occur in low- and middle-income countries (WHO, 2021). In the Philippines, the highest incidence of poverty was recorded among the fisherfolk in 2021 (PSA, 2023). The relationship between poverty and malnutrition incidence was confirmed by a study by Capanzana et al. (2018), which showed that children from fishing households exhibited the highest prevalence of underweight among occupational communities and showed an increased likelihood of stunting and underweight by 1.36 and 1.44, respectively (Capanzana et al., 2018).

It has been discovered that diet quality and diversity are strongly correlated with both household and individual food insecurity (Hoddinott and Yohannes, 2002). Meanwhile, limited or constrained income can force households to make difficult decisions, potentially resulting in an inadequate food supply (Wight et al., 2014). The availability and accessibility of food at the household level are dependent on food security, and insufficient access to healthy foods leads to inadequate dietary intake (dela Luna et al., 2020). A diverse diet is crucial for providing the necessary daily nutrient needs of vulnerable groups, especially among young children, to support their growth and development. Dietary diversity is therefore an essential component of nutritious diets, ensuring individuals receive a range of essential nutrients to sustain their well-being. In a study conducted by Faber et al. (2009) in Africa, it was found that food-insecure households demonstrated poor diversity in food consumed compared to food secure households (Faber et al., 2009).

The fisherfolk community was recorded to have the highest poverty incidence in the Philippines (PSA, 2023). Recent statistics showed that there are nearly two million fisherfolks in the country, more than 80% of whom are classified as small-scale fishers (SSF) who earn an annual income of Php107,000 or Php8,916.67 monthly (FAO, 2021b). Their income is below the country's poverty threshold and barely covers the amount needed to meet their monthly basic food needs (PSA, 2022). The nutritional status of children is affected with the level of food security and dietary diversity they have in their respective households which is directly influenced by low income, compounded by the seasonality of produce.

Despite being a global concern, there are very limited studies regarding food insecurity at the local level, specifically those from the agricultural sector, like the fisherfolks. Because of this, investigating and understanding the dietary diversity and food security status of fishing households and how it influences the nutritional status of their children is crucial for several reasons. By examining these interrelated factors, the study seeks to provide valuable insights that can inform targeted interventions, develop appropriate policies and programs to enhance the nutrition, health, and overall well-being of individuals from fishing communities. Additionally, examining diet diversity and exploring the factors that influence dietary choices within these households can help identify potential gaps in nutrition and help develop interventions that promote a more diverse and balanced diet.

One of the fishing communities in the Philippines is situated in San Pablo City, Laguna which is well-known for its seven lakes – Sampaloc, Bunot, Palakpakin, Pandin, Yambo, Calibato and Mohicap– which offer valuable ecosystem services to both the local community and tourists, from which local fisherfolks get their primary source of income. This study aims to determine the food security and diet diversity situation of the fishing households in the said



fishing community and investigate its impact on the nutritional status of the preschool children aged 36 to 59 months old from the same fishing households.

Methodology

Research Design

A quantitative, cross-sectional study design was used to determine the association of household food insecurity status to the nutritional status of preschool children aged 36 to 59 months old from the fishing households in the seven lakes of San Pablo City, Laguna, Philippines. Other pertinent information including the sociodemographic characteristics and dietary diversity of the household and the anthropometric measurements of the preschool children were gathered through a structured interview using a sociodemographic profile questionnaire, a translated and validated Household Food Insecurity Access Scale (HFIAS), and Food Consumption Score (FCS).

Locale and Population of the Study

The study was conducted from March to July 2023 in San Pablo City, Laguna, Philippines where the lakes Sampaloc, Bunot, Yambo, Pandin, Mohicap, Calibato, and Palakpakin are situated. The study site is a first-class municipality in the southern part of Laguna with a land area of 197.56 square kilometers which is divided into eighty (80) barangays and a total population of 285,348 people (PhilAtlas, 2020). From these figures, the city's population density was computed to be 1,444 inhabitants per square kilometer, majority of which belongs to the Tagalog ethnolinguistic classification.

Sampling Design

The selection of participants was done through purposive sampling to ensure that the chosen respondents satisfy the inclusion and exclusion criteria for the population of the study. Inclusion criteria include having fishing as their primary source of livelihood, a household head that oversees the food management and preparation in the house, and a child aged 36 to 59 months old in the household. Meanwhile, households that live around the lake area but do not engage in fishing and/or do not have children aged 0 to 59 months in the household are excluded from the study. The researcher did a complete enumeration of all the available fishing households and was able to include 86 households in the study. This was done to capture an accurate representation of the living and nutrition conditions of the fishing households in San Pablo City, Laguna.

Data Collection Methods

A letter was sent to the respective Barangay Chairmen and Barangay Nutrition Scholars (BNS) to ask for permission and support to conduct the study in their area. An informed consent form, containing information, objectives, and the purpose of the study, was provided to the selected households prior to the initiation of data collection. Once given consent, a three-part interview-administered questionnaire which included questions about their sociodemographic profile, the Household Food Insecurity Access Scale (HFIAS), and Food Consumption Score (FCS) was used to collect data from the fishing households.

The first part of the interview was designed to ascertain the sociodemographic characteristics of the household. This included questions such as the age, gender, educational background, and marital status of the household head, as well as the average monthly income, money spent on food, size, source of drinking water, and access to electricity of the household. Aside from this, questions regarding their livelihood such as the number of years in the industry, number of



hours spent working in a day, ownership of tools and equipment for fishing, and attendance to seminars were also asked. This tool aims to gain a comprehensive understanding of the characteristics of the population being studied, which can help correlate possible factors that causes the determines nutritional problems. This method may involve response bias where respondents unintentionally or intentionally provide misleading or incomplete responses. To prevent this, the researchers must ensure confidentiality, anonymity, and neutrality in survey design and administration, and employ validated scales or instruments while minimizing leading or suggestive questions.

A validated HFIAS questionnaire, adapted from the HFIAS developed by Food and Nutrition Technical Assistance III Project (FANTA), was used to capture and quantify the responses and perceptions of the households on their experience of food insecurity. This tool was used in several developing countries as research has shown that it can correlate the indicators of food consumption and poverty (Coates et al., 2007). However, it is important to note that this tool primarily examines "access" to food and relies on subjective self-reported data, potentially introducing bias and measurement errors, while also being susceptible to recall bias due to the 30-day recall period. The characteristics and food insecurity experience of the surveyed households were evaluated using the three indicators of HFIAS which provide information on the Household Food Insecurity Access-related Conditions, Household Food Insecurity Access Scale Score, and Household Food Insecurity Access Prevalence. Ultimately, the surveyed households were coded into the four levels of food insecurity using their HFIAS Score and are categorized as food secure, mildly, moderately, and severely food insecure.

Meanwhile, the FCS questionnaire was used to provide a quantitative measure of the variety and frequency of the different food groups consumed by the household, seven days before the survey. This tool reflects a household's access to a wide range of food options and serves as a proxy for evaluating nutrient adequacy, making dietary diversity a vital component of high-quality diets (FAO, 2013). The only limitation with this tool is its inability to capture long-term dietary patterns or seasonal variations in food availability and consumption since it only focuses on the food consumed within the past week. The questionnaire included nine different food groups namely main staples, pulses, vegetables, fruits, meat and fish, milk, sugar, oil, and condiments (WFP, 2006). The resulting score for each household is then classified into one of three Food Consumption Groups (FCGs): poor, borderline, and acceptable, which are determined using standard cut-off points of 0 to 28, 29 to 42, and 42 and above, respectively (DOST-FNRI, 2016a). A cumulative food consumption score of 28 and below is indicative of poor food consumption and may reflect a deficient energy consumption.

Lastly, anthropometric measures (weight and height) of the preschool children aged 36 to 59 months from the participating households were provided by the Barangay Nutrition Scholars of the involved barangays. This was collected from the most recent data of the Oplan Timbang Plus (OPT Plus) which was conducted last January to March 2023. Oplan Timbang Plus is the annual weighing and height measurement all children aged 0 to 59 months old to evaluate the nutritional status and locate malnourished children in a community (NNC, 2014). The nutritional status of the children was counterchecked using the World Health Organization Child Growth Standards (2006) cut-off points.

Data Analysis

Data collected in this study were processed and analyzed using R Studio Desktop software v2023.06.1-524. Due to the categorical nature of food security, dietary diversity, and nutritional



status data, normality testing was unnecessary, and non-parametric tests were employed. Descriptive statistics, including frequency analysis, percentage calculations, and mean or median scores, summarized the data, particularly the sociodemographic profile of households. The association between household food insecurity, dietary diversity, and preschool children's nutritional status was investigated using the Kendall's rank correlation test with a 5% significance level—an approach measuring the strength and direction of association between two ranked variables.

Ethical Considerations

The study obtained approval from the city mayor and barangay captains, and strict inclusion and exclusion criteria were established to prevent manipulation of participant recruitment. Prior to data collection, prospective household heads received an informed consent letter outlining research objectives, risks, benefits, duration, participant rights, and data collection procedures. Participants were assured of voluntary participation with the freedom to withdraw at any stage. To maintain objectivity, the researcher had no personal connections with any participants, minimizing potential biases and conflicts of interest.

Results and discussion

Demographic and socio-economic characteristics of the fishing households from San Pablo City, Laguna, Philippines

The demographic characteristics of the surveyed fishing households were summarized in Table 1. Predominantly, household heads are female (84.9%), aged 20-29 (39.5%), and 30-39 (30.2%), with 53.5% reaching secondary education; most are married (97.7%). In terms of monthly income, 44.2% earn less than \$200 (Php 10,000) which coincides with the average monthly income of small-scale fishermen amounting to \$177 (Php 8,916.67) as reported by the Food and Agriculture Organization (FAO, 2021b). Consequently, majority (31.4%) of the households spend \$60-\$100 (Php 3,000 to Php 5,000), while an additional 24.4% of the households spend less than \$60 (Php 3,000) as monthly food allowance. The results are consistent with the findings of the Philippine Statistics Authority which state that fisherfolks were recorded as the basic sector with the highest poverty incidence in 2021 (PSA, 2023). People living below the poverty threshold earns about \$240 (Php 12,030) per month and needs \$167 (Php 8,379) to sustain the basic food needs for a family of five (PSA, 2022). Investigating these demographics is crucial, as lower educational attainment, weak social connections, low income, and unemployment have been associated with increased susceptibility to food insecurity (Smith et al., 2017).

Table 1. Summary of the demographic characteristics of the household heads from the fishing households.

Characteristics	Frequency (n=86)	Percentage (%)
<i>Gender</i>		
Male	13	15.1
Female	73	84.9
<i>Age</i>		
20 to 29 years old	34	39.5
30 to 39 years old	26	30.2
40 to 49 years old	16	18.6
50 to 59 years old	6	7.0
60 years old and above	4	4.7
<i>Educational Attainment</i>		



Characteristics	Frequency (n=86)	Percentage (%)
No formal education	2	2.3
Elementary	13	15.1
High School	46	53.5
Technical Vocational	1	1.2
College Undergraduate	9	10.5
College Graduate	15	17.4
<i>Marital Status</i>		
Married	84	97.7
Separated	2	2.3
<i>Household Size</i>		
≤ 5	54	62.8
6 to 7	16	18.6
≥ 8	16	18.6
<i>Average Monthly Income</i>		
< Php 10,000	38	44.2
Php 10,000 to Php 15,000	25	29.1
Php 15,001 to Php 20,000	12	14.0
Php 20,001 to Php 25,000	7	8.1
Php 25,001 to Php 30,000	2	2.3
> Php 30,000	2	2.3
<i>Estimated Monthly Food Allowance</i>		
< Php 3,000	21	24.4
Php 3,0001 to Php 5,000	27	31.4
Php 5,000 to Php 7,000	17	19.8
Php 7,001 to Php 10,000	15	17.4
> Php 10,000	6	7.0

Food security status of the fishing households from San Pablo City, Laguna, Philippines

Table 2 summarizes the prevalence of food insecurity among the fishing households from San Pablo City, Laguna, Philippines. Only one (1) in every seventeen (17) households were food secure. The majority of the households were classified as mildly (39.5%) and moderately (45.3%) food insecure. Alarming, a tenth of the target population was found to be severely food insecure. Reducing the quality and quantity of food and facing uncertainties in their ability to obtain food due to insufficient money and resources are among the qualities observed in moderately food insecure individuals. On the other hand, severely food insecure individuals, those who we call “hungry,” experience running out of food, and in worst cases, go days without eating any food (FAO, 2022).

Table 2. Distribution of fishing households based on food insecurity level using HFIAS.

Food Security Status	Frequency (n=86)	Prevalence (%)
Food Secure	5	5.8
Mildly Food Insecure	34	39.5
Moderately Food Insecure	39	45.3
Severely Food Insecure	8	9.3

The study reveals a significant food insecurity issue among fishing households in San Pablo City, Laguna. Figure 1 illustrates the comparison of food insecurity prevalence in these

households against national, regional, and provincial levels in the Philippines. This underscores the heightened vulnerability of San Pablo City's fishing households to food insecurity, despite the overall food security status of their region and province. Food insecurity increases the risk of malnutrition, including issues like childhood stunting and adult micronutrient deficiencies and obesity (FAO, 2022). The prevalence and frequency of various food insecurity conditions among fishing households in San Pablo City exceed those reported in the 2021 ENNS (DOST-FNRI, 2022).

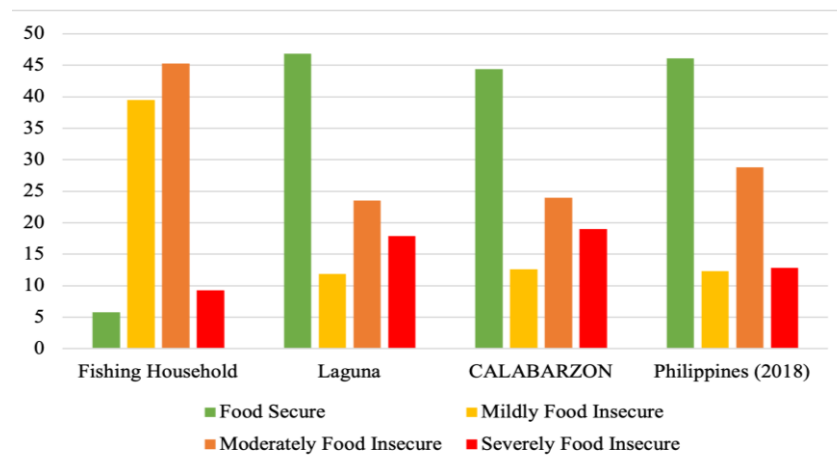


Figure 1. Comparison of prevalence of food insecurity in the fishing households versus the national, regional, and provincial estimates (DOST-FNRI, 2016b).

Food security, as outlined by the UNICEF Conceptual Framework (2021), is a critical factor in maternal and child nutrition. It directly shapes household dietary choices and nutritional intake. Food insecurity, characterized by limited access to sufficient, safe, and nutritious food, can lead to inadequate dietary intake, nutrient deficiencies, and increased vulnerability to infections and diseases. Children are particularly affected, facing consequences such as poor nutrition, impaired growth, disability, and, in extreme cases, death (UNICEF, 2021). Addressing food insecurity is vital for breaking the cycle of malnutrition, playing a significant role in preventing and mitigating poor nutritional outcomes among children.

Dietary diversity and food consumption score of fishing households in San Pablo City, Laguna, Philippines

Table 3 reveals that 70.9% of respondents had an acceptable food consumption category, with a food consumption score above 42, while a quarter (25%) had a borderline score (28 to 42), and 4.7% were categorized with poor food consumption. The mean dietary diversity score of the households was 55.63 which is equivalent to an acceptable food consumption. Contrary to the findings using HFIAS, majority of the households were found to have an acceptable diet diversity despite experiencing food insecurity and having a low income. This is consistent with DOST-FNRI's report which showed the comparable diet diversity between poor and rich populations (DOST-FNRI, 2016b). This emphasizes that a household can still have a diverse and acceptable food consumption despite being food insecure. Possible reasons for this unexpected dietary diversity in food-insecure households include non-monetary food sources like backyard gardening, hunting, gathering, and food sharing from relatives and friends, as well as the addition of processed foods under different food groups. Therefore, dietary diversity alone cannot be used to guarantee nutrient adequacy since a diverse diet may still lack sufficient



quantity and or essential nutrients which may lead to micronutrient deficiencies and hidden hunger.

Table 3. Distribution of the fishing households based on Food Consumption Score.

Food Consumption Score Category	Frequency (n=86)	Percentage (%)
Poor Food Consumption	4	4.7
Borderline Food Consumption	21	24.4
Acceptable Food Consumption	61	70.9

Table 4 outlines the average frequency of food group consumption. Staples were consumed daily, while spices, condiments, and beverages were consumed about six times a week. The least consumed group was legumes, nuts, and seeds, eaten weekly by half of the households. Many groups, including vegetables, eggs, fish, oils, fats, and sweets, were consumed at least four times a week. Meat and milk products were available at least three times a week, and fruits and white tubers and roots were served at least twice a week. It was also found that moderately and severely food insecure households have a significantly low intake of fruits and milk products compared to the food secure households. This is parallel to the results of the study of Angeles-Agdeppa (2021) which revealed that food-insecure Filipinos have diets lacking in nutrients such as vitamin A, riboflavin, niacin, calcium, and thiamin which are usually sourced from fruits and milk, therefore putting them at a greater risk for malnutrition and micronutrient deficiencies which can ultimately lead to compromised immune system, susceptibility to chronic diseases, obesity, and certain types of cancer (Angeles-Agdeppa et al., 2021; Aune et al., 2017; Gupta et al., 2020). Meanwhile, low consumption of milk products, which are rich sources of calcium and vitamin D, can lead to poor bone health and an increased risk of osteoporosis and fractures (Guo et al., 2022). This emphasizes the importance of incorporating diverse food groups in the meals consumed in the household to ensure optimal health and nutrition.

Table 4. Average frequency of consumption of the different food groups.

Food Groups	Mean Score*	Interpretation
Cereals	7	Everyday
White tubers and roots	1.55	Twice a week
Vegetables	4.10	Four times a week
Fruits	2.48	Twice a week
Meat	3.20	Thrice a week
Eggs	4.13	Four times a week
Fish and other seafood	3.72	Four times a week
Legumes, nuts, and seeds	0.78	Once a week
Milk and milk products	2.78	Thrice a week
Oils and fats	3.50	Four times a week
Sweets	3.51	Four times a week
Spices, condiments, and beverages	6.21	Six times a week

* The mean score refers to the average frequency of consumption of the food groups by the fishing households in one week

Nutritional status of preschool children (36 to 59 months) from fishing households in San Pablo City, Laguna, Philippines

As shown in Table 5, it was found that more than half of the preschool children were normal, one (1) child was classified as tall, a quarter (26.7%) was stunted, while about one (1) in every five (5) children were severely stunted. In the weight-for-age assessment of preschool children, 64% were found to have a normal weight for their age, while 22.1% were underweight, and 14% were severely underweight. Regarding the weight-for-height indicator, 72.1% were classified as normal, 1 child as obese, and 6 children as overweight. Additionally, 12.8% were wasted, and 7% were severely wasted. The prevalence of normal weight-for-height might be attributed to stunted children whose height is proportionate to their underweight status, both falling below expected norms for their age. This aligns with Ross and Janiszewski's 2008 findings emphasizing the limitations of body mass index (BMI) as a sole indicator of overall health and dietary balance, suggesting the need for a more comprehensive approach to assess nutritional status (Ross and Janiszewski, 2008).

Table 5. Nutritional status of preschool children (36 to 59 months) from the fishing households.

Nutritional Status	Frequency (n=86)	Percentage (%)
<i>Height-for-Age</i>		
Tall	1	1.2
Normal	46	53.5
Stunted	23	26.7
Severely stunted	16	18.6
<i>Weight-for-Age</i>		
Overweight	0	0
Normal	55	64
Underweight	19	22.1
Severely underweight	12	14
<i>Weight-for-Height</i>		
Obese	1	1.2
Overweight	6	7
Normal	62	72.1
Wasted	11	12.8
Severely wasted	6	7

Undernutrition has been a serious problem in the Philippines, and there has been no significant improvement in the prevalence of undernutrition for nearly thirty years now. According to UNICEF (2014), about 95 children die of malnutrition every day in the Philippines. Additionally, stunting is found to be the most common face of malnutrition among children in the country affecting 26.6% of Filipino children aged 36 to 59 months old (DOST-FNRI, 2022). The findings of the study were also supported by the data reported by Capanzana et al. (2018) that children from households headed by fisherfolks demonstrated a higher prevalence of malnutrition compared to the overall prevalence of malnutrition among young children in the Philippines. Furthermore, children from fishing households also exhibited the highest prevalence of stunting, wasting, and underweight among all the occupational groups (Capanzana et al., 2018). These results underscore the vulnerability of children in fishing households to malnutrition and its repercussions making it imperative for policymakers and stakeholders to prioritize and reassess targeted interventions for these communities, aiming to

mitigate malnutrition. Without effective measures, the cycle of malnutrition is likely to persist, posing enduring health and developmental risks for children in these areas.

Correlation of food insecurity and dietary diversity of the fishing households to the nutritional status of preschool children (36 to 59 months)

The predicted value on the correlation of the food security status of the household with their diet diversity and household income are shown in Table 6. Results showed that there exists a positive moderate correlation ($\tau=0.290158$) between food insecurity status and the dietary diversity of the household ($p=0.004035$), suggesting that food insecurity significantly impacts the dietary diversity of the household. This finding is consistent with the results of the study by dela Luna et al (2020) which concluded that increasing severity of food insecurity is associated with a greater probability of experiencing food shortage and consuming diets with poor diversity (de la Luna et al., 2020). Additionally, a positive moderate correlation ($\tau=0.2331839$) exists between the average monthly income of the household and their food security status ($p=0.01405$), suggesting that a higher income translates to a more food secure household, and vice-versa. Among the sociodemographic factors that may have affected the income of the fishing household were the educational attainment of the household head and the fishing-related training activities and seminars attended.

Table 6. Kendall's rank correlation tau analysis between the food security status and other variables tested in the study.

	Food Security Status (HFIAS)	
	<i>p-value</i>	<i>tau</i>
Dietary Diversity	0.0040*	0.2902
Household Income	0.0141*	0.2332

Kendall's rank correlation tau test; significant at $\alpha=0.05$; *significant.

Additionally, a positive moderate correlation ($\tau=0.2331839$) was found to exist between the average monthly income of the household and their food security status ($p=0.01405$). This means that the higher the household income, the more food secure they are and vice versa. This proves that household income plays a significant role in determining the ability of the household to have access to sufficient, safe, and nutritious food. Among the sociodemographic factors that may have affected the income of the fishing household were the educational attainment of the household head and the fishing-related training activities and seminars attended. Studies by Tan et al. (2023) and Mahmud et al (2012) showed that an increase in trainings received enhances the chances of increasing their income.

The study also revealed significant associations between the nutritional status of children and the food security status of their households. As shown in Table 7, height-for-age showed a strong positive correlation ($\tau=0.4152$) with household food security and a moderate positive correlation ($\tau=0.2004$) with the household's food consumption score. This implies that children have a normal height for their age when their households are food secure and exhibit acceptable food consumption. Similarly, a moderate positive correlation ($\tau=0.2968713$) was found between household food security and the weight-for-age of children, indicating appropriate weight for their age in food-secure households. However, no correlations were observed between household food security and weight-for-height status or between weight-for-age and weight-for-height status in children and their food consumption score.

Table 7. Kendall's rank correlation tau analysis on the association between food security status and dietary diversity of the household to the nutritional status of the preschool children.

Nutritional Status Indicator		Food Security Status	Food Consumption Score
Height-for-age	<i>p-value</i>	2.11e ⁻⁰⁵ *	0.0474*
	<i>tau</i>	0.4152	0.2004
Weight-for-age	<i>p-value</i>	0.0027*	0.1318
	<i>tau</i>	0.2969	0.1542
Weight-for-height	<i>p-value</i>	0.2564	0.0653
	<i>tau</i>	0.1116	-0.0468

Kendall's rank correlation tau test; significant at $\alpha=0.05$; *significant.

The lack of correlation between the weight-for-age status of the children to the dietary diversity of the household may be due to the relatively high percentage of children with normal weight for their age. One reason for this is the calorie content of the foods that they usually consume. According to Hoddinott and Yohannes (2002), greater dietary diversity is associated with higher calorie availability. However, there was no mention that dietary diversity is equivalent to a better diet quality since the latter was commonly influenced by household income to a greater extent, which can impact the types of foods a household can afford and therefore consume. Moreover, a study by Angeles-Agdeppa et al. (2021) revealed that Filipino households experiencing moderate to severe food insecurity have the tendency to consume more calorie-dense foods, but significantly low intake of vitamin A, riboflavin, niacin, and total fat as compared to food secure households (Angeles-Agdeppa et al., 2021). Following this logic, it was possible that the children were able to obtain a normal weight due to the consumption of calorie-dense food, but there was no guarantee that they were having an adequate nutrient intake to support normal growth and development, hence leading to high prevalence of stunting among the children.

Vozoris and Tarasuk (2003) examined the relationship between food insecurity and dietary quality among Canadian households. The study revealed that households experiencing food insecurity tend to have lower dietary quality, even if they have access to a diverse range of foods. Households with limited financial resources opt for cheaper, energy-dense but nutrient-poor foods, leading to inadequate nutrition despite food diversity (Vozoris and Tarasuk, 2003). A study by Darmon and Drewnowski (2015) supports this notion, highlighting the impact of socioeconomic constraints on food choices and nutritional outcomes. By addressing these factors, public health interventions can effectively improve the nutritional status and overall well-being of vulnerable populations (Darmon and Drewnowski, 2015).

Conclusion

The fishing households from San Pablo City, Laguna, Philippines serve as a microcosm of the greater national setting, highlighting the challenges encountered by fisherfolk communities in terms of food insecurity and malnutrition. The interplay between sociodemographic factors, food security status, dietary diversity, and the nutritional status of children exhibits a multifaceted and complex nature. Sociodemographic factors can influence the household's ability to secure sufficient and nutritious food. In turn, food security status, which reflects the availability and accessibility of food, impacts the dietary choices made by households. In this study, it was highlighted that adequate dietary diversity may be able to provide the energy needs of the individuals, but it does not necessarily guarantee a good quality diet. It is important to note that a diverse diet must encompass a wide range of nutrient-rich foods that are essential



for optimal nutrition, growth, and development in children. Insufficient dietary diversity can lead to deficiencies in essential nutrients, contributing to poor nutritional status. Conversely, children from food-secure households with diverse diets are more likely to experience improved nutritional outcomes and overall health. Understanding how these factors work together is important for making effective interventions and policies that aim to improve the health and nutrition of children and vulnerable groups, especially in the fishing community. Based on the findings and insights derived from this study, several recommendations are proposed to address the multifaceted challenges posed by food insecurity and its impact on child nutrition in fishing communities:

Community-Based Nutrition Programs. Develop and implement community-driven nutrition education programs that emphasize the importance of diverse and balanced diets. These programs will help empower families in fishing households to make informed food choices, enhance their understanding of nutritional needs, and promote the consumption of locally available and nutrient-rich foods.

Livelihood Support and Diversification. Collaborate with local authorities and non-governmental organizations to establish livelihood support initiatives that enhance the economic stability of fishing households. By promoting alternative income sources and skill development, families can better afford a diverse range of foods, thereby improving overall diet quality.

Sustainable Fishing Practices. Introduce sustainable fishing practices and resource management strategies to ensure the long-term availability of fish stocks. This could include training fishermen in responsible fishing techniques, advocating for conservation measures, and fostering community engagement in resource preservation.

To further explore the situation of fishing communities, future studies may want to consider the seasonality of produce and income to compare the food security status and dietary diversity of the household before, during, and after harvest seasons. Future researchers may also want to investigate the nutritional status of the other age groups of children such as toddlers and school-age children, and the nutritional status of other members of the household to explore the possible existence of the double burden of malnutrition. Moreover, another tool may also be incorporated in assessing the dietary diversity of the household to capture the adequacy of their intake and compare it with food and nutrition adequacy indicators such as the Minimum Acceptable Diet (MAD) and Minimum Dietary Diversity (MDD). Through this, the triple burden of malnutrition (undernutrition, micronutrient deficiencies, and overnutrition) may be investigated.

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Track 8

Food system and innovation



Drinking Water and Beverage Intake after COVID-19: Case study in Nay Pyi Taw Council Area, Myanmar

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Abstract

The health crisis has posed a threat not only to people's health but also to their well-being after the COVID-19 pandemic. It has prompted a shift in dietary patterns and drinking habits based on people's preference toward healthier behaviour and items with affordable prices. The objective of this research is to assess the drinking water and beverage intake among selected households in Nay Pyi Taw, Myanmar. Based on the selected respondents (n=400), majority of selected households were from the public sector, with a high level of education. On the average, food costs constituted 70% of the total expenditure and 60% of the income. An observed intake is that a significant percentage of households allocate spending to drinking water, coffee, and tea mix, excluding alcohol. In contrast to the average monthly per capita consumption, drinking water, coffee and tea mix and alcohol are commonly consumed. The commonly purified drinking water among the selected respondents leans toward a healthy food system and signifies a positive preference. Consequently, it is proposed that preferences and for various types of drinking water and coffee and tea mix be strengthened to meet local demand, thereby enhancing household health and nutrition. This behavioural and preference could also accelerate a healthy lifestyle for everyone. For further research and development, the accessibility of purified drinking water and beverages could be promoted to improve a healthy lifestyle and sustainable intake.

Keywords: Nay Pyi Taw, intake of drinking water and beverage, per capita drink water and beverage consumption

JEL code: D10, E 29, L66

SDG goals: Zero Hunger, Good Health and Well-being, Clean Water and Sanitation, Responsible Consumption and Production

Introduction

Drinking water and food is the basic need and necessity of life and inadequate nutrition is considered as measure of poverty in many societies. According to Food and Agriculture Organization (1996) suggested that a healthy life have safe and nutritious food to meet their dietary needs and food preferences which is one of the definitions of food security. Rural households continue to face varied economic conditions which impact on their living standard and food security situation which consequently create gaps in resource availability and considerable imbalance between the demand and supply of food among the poor households.

The outbreak of COVID-19 has raised concern regarding with public health, economic and food crises (Kakaei H et.al, 2022, p.8). During the COVID-19 pandemic, food insecurity was seriously leading an estimated one million who need food assistance (OCHA, 2020, para.7). In Myanmar, six rounds of the Rural-Urban Food Security Survey in 2020 verified the impacts of the COVID-19 crisis on poverty and food insecurity among approximately 2,000 households in urban Yangon and the rural Dry Zone.



In addition, dietary diversity in rural areas has declined due to imbalance of income and expenditure. People have become more conscious about their protein intake in their daily diets. May Thet Htar et.al (2022) mentioned that changes in consumption due to health were most significant in the consumption of rice, vegetables, and pulses, purified water, and fruits (p.6). Regarding these consumption changes, health contributed more than half of all other reasons. Majority of the samples indicated that health is the main reason for the increased consumption and contributed. Purified drinking water ranked as the second highest in water intake when compared to rice, vegetables, and pulses. Water is an essential nutrient and a major constituent of the human body. It is vital to numerous transports of nutrients and waste products. There are different categories in Myanmar drinking water and beverages market include purified drinking water, soft and hot drinks, dairy and milk alternatives, and alcoholic drinks. In Myanmar, most of adult in both rural and urban areas custom of drinking tea is an integral part of everyday life. There are different types of tea which includes sweetened tea prepared with sugar, and hot milk, and plain tea. Tea is prepared and drunk in many ways in Myanmar (Lei Shwe Sin Myint, 2020, p.1).

The research holds significance in examining the trends and status of drinking consumption following a health crisis. The findings will directly contribute to supporting small and medium enterprises, as well as commercial groups, by providing insights into the shifting consumption patterns of drinking water and beverages. This information is crucial for those seeking to comprehend the trends and changes in people's daily or monthly expenditure on various types of beverages and drinking water. This research is particularly valuable for researchers aiming to generate ideas and conduct in-depth analyses of specific aspects such as brand preferences and expenditure patterns related to drinking water and various beverage types. Such a study plays a pivotal role in determining the impact on human health and forecasting changes in lifestyle from a medicinal perspective. Therefore, the primary focus of the study is to examine the trend of drinking consumption and per capita drinking water and beverage consumption based on different drink types, providing valuable insights into evolving consumption patterns. The specific objectives are to categorize the ratio of food cost and income and expenditure of selected households, to establish the trend of drinking water and beverage consumption and to identify per capita drinking water and beverage consumption of the selected households in Nay Pyi Taw.

Methodology

Sampling method and selection of the study area

This study employed a purposive random sampling method, targeting residents from Zeyarthiri, Ottarathiri, and Pobbathiri Townships in Nay Pyi Taw, Myanmar, in November 2021. Among the study areas, Zeyarthiri Township is located near the governmental institutions such as Department of Agricultural Research, Yezin Agricultural University, University of Veterinary Science and Forest Research Institute. According to the sample size, the majority of sample who are living in pre-urban areas based on these study areas. To gather pertinent information, the research utilized the face-to-face interview method to collect total sample (400) from these three study areas. The potential respondents were based on the fact that they are the main household members managing food at the households in order to collect data on food consumption changes. The research was based on convenience sampling and the potential participants were self-selected with a voluntary way in as much as they choose to participate or not. This approach facilitated the collection of demographic characteristics, household composition by age groups, specific in monthly income, expenditure, total cost of food and drink, cost of specific drink items, the intake amount of monthly drinking water and



beverage, preference on particular food items. The primary data gathering survey was conducted using a structured questionnaire.

Adult equivalent

Equivalence scales and the assumptions on which it is based on various criticisms and used to compare the standard of living of households of different size and composition, take into account the economies of scale resulting from pooling income and expenditure within households (Martin, H, 2017, p.93). In this research paper, only one criticism involves to assume that household age and raise the question of how to find the intake of the sample households and different household members. On these issues, the use of an equivalence scale implicitly assumes that the age of all members of the household is pooled to have the same standard of age. To classify the adult equivalent, there were four age groups which identified as senior adult group (above 60 and 60 years), adult group (between 59 and 19 years), adolescent group (between 18 and 10 years), young child group (between 9 years and 2 years) and under young group. In this study, per capita drinking water and beverage consumption was calculated by the amount of household (n=400) and their family member's drink and beverage consumption per month divided by the total adult equivalent number of the household members based on classification of age group (See Table 1).

Table 1. Adult equivalent conversion for the age range (years)

	Adult equivalent conversion factor	Adult equivalent	Total Adult equivalent
Above 60 and 60	0.7	99	1430
50-19	1.0	986	
18-10	1.1	244	
9-2	0.7	94	
Under one year	0.5	7	

Source: MOHS, 2019, p.36

Data analysis

The collected data were digitally loaded into Microsoft Excel with the assistance of STATA 15 statistical software. Descriptive analysis was employed to cluster different items and calculate the cost, as well as to determine the level of per capita drink and beverage consumption.

Results and discussion

Demographic information of respondents of selected households

The socio-economic characteristics of the study area's 400 respondents are detailed in Table 2. The female-to-male respondent ratio was 15.67 based on the total sample of 400 from Nay Pyi Taw. The average household size in the study area was 4, ranging from 1 to 13 household members. Respondents in selected households had an average age of 44.37 years, with the oldest participant being 91 years old and the youngest being 18 years old. Regarding education level, 40% of the selected respondents were graduates, while 22.75% had completed secondary education. The remaining 19.50% and 17.75% were at high school and primary education levels, respectively (as illustrated in Table 1). In the study area, 36.75% of respondents were employed in the public sector, whereas 24.75% worked in the private sector, serving as their primary sources of income. Farm households constituted 15.25% of the sampled households. Additionally, 23.25% of the sample respondents were engaged in housework activities such as cooking, washing, and child-caring. Based on the result, the selected respondents were based



on the main household members who manage and care for their family members. Therefore, the result can understand that the major role for management in family found mother (female) than father (male). In Myanmar culture, mostly those of women (mothers) were more responsible for coking in their families and make the decision not only the different consumption pattern but also needs and wants of their family members (Thi Thi Soe et.al, 2022.p .8).

Table 2. Demographic Information of Respondents of Selected Households

Item	Grouping	Frequency	Percent		
Gender	Female	376	94.00		
	Male	24	6.00		
Education level	Primary	71	17.75		
	Secondary	91	22.75		
	High school	78	19.50		
	Graduate	160	40.00		
Occupation	Public sector	147	36.75		
	Private sector	99	24.75		
	Farmer	61	15.25		
	House-work	93	23.25		
Item	Unit	Average	Maximum	Minimum	SD
Age of respondent	Year	44.37	91	18	12.25
Household size	No.	3.75	13	1	1.76

Source: Survey data of Department of Agricultural Economics, 2021

The intake amount is different depending on the age group. Therefore, the adult equivalent number of sample household members was calculated to find out per capita drinking water and beverage. Although there were 1,498 household members in the selected household by their age group, only 1,430 household members in total could be found according to adult equivalent ratio (Table 3) based on the description rate of adult equivalent conversion factor as described in Table 1.

Table 3. Total household members by adult equivalent of the sample respondents

Items	Frequency (n= 400)
Total household members by age group	1,498
Total household members by adult equivalent	1,430

Source: Survey data of Department of Agricultural Economics, 2021

Income, expenditure and food cost information

Table 4 displays the monthly income, expenditure, and food costs of 400 selected households. The average total household income was US\$ 232 per month, with US\$ 169 allocated to household expenditure and US\$ 115 dedicated to monthly food costs. Based on country notes (CGIAR, 2021), the disruptions caused by COVID-19 have affected the ability of both men and women to access paid work, particularly when mills experienced lower overall production, employee layoffs, and reduced credit availability.



Table 4. Household Monthly Income, Expenditure and Food Cost of Selected Households

Item	Unit	Average	Maximum	Minimum	SD	N
Monthly Income	US \$	232	2073	29	179	400
Expenditure	US \$	169	691	29	91	400
Food Cost	US \$	115	403	23	57	400

Source: Survey data of Department of Agricultural Economics, 2021

Note: 1US\$ = 1773 MMK (Exchange rate of 1st November, 2021)

The household monthly income, expenditure, and food cost ratios are presented in Table 5. According to the results, the typical contribution of expenditure to the income of sample households (n=400) was 84.37%, with the maximum contribution reaching 300%. This indicates that some households were in debt due to limited income, spending more money than they could earn. The average share of food costs to income was 59.68%, reflecting monthly food costs that exceeded their monthly income. The typical proportion of food costs in relation to expenditure was 70.20%, and the maximum proportion within households was 100%. This reveals that for some households, the food costs and expenditure were equal, leaving no income for other uses.

Table 5. Ratio of Household Monthly Income, Expenditure and Food Cost (Percent) (n=400)

Item	Average	Maximum	Minimum	SD	N
Expenditure/Income	84.37	300.00	23.40	36.50	400
Food cost/Income	59.68	250.00	10.00	30.75	400
Food cost/ Expenditure	70.20	100.00	20.00	14.24	400

Source: Survey data of Department of Agricultural Economics, 2021

Expenditure for drinking water and beverage

The information regarding the proportion of various types of drinks and beverages consumed by sample households in the study area is illustrated in Figure 1. The consumption patterns varied among different types of drinks. Primarily, the highest proportion was attributed to drinking water, exceeding 80%, followed closely by coffee and tea mix at nearly 80%, dried tea at around 70%, beverages at 60%, milk at approximately 54%, and alcohol at less than 15%. Among the different types of drinks and beverages, drinking water emerged as the most widely consumed, while coffee and tea mix took the second-highest spot. Furthermore, dried tea and soft drinks constituted the third-highest proportion in the sample, surpassing the proportion of drinking water. This shift in beverage consumption reflects changes in food preferences after the Covid-19 pandemic period in the study area.

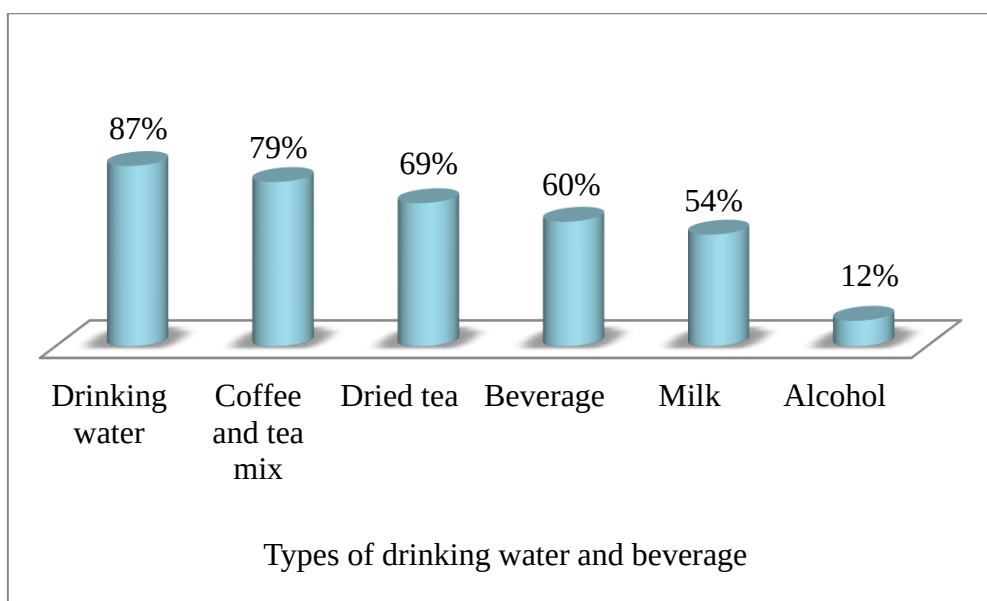


Figure 1. The proportion of various types of drinks and beverages consumed by sample households (n=400)

Source: Survey data of Department of Agricultural Economics, 2021

The household monthly expenditure on drinks and beverages is detailed in Table 6. According to the results, the typical contribution of monthly expenditure on drinking water was 3.01%, which is nearly the same as the cost for milk and beverages, while it ranged between 15% and 0.35% for drinking water. The average monthly expenditure for coffee and tea mix, as well as dried tea, stood at approximately 3.20% and 1.11%, respectively. The average monthly expenditure on beverages was 2.93%, which was more than half of the average proportion of monthly expenditure on dried tea. Meanwhile, the average proportion of monthly expenditure on milk exceeded that of drinking water, highlighting its significance as a nutritional and essential element in drinking culture with health concerns (May Thet Htar et.al, 2022, p.6). According to the results, the average proportion of monthly expenditure on alcohol was the highest, reaching 9.29%, reflecting variations in price and brand among different alcoholic beverages. Therefore, the maximum proportion within households was the cost of coffee and tea, and drinking water, excluding alcohol. This indicates that household monthly expenditures varied significantly, with the lowest proportion attributed to dried tea based on the quantity and price of the consumed items.

Table 6. Monthly Cost of drinking water and beverage by the selected households (Percent) (n=400)

No.	Items	Monthly expenditure for drinking water and beverage			
		Average	Maximum	Minimum	N
1	Drinking water	3.01	15.00	0.35	350
2	Coffee and tea mix	3.20	16.47	0.25	319
3	Dried tea	1.11	10.5	0.08	278
4	Beverage	2.93	18.13	0.2	242
5	Milk	3.05	16.67	0.25	217
6	Alcohol	9.29	37.50	1.60	50

Source: Survey data of Department of Agricultural Economics, 2021



Types of drinking water consumed by the selected households are presented in Table 7. Among the households, 81.01 percent consumed purified drinking water. In contrast, 24.56 percent of the households consumed water from tube-well while 5.82 percent of the households consumed water from dam. The households that consumed these latter two water types were presumably purifying the water they consumed themselves. Among the households, 81.01 percent consumed for purified drinking water. In contrast, 24.56 percent of the households relied on water from tube wells, while 5.82 percent chose drinking water from dams in the selected sample. It is supposed that the majority of the sample who consumed purified water was more likely to do so than those who relied on tube wells and dams. This suggests that consumers prioritize affordability and express a preference based on health concerns when selecting their drinking water.

Table 7. Preference for different type of drinking water (n=395)

No.	Item	Frequency	Percent
1	Purified water	320	81.01
2	Tube-well water	97	24.56
3	Dam water	23	5.82

Source: Survey data of Department of Agricultural Economics, 2021

Per capita drinking water and beverage consumption

The total adult equivalent population was 1,430. Regarding the average daily, monthly, and yearly per capita consumption of different drink and beverage types, variations were observed, as detailed in the Table 7. The calculated average daily per capita consumption rate for drinking water (n=350) by the sample group was the highest (2.31 liters per day) compared to other types of beverages. The second-highest drinking item was alcohol (0.09 bottles per day), followed by soft drinks (0.08 bottles per day). The average daily per capita consumption for coffee and tea mix was 0.34 cups per day, greater the daily per capita consumption of other beverages. The average daily per capita consumption for beverages, as well as milk, was approximately 0.08 bottles per day and 0.09 liters per day, respectively. Furthermore, the calculated average monthly per capita consumption rate for drinking water was also the highest amount (70.27 liters per month) compared to other types of drinks and beverages. The second-highest drinking item was coffee and tea mix (10.31 cups per month), followed by alcohol (2.63 bottles per month). Meanwhile, the calculated average monthly per capita consumption rate for beverages was about 2.52 bottles per day. Therefore, the yearly per capita consumption rates of drinking water, coffee and tea mix, and alcohol by the sample group were about 843.24 liters per year, 123.77 cups per year, and 31.53 bottles per year, respectively. As demonstrated in Table 8, the highest drink and beverage consumption rates per capita were for drinking water, coffee and tea mix, and alcohol compared to other types of beverages.

Table 8. Amount of per capita drinking water and beverage consumption

Items	Sample size	Unit		Daily	Monthly	Annually
Drinking water	(n=1212)	Liter	Average	2.31	70.27	843.24
			Maximum	14.09	428.57	5142.84
			Minimum	0.15	4.44	53.28
Coffee and tea mix	(n=1153)	No. cup	Average	0.34	10.31	123.77
			Maximum	2.92	88.89	1066.67
			Minimum	0.01	0.18	2.16
Dried tea	(n=1067)		Average	0.006	0.14	1.71



Items	Sample size	Unit		Daily	Monthly	Annually
		No.	Maximum	0.120	3.70	44.44
		cup	Minimum	0.000	0.01	0.12
Beverage	(n=684)	Bottle	Average	0.08	2.52	30.28
			Maximum	0.59	18.00	216.00
			Minimum	0.00	0.07	0.90
Milk	(n=746)	Liter	Average	0.06	1.80	21.65
			Maximum	0.49	15.00	180.00
			Minimum	0.00	0.12	1.46
Alcohol	(n=155)	Bottle	Average	0.09	2.63	31.53
			Maximum	0.32	9.68	116.13
			Minimum	0.01	0.20	2.40

Source: Survey data of Department of Agricultural Economics, 2021

Conclusion

In this research, the average household size of the sample respondents was 4 and the average age was 44 years as well as most of the sample respondents were female. About nearly half of the respondents were graduates and they were working in the public sector. The average total household income was US\$ 232 per month. On average, the share of food costs constituted 70% of the total expenditure and 60% of the income. The observation that a significant percentage of households allocate a substantial portion of their expenditure to drink costs suggests that a considerable proportion within households is spent on coffee and tea mix, and drinking water, excluding alcohol. Household monthly expenditures exhibited significant variations, with the lowest proportion attributed to dried tea based on the quantity and price of the consumed items. Purified drinking water emerged as the commonly consumed type among households. It is presumed that the majority of the sample, which consumed purified water and prioritize affordability and express a preference based on health concerns when selecting their drinking criteria, particularly for water. The average monthly per capita consumption rates for commonly consumed drinks and beverages were as follows: drinking water (70.27 litres), coffee and tea mix (10.31 cups), and alcohol (263 bottles), compared to other types of beverages. Therefore, in the study, the most common drink and beverage consumed by the sample respondents was drinking water, followed by coffee and tea mix among the different types of drinks and beverages. The common preference of purified drinking water among the selected respondents in the study area lean towards a healthy food system and signify their preference, involving a combination of diverse drinking water and various types of beverage items. Consequently, it is proposed that preferences and demands for various types of drinking water and coffee and tea mix be strengthened to meet local demand, enhancing household health and nutrition. For future research, small and medium enterprises in the business need to modify and focus on consumer demand, pricing, and trends in drinking, particularly related to purified drinking water and beverage items. This approach can create a win-win situation that aligns with both producers' offerings and consumers' preferences.

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Innovation Models in Agriculture and Rural Development in the Lao PDR

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Abstract

This study focuses on addressing the innovation gap in the agricultural sector of Lao PDR, a critical component of the population's primary livelihood. Emphasizing the 9th National Socio-Economic Development Plan for 2021-2025 and the Ministry of Agriculture and Forestry Strategy 2025 and Vision 2030, the research examines recent innovation models in agriculture and rural development in the country. Out of the 30 models interviewed, 10 are highlighted for their significant impact on the development of agriculture, rural areas, and smallholder farmers, demonstrating the applicability of these innovations. The study explores potential innovations, such as the role of the Lao Farmer Network as a national platform for information sharing, the Coffee Production Cooperative in connecting domestic producers with foreign consumers, and the creative use of saffron to reduce waste from coffee processing. Despite their potential, certain innovations, including Beef Research and Development Farm cost-effective animal feed formulas and specific rice-growing techniques, encounter limited adoption among farmers or production groups. Challenges impeding widespread implementation encompass insufficient investment, an unsuitable environment, and limited markets. Notably, hydroponics vegetable farming poses challenges due to its requirement for significant investment and specialized knowledge, potentially excluding smallholder farmers. To foster agricultural innovation, the study proposes several policy implications: collaboration between governments and the private sector in R&D investment, improving access and adopt innovations through tax incentives and financial support, establishing a platform for technology sharing, allocating resources to education and training programs, prioritizing environmental sustainability in agricultural innovation to prevent harm to the environment.

Keywords: innovation, technology, production group, cooperative

JEL code: R, O1, O13

SDG goal: Zero Hunger

Introduction

The agricultural sector in Lao PDR constitutes the primary livelihood for approximately 70% of the population, despite contributing only 16.4% to the GDP in 2021. This sector plays a crucial role in food production, supplying raw materials to agro-food processing and animal feed industries, and providing commodities for both local and international markets (Bank of Lao PDR, 2022).

The 9th National Socio-Economic Development Plan (NSED) for 2021-2025 and Strategy 2025 and Vision 2030 of the Department of Agriculture, Ministry of Agriculture and Forestry underscores the importance of leveraging science, technology, and innovation to propel national development. This involves integrating technical and scientific research, technology, innovation, and a knowledge-based economy into production and service processes. Key initiatives include establishing an information exchange centre, sharing best practices in science and technology, and production groups and cooperatives (Ministry of Planning and Investment, 2021; Ministry of Agriculture and Forestry, 2021).

Numerous studies have investigated the impact of innovation on agriculture and rural development across various dimensions. Research exploring the influence of innovation on enhancing productivity has been conducted across diverse products and countries (Carberry,



2011; Viaggi, 2015; Andrianarison et al., 2022). An essential aspect involves the adoption of innovative agricultural practices to address the challenges posed by climate change, as investigated by Smithers and Baly-Palmer (2001), Sayer and Cassman (2013), and Takacs-Gyogry (2022).

The impact of agricultural innovation extends to various facets of rural development, including production groups, finance, and education, as evidenced by studies conducted by Knickel et al. (2009), Shpykuliak and Sakovska (2020), and Pan and Zhang (2024). These research endeavours collectively underscore the multifaceted influence of innovation on agriculture and its broader implications for rural development.

Despite the critical role of innovation and technology in Lao PDR's agriculture and rural development, limited comprehensive studies exist on this subject. Existing research often focuses on specific products and technologies rather than providing broad coverage across agricultural products and geographic areas. Studies by Evans et al. (2011) and Sonethavixay and Keomanyphet (2018) concentrate on specific products and technologies without conducting in-depth analyses of their impacts. FAO (2021) assessed constraints and opportunities in agricultural innovation, identifying major constraints such as the absence of targeted and comprehensive strategies, limited capacity to formulate and adopt effective innovation policies, and challenges faced by farmers in accessing government services. Proposed solutions include promoting an understanding of the innovation systems approach in the Lao agriculture sector through the development of curricula and training programs.

Agriculture and rural development in Lao PDR face numerous challenges, including climate change, high production costs, low productivity, pest infestations, market limitations, and financial constraints. In addressing these challenges, innovation emerges as a potential solution. However, there is a lack of clarity regarding the developed models in Lao PDR and the impact of these innovations on agriculture and rural development. The scarcity of information on innovation in Lao PDR impedes the dissemination of agricultural technologies.

Agricultural innovation, as defined in this research, encompasses the process by which individuals or organizations introduce new or existing products, processes, or organizational methods into a specific context. This introduction aims to enhance effectiveness, competitiveness, resilience to shocks, or environmental sustainability, ultimately contributing to food security and nutrition, economic development, and sustainable natural resource management (FAO, 2018).

This study seeks to address the existing knowledge gap by examining recent innovation models in agriculture and rural development within Lao PDR. The primary objective is to thoroughly examine the innovation processes and evaluate their impact on agriculture, rural communities, and government policies. Specific objectives include analysing the historical context of innovation and technology, comprehending the processes involved in innovation development, and assessing their effects on farmers, communities, and government policies.

Methodology

In this study, a qualitative research methodology was utilized to examine innovations in agriculture and rural development. Before conducting field surveys, a structured interview guideline was formulated. The questions covered the background of the innovation, its development process, its impact on other farmers, the support mechanisms involved, and the challenges faced during its implementation. The previous research, studies, and reports were



reviewed to select representative innovation models for in-depth surveys. The in-depth surveys aimed to provide insights into lessons learned, assess conditions for expansion, the impact of the innovation, and evaluate the models' contributions to policy improvement.

Approximately 30 innovation models were interviewed, encompassing the areas of Vientiane Capital, Luang Prabang, and Champasak provinces, to represent the northern, central, and southern regions of Laos. Recommendations from experts in the agriculture sector guided these selections. However, it was observed that many of the innovation models had limited impact on the agriculture sector and did not apply to smallholder farmers. Therefore, this paper focuses on presenting ten models that have demonstrated tangible impacts on farmers while ensuring validity and sustainability.

Results and discussion

The study results present an innovation model highlighting the commonalities among innovations, such as networks and cooperation, research and development, and the introduction of new products and processes.

Networks and Cooperatives

Lao Farmer Network

On February 20th, 2020, the Lao Farmer Network (LFN) was founded with a membership of 164 individuals, representing 42,685 people across 16 provinces. The network includes agricultural production groups, cooperatives, and associations, and has been actively working to enhance the capacity of farmers' organizations, facilitate the development of agricultural businesses, promote peer-to-peer learning among farmers, and contribute to policy discussions. Among the LFN's members, 20,090 are women (Lao Farmer Network, 2023).

To enhance its organization, LFN aids the network in establishing a production network based on the product. This includes sub-networks such as the Vegetable Farmers Network, Rice Farmer Network, Industrial Crops Network, NTFP Farmers Network, Coffee Farmers Network, Tea Farmers Network, and Livestock Farmer Network. Furthermore, LFN assists these sub-networks to improve their group management, financial management, and group database. LFN also assists members in promoting their products through various means, such as seminars, websites, YouTube, Facebook, and others. LFN additionally supports the network in upgrading its farming techniques through self-conducted experimental research, group learning, and dissemination of information.

The LFN has introduced various innovations to help its members. The LFN assists farmers in establishing connections with business partners, such as Mueng Lao Food for vegetable sales, Phoun Nguen for rice sales, and Gentera for asparagus sales. The farmers produce a specific amount according to the contract they have signed with LFN's business partners. Furthermore, the LFN supports rice farmers in Jaeng village to have a contract with a rice mill factory, enabling them to earn more than the market price of around LAK 500/Kg, which encourages them to become more commercialized.

Jhai Coffee Cooperatives have received financial assistance from the LFN to use as working capital during the coffee collection period. The LFN lent a total of 200,000 USD to the JCFC with 3% interest for 6 months.

In terms of vegetable production, the LFN provides seeds, training, materials, and funds to its members. During the Covid-19 pandemic, the vegetable network had a significant impact on



the restriction policy. To prevent overproduction, the LFN recommended that the network collect seeds instead. This helped to avoid an estimated total loss of LAK 17 billion.

The LFN also connects Thongmung Farmer Cooperatives and customers through direct sales. Thongmung Organic Agriculture Cooperative (TOAC) delivers vegetables in a set menu, such as a bamboo soup set, chicken soup set, and suki set, to customers. However, TOAC signed a contract with CP company to supply vegetables of around 50 Kg per day, and they are not able to continue delivering the set menu to customers.

LFN faces numerous obstacles in supporting its members due to the growing number of members and limited budget. Providing new technology and innovation to members is challenging since they are accustomed to traditional production methods. LFN's budget primarily depends on donations, but the organization aims to become self-sufficient by 2025.

Jhai Coffee Farmer Cooperative

Coffee is a crucial agricultural commodity in Lao People's Democratic Republic, particularly in the Bolaven Plateau, which spans 500 square kilometers and ranges from 600 to 1,300 meters above sea level at latitude 15°North in Champasack, Sekong, and Saravan provinces, producing around 80% of Lao coffee. The production of coffee in 2020 was 158,190 tons, which increased to 161,200 tons in 2021 (Lao Coffee Association, 2023).

Lao PDR's primary coffee export market is the ASEAN region, with coffee exports valued at USD 37.99 million to Vietnam, USD 27 million to Thailand, USD 5 million to Cambodia, and USD 0.02 million to Singapore in 2020, under the bilateral trade agreement with Vietnam. Coffee exports to the EU under GSP amounted to USD 11.39 million, with Belgium importing approximately USD 5.92 million, and Germany importing about USD 3.1 million. Japan and the United States also imported coffee from Laos worth USD 2.67 million and USD 1.22 million, respectively, under the GSP in 2020 (Ministry of Industry and Commerce, 2022).

Jhai Coffee Farmer Cooperative (JCFC) was established in 2000 in response to the traditional coffee-growing practices employed by farmers in the region, who were observed to be highly skilled in the grading process but were unable to extract additional value from their product due to the predominant sale of red bean coffee to intermediaries. To introduce a quality-focused approach to coffee production, one of the founders of JCFC recognized the need for a cooperative that would enable farmers to better capitalize on their skills and thus established JCFC, deriving its name from the Lao term "Jhai," meaning meticulous categorization, which reflects the organization's fundamental philosophy.

In 2004, JCFC agreed with a Japanese purchaser to export coffee to Japan, subject to the condition that the quality of the coffee must be improved. However, at the time, the farmers were only familiar with two types of coffee, namely Arabica and Robusta. To satisfy the Japanese buyer's demand for specific types of coffee, such as Arabica SJ133, Arabica Catimor B02, and Arabica Cartimor S795, farmers needed to develop their expertise in improving coffee quality and variety. The knowledge transfer from the Japanese buyer to JCFC and the farmers had a significant impact, resulting in the enhancement of their skills and knowledge, as well as their ability to purchase a milling machine, which contributed to increased income.

JCFC's membership has grown significantly since its inception, with over 450 members across 19 villages in the Parksong district, compared to just three members at the outset. To enhance



value-added production, the JCFC committee has established eight critical processes spanning from plantation and care to harvesting, processing, roasting, brewing, cupping, and packaging. While most farmers have a good understanding of the first four steps, the latter four are crucial for maximizing value. To facilitate learning for JCFC members, one of the committees established Jhai Café, which serves as an educational hub for coffee production. Jhai Café offers a variety of training programs for up to 30 members, as well as Japanese students, each year.

JCFC has emerged as one of the most prosperous cooperatives in Lao PDR, largely due to its innovation in various aspects of coffee production, such as variety selection, processing, and quality improvement. The cooperative has effectively transferred these innovations to its members, resulting in a significant increase in their income. Moreover, the introduction of value-added production along the coffee value chain has created additional economic benefits for the cooperative's members.

Bolaven Plateau Coffee Producers Cooperative

Bolaven is situated in the southern region of Laos and is one of the three highlands that span across four provinces, namely Champasack, Saravan, Sekong, and Attapue. Unlike the other two plateaus in the central and northern areas, Bolaven is well-suited for coffee farming due to its fertile volcanic soil. The French introduced coffee cultivation to Bolaven in the early 1900s, and since then, coffee plantations have become a crucial source of income for thousands of households, leading to an improvement in their livelihoods (Livermore, 2020).

Despite the considerable growth of coffee plantations in Bolaven, small-scale coffee farmers face numerous challenges, including restricted market access, weak bargaining power, limited value-added processing, and the use of chemicals in production. In response to these issues, the Bolaven Plateaus Coffee Producer Cooperative (CPC) was established. Since its inception, CPC has become a model for other production groups and cooperatives, particularly in terms of organizational management, value-added product creation, and environmentally friendly production methods. CPC's success is evidenced by numerous accolades, including the Lao Best Coffee Exporter 2012 award for quality and price from the Ministry of Industry and Commerce, as well as certifications for Fairtrade and organic products that have enabled its products to reach global markets.

CPC was established in 2007 with the assistance of the Ministry of Agriculture and Forestry and the French Development Agency (AFD), initially known as the Association of Coffee Producer Group in Bolaven Plateau before being renamed to Bolaven Plateau Coffee Producer Cooperative in 2014. CPC currently employs approximately 36 staff and has over 1,800 household members from 55 villages across three provinces, namely Champasack, Saravan, and Sekong (AFD, 2023).

The success of the CPC can be attributed to various factors. One of the strengths of CPC is its commitment to inclusive development. Through official elections, all members can directly vote for their representatives, who make decisions related to planning, managing the organization, sharing benefits, and determining the direction of organization development. This allows coffee farmers to be involved at all levels of the administration hierarchy, making CPC a true farmers' organization.



To ensure the quality of coffee, CPC pays careful attention to every process of production. Members are provided with technical assistance in selecting seeds, planting, taking care of, utilizing organic fertilizer, and harvesting. CPC has also invested in primary infrastructure such as building processing plants and organic fertilizer plants. With around 39 collective wet processing centers across communities where CPC members live, farmers can bring freshly harvested red coffee into the wet process (pulping and fermenting process) with strict specifications to produce high-quality coffee. This wet process greatly enhances the organoleptic qualities of Arabica.

Sustainability is also a key priority for CPC. The organization supports farmers in producing organic coffee, which presently covers an area of more than 4,000 hectares. Organic production is not only environmentally friendly and healthy for farmers, but it also increases the value of CPC products. Additionally, the promotion of integrated crop-forestry production is considered a successful innovation of CPC. Farmers are encouraged to grow coffee with other local plants that support the growth of coffee trees and lower the cost of production. This system not only increases productivity but also enhances farmers' ability to adapt to climate change, making their coffee production more resilient.

Being a member of the Bolaven Plateau Coffee Producer Cooperative (CPC) directly benefits farmers in various ways. One such benefit is a notable increase in household income. Through the Fairtrade and Organic certificates, CPC guarantees farmers a minimum price that is roughly 45 percent higher than the general market price over the past five years.

Moreover, some of the profits earned by CPC are allocated towards investing in the infrastructure of the members' communities. For instance, CPC has constructed over 11 schools, drilled 15 groundwaters, donated more than 220 water filters to 42 schools, built a health dispensary, and provided medical equipment to hospitals in Champasack provinces. These efforts significantly improve the standard of living for farmers and their communities. Small-scale farming is prevalent in Laos, and production groups and cooperatives are expected to provide farmers with market power. However, the failure of cooperatives in the 1980s still affects farmers. Nonetheless, the success of the CPC demonstrates that production cooperatives can improve farmers' bargaining power and enhance their livelihoods. The CPC's achievements in organizational management, value-added creation, and environmentally and socially conscious production are noteworthy examples.

The lessons and experiences of the CPC should be disseminated through various channels to other cooperatives. Manuals on cooperative management, production management, value-added creation, technical production, and environmentally and socially conscious production should be created to facilitate the widespread adoption of CPC's innovations and knowledge by other cooperatives.

Thong Mung Agricultural Cooperative

Thong Mang Agricultural Cooperative (TMAC) began as an organic vegetable production group on June 27, 2015, in Thong Mang village, Saythany district, Vientiane capital, with 12 family members 1.5 hectares of production areas, and 15 greenhouses. The group's inception was driven by the rapid spoilage of vegetables in the market, concerns about the use of chemical fertilizers and pesticides, and a desire among female farmers to earn more income after the harvest season.



The capacity of TMAC has been enhanced with assistance from the government and NGOs. Lao Farmer Network supported the group in finding markets and studying programs in Thailand, Vietnam, and Cambodia in 2019. Consequently, TMAC began selling vegetables to hotels, restaurants, and retail shops. However, the responsibility of managing the plantation, marketing, and other duties was a challenge. Thus, TMAC decided to restructure into six functions. These are:

- **Technical control system:** This includes a monthly crop planting calendar, regular lessons on pest and herbicide management, and controls among members.
- **Internal Control System:** This involves the selection process of new members and the regular monitoring of current farmers' production techniques.
- **Marketing:** This function includes a production-based schedule of demands and online advertisements, including farmers' baskets that offer a variety of vegetables.
- **Accounting and Finance:** This function records income and expenditures according to the cooperative's rules and regulations using a record book.
- **Credit:** This function ensures that credit interest is paid on time back to the credit provider, and there is trust and liability for continuing sustainable collaboration.
- **Organization management:** This involves managing the cooperative based on the rules and regulations of cooperative decrees. The president and board members are elected officially with job descriptions.

In 2020, TMAC agreed to provide 400 Kg of vegetables daily to CP Company through a contract. Due to the Covid-19 pandemic, the CP Company decreased its order to only 50 Kg per day. TMAC also supplied vegetables to Mueng Lao Food Company, and LFN helped promote TMAC through online channels. In the past, TMAC had to borrow money from microfinance institutions with a high-interest rate of 36% annually, but with government support, it can now borrow from banks at a lower interest rate of 6% per year.

The government's technical and policy support, market demand for organic vegetables, and development projects from various partners have helped TMAC grow steadily. In 2020, TMAC officially be formed with 44 family members from 5 villages in Saythany district, Vientiane Capital, and had a total production area of 36.4 hectares with 116 greenhouses. However, in 2022, the number of members decreased to 33, and the production area was reduced to 30 hectares due to some families selling their land to Potash Factories in the village.

TMAC focuses on producing organic vegetables, fruits, fish, and poultry, with a vision of mutual support, self-responsibility, shared ownership, and fair benefits based on members' capacity for income and livelihood improvement. The cooperative's goals and objectives are to ensure members' quality production and access to a definite market demand and to facilitate effective production and product distribution segments through input, equipment, and financial capital provision and contract farming with price guarantees.

TMAC is regarded as a successful model for cooperative management in Laos. They regularly share their expertise on managing cooperatives with various groups across the country, including the Lao Women Union, Production Group, and Cooperatives, benefitting more than 200 production groups and over 1,000 farmers. Despite their success, TMAC faces challenges in finding qualified staff to manage operations and expanding their infrastructure due to a shortage of funds. Furthermore, the decreasing number of members may affect the cooperative's long-term production capabilities.



Research Center

Beef Research and Development Farm

The Beef Research and Development Farm (BRDF) was established as a demonstration farm with assistance from the Japan International Research Center for Agricultural Sciences (JIRCAS). The BRDF's primary objectives are to improve cattle husbandry techniques and develop animal feed and breeding practices, while also serving as a knowledge hub for farmers. In 2018, the Faculty of Agriculture (FAG) at the National University of Laos (NUOL) collaborated with the Institute for Global Social Responsibility at Seoul National University (SNUSR) and Milk for Laos, a local partner, with the support of volunteers from both institutions. The primary objective of the collaboration was to exchange experiences and promote community development and knowledge sharing of scientific research and culture between the two institutions. Additionally, the program involved activities with students from Ban Pakxapmai Primary School in Xaythany District, Vientiane Capital, which included hygiene, science and technology, environmental protection, sports, culture, and more. The primary school students were taught about hygiene practices such as handwashing and tooth brushing, the importance of drinking milk, tree planting, and proper waste disposal, and helped in repairing and repainting the school.

BRDF has developed several innovations. One of them is the Green Project which provides 200 chickens per household in 66 households in 11 villages in Xaythany district, Vientiane Capital. The project uses a free-range technique which reduces animal feed costs for farmers. The eggs produced are then sold to the Green Project, which packs and supplies them to department and convenience stores at a price 20% higher than the market price of an egg. The BRGF aims to provide more than 10,000 chickens to farmers in the northern part of Lao PDR. BRDF has also developed various formulas for cattle feed, using local by-products from the agriculture processing industry such as maize, cassava, and by-products from beer factories. This has helped reduce the cost of cattle feed from USD 0.5 per Kg to USD 0.2 per Kg. Furthermore, BRDF has developed a mineral cake for cattle which can be used to prevent the loss of cattle weight during the dry season.

Several innovations and technology are developed by the BRDF, especially animal feed. Animal feeds have a limited impact on cattle farmers because most of the farmers still use free-range husbandry. However, the Green Project is growing in terms of the number of members and production. In addition, it extends the project to the Northern part of Lao PDR

Rice Research Center

Rice is the primary crop grown in Laos, accounting for 80% of cultivated land. Despite having extensive experience in rice farming, Lao farmers have not been able to achieve high yields due to using traditional rice varieties with low quality and productivity. Local rice strains, while resistant to disease, are not able to withstand extreme climate variations like floods and droughts. Introducing innovative techniques to improve crop varieties is an effective way to address these challenges. While private-sector research is limited, public investment in this sector is crucial, and the Rice Research Center is one of the top government agencies with a performance-based evaluation. The center is well-known for improving rice and other crop varieties, preserving local rice strains, and developing adaptive production methods in response to climate change.

The Naphok Research Center, which is located 25 kilometers from Vientiane Capital, was established in 1983 and was initially a part of the Lao Comprehensive Agriculture Project. It has since been renamed and reorganized several times. The research center covers a total area



of 185 hectares, including 28 hectares of building space, 7 hectares for fruit production, 37 hectares for field experiments, 110 hectares for crop seed production, and 3 hectares for conserving wild rice strains. The Naphok Research Center is one of thirteen agricultural and forestry research centers under the National Agriculture and Forestry Research Institute (NAFRI). Its key objectives are conducting sustainable research, managing and applying crop varieties, researching crop varieties and production techniques to improve productivity, and conducting agriculture and forestry research that is resilient to climate change.

Over the past 40 years, the Naphok Research Center has been a highly effective government agency, achieving several explicit outcomes in various areas, such as local crop variety conservation, new crop variety production, and improved production techniques.

The Research Center has successfully conserved many native rice varieties and other crops using modern innovation techniques. They have stored nearly 14,700 native rice varieties, the second largest number of conserved rice varieties in the world, after India. The center uses both short-term and long-term conservation methods to preserve the genetic resources of native rice and other crops.

The Research Center has also produced many new crop varieties that are highly resilient to diseases and climate change. For example, the sticky rice variety "Hom-Xebangfai 4" can withstand flood and drought, and the new rice variety "Thadokkham 15" is resistant to various diseases. The center has also developed new crop varieties, such as cassava, which is resistant to a mosaic virus that is common in neighboring countries.

Finally, the Naphok Research Center has developed new production techniques to fight against weeds and climate change. They have introduced a direct seeding technique to avoid drought and flood during the early growing season, which reduces labor costs. The center has also developed an integrated crop variety technique, using mung bean and sun hemp to control weeds when implementing the direct seeding of rice.

The Naphok Research Center has brought significant advantages to Lao farmers through its innovative research. These include the availability of new and improved rice and crop varieties that exhibit better quality, higher productivity, and greater resistance to climate change and disease. As a result, farmers have fully embraced these innovations, with 100 percent of dry season rice production being comprised of new rice varieties (90 percent using Lao rice varieties and 10 percent using imported varieties), and about 80 percent of rainy season rice production using new rice varieties.

Breeding crops and animals is vital to ensure food security, and the Naphok Research Center has been instrumental in developing rice and other crop varieties that meet farmers' needs for both quality and quantity. With climate change being an inevitable phenomenon, it's important for the Naphok Research Center to develop production techniques and new varieties that can withstand the impacts of climate change. Despite having limited financial resources, the Research Center has made significant efforts to bring innovations into the agricultural sector. The number of new crop varieties and production techniques that have been introduced to farmers is evidence of this. These tangible outcomes demonstrate the importance of the Naphok Research Center in the agricultural sector of Lao PDR.

Living Aquatic Resource Research Center

The National Agriculture and Forestry Research Institute oversees 13 research centers, including the Living Aquatic Resource Research Center (LARReC), which was established in



1999. LARReC's responsibilities include researching fish propagation, providing high-quality fish broodstock for farmers and private enterprises, implementing suitable aquaculture systems based on the potential of different agroecological zones, assessing living aquatic resources in rivers, streams, reservoirs, and wetlands, and offering data, information, and technologies related to fishery. LARReC currently comprises three units and one research station, with a total of 29 staff members.

LARReC has played an important role in helping the Lao government achieve its objectives of ensuring food security and rural development. Over the past two decades, LARReC has collaborated with several international organizations, including the Australian Center for International Agricultural Research (ACIAR), Japan International Research for Agriculture Science (JIRAS), Japan International Cooperation Agency (JICA), Mekong River Commission (MRC), Food and Agriculture Organization (FAO), United States Agency for International Development (USAID), and Research Institute for Fishery Aquaculture and Irrigation (HAKI). As a result of its extensive collaboration, LARReC has made significant contributions in a variety of areas, such as propagating and conserving native fish species, breeding fish for improved productivity, developing appropriate aquaculture methods for different climatic conditions, and producing fish and aquatic feeds.

Farmers who are engaged in aquaculture are experiencing a sharp rise in the cost of aquatic feeds, most of which is imported from foreign countries. To address this issue, the Living Aquatic Resource Research Center (LARReC) has focused on developing aquatic feeds using locally available inputs, which could lower production costs and reduce dependence on imports. LARReC researched producing aquatic feeds using duckweed and fermented cassava as the primary ingredients. Duckweed contains essential nutrients and vitamins that promote fish health and growth, while fermented cassava is a rich source of protein. By using this feed formula, the growth rate of fish is nearly the same as with commercially available fish feed, but at a 20-30% lower cost. This feed has been widely adopted by farmers in Nasaithong for their aquaculture needs.

During the dry season, aquaculture farmers face the problem of insufficient water resources, particularly in areas where soil cannot retain water. LARReC collaborated with farmers and communities in northern Laos to develop a solution to this problem by introducing the use of pond liners and fish species that can thrive in a low-water environment. This approach ensures that farmers have enough water for the entire fish production period. LARReC has successfully implemented this technique in 20 schools in Sekong province, 10 districts in Oudomsay, and 8 districts in Phongsaly, resulting in healthy fish growth.

The Living Aquatic Resource Research Center has produced research outcomes and innovations that have been widely adopted by aquaculture farmers. One of their breakthroughs, the development of aquatic feed made from duckweed and fermented cassava, has gained significant popularity among farmers. By using LARReC's fish feed, farmers can save on production costs without compromising the health of the fish. Moreover, their research on the use of pond liners for fish feeding has brought substantial benefits to farmers residing in areas with low water retention.

LARReC is a national institution in Laos that is dedicated to developing innovative solutions for the advancement of aquaculture. Innovations such as fish feed and the use of pond liners have proven to be advantageous for farmers. These innovations align with the Lao



government's policy of promoting food security and reducing reliance on imported aquatic feed. LARReC has several other innovations that can benefit farmers and the Lao government should promote these innovations to encourage their widespread adoption. Additionally, the government should increase funding for LARReC's research and development efforts to facilitate the creation of more innovative solutions.

New products and processes

Buffalo Dairy Farm

Consuming cow dairy products is common, while buffalo dairy products are less known and less consumed. This has made a buffalo dairy farm in Luang Prabang an interesting and unique destination for both local and foreign tourists. The idea for this farm came about a decade ago when three Australians, Susie, Steven, and Rachel, visited Luang Prabang and realized that it was difficult to find high-quality cheese in the city. They noticed the abundance of buffalos in the rural area of Luang Prabang and were inspired to create their cheese using buffalo milk. After many failed attempts, they finally developed successful recipes to make cheese and other products from buffalo milk. The story of the buffalo dairy farm goes beyond cheese and other dairy products; it is also about their collaboration with local villagers and their contribution to the sustainable development of the community.

The buffalo dairy farm is situated in Muangkhai village, approximately 25 kilometers from Luang Prabang's city center. Its establishment dates back to 2016, and it presently employs 30 full-time staff members. Initially, only four households contributed their buffalos to the milking process, but now over 150 households participate, each owning an average of one to three buffalos. The buffalo dairy farm is an environmentally and socially responsible farm that aims to enhance local agriculture by promoting buffalo farming, administering vaccinations, and providing animal husbandry, veterinary care, and nutrition programs. It is a unique farm that integrates an organic farm, petting zoo, cheese-making workshop, ice cream shop, and community support center.

The Buffalo Dairy Farm is a great example of a farm that thinks creatively and outside of the box when it comes to introducing new products. One such product is buffalo milk, which is not widely available in Luang Prabang or Laos. The farm works with local villagers by renting their pregnant buffalo, taking care of them and their calves, and milking them for approximately six months before returning them. During this time, the farm provides feed, care, and vaccinations to the buffalo. Native buffalo usually produce between 1.5 to 4 liters of milk per day, whereas Thai Murrah Buffalo produces around 15 to 20 liters of milk per day. To improve milk yield, genetic health, and calf survival rates, the farm is crossbreeding Lao native buffalo with Indian Murrah buffalo. This will also increase the farm's income from productive buffalos.

The Buffalo dairy farm produces a diverse range of products that are made using buffalo milk. The founders started with cheese-making and Rachel, one of them, reached out to cheese-making experts to find the right recipe. After numerous attempts, they discovered a recipe for mozzarella cheese using buffalo milk. In addition to mozzarella cheese, the farm uses buffalo milk as the primary ingredient in creating other products such as ice cream, yogurt, and cheesecake. These products are popular with both domestic and foreign tourists who visit the farm. Buffalo dairy products can now be found in many restaurants, hotels, and supermarkets in Luang Prabang and Laos. Due to the increase in production, the farm plans to export its products to China and ASEAN.



The buffalo dairy farm has made several contributions to the development of the rural community in multiple ways. Villagers have found a new source of income by renting their buffalo and land to the dairy farm, earning approximately 40,000 per annum. The farm also provides employment opportunities to community members, allowing them to earn income and gain skills in areas such as animal husbandry, veterinary care, and the milking process. The farm also takes care of the buffalo and their calves and has implemented a breeding program to improve calf survival rates. Additionally, the dairy farm provides new income and skills to community members who are employed in various roles such as dairy, production, and administration. Workshops are also conducted at the dairy farm to provide practical experience for teachers and students from the Northern Agricultural College.

The sustainable development of the agricultural sector requires the contribution of many farms and businesses that are socially and environmentally responsible. Surely, the buffalo dairy farm in Luangprabang is one of those. Milk and other milk-related products from buffalo are innovative products in Luangprabang and Laos. The buffalo dairy farm considerably contributes to the development of rural communities. Renting farmers' buffalo is win-win cooperation. The dairy farm can make a profit while it provides a new source of income and job opportunities for local villages. Moreover, the buffalo dairy farm is not only a farm-feeding animal, it is a place where founders with adventurous souls cooperate with villagers, practitioners, and experts. The dairy farm is like a working room where we can learn practical knowledge in farming, cooperate with the local community, and bring innovation into farming production.

Saffron

The EU project in 1997 provided support to farmers in the mountainous region of Northern Laos to cultivate coffee as an alternative cash crop since the opium harvest had been outlawed, and the goal was to create a sustainable income for the hill tribe villagers. However, due to a limited market and low coffee prices, many farmers abandoned coffee for other crops. In 2004, David Dale, an American residing in Laos, surveyed the highlands near Luang Prabang and discovered the coffee plantation area established under the EU project. As a result, Saffron Coffee was established in 2006.

Saffron Coffee currently processes 12-15 tons of unroasted coffee per year. While this amount may seem modest on a global scale, the company has taken a deliberate and gradual approach to ensure long-term sustainability. This has included developing strong, enduring relationships with individual farmers and villages, as well as promoting a shift in mindset regarding coffee farming as a viable alternative to other cash crops.

Over the past decade, Saffron Coffee has introduced several innovations. They grow coffee in the forest using organic methods, with shade trees that provide environmental benefits such as soil nitrogen fixation, erosion reduction, and conservation of native plants and animals. They offer training in organic fertilization techniques and provide shade trees and ground cover to complement the coffee plants.

Saffron Coffee aims to minimize waste in coffee processing. They use the fruit of the coffee berry to make coffee tea, jam, soap, and fertilizer. They recycle water in their wet process,



reuse glass bottles and bamboo straws in their café, and use waste from the café to produce fertilizer.

Saffron's gradual growth and progress over 12 years has enabled them to gain the trust and credibility of the local communities. This is due to the observable and substantial positive impact that the company has had on the lives of people in the affected villages. Consequently, Saffron has formed partnerships with various non-governmental organizations and charitable institutions to further promote coffee cultivation to farmers in the northern regions of Laos, which encompasses 4 provinces, 36 villages, and over 800 farmers.

Saffron coffee is the first company to develop the coffee industry in the northern part of Lao PDR. They adopted shade trees to grow coffee which is environmentally friendly and organic. Farmers benefit from skill improvement and income generation from coffee farm.

Agro Vege Farm

For over 15 years, hydroponic vegetable farming has been commonly used in Laos to cultivate a variety of vegetables. A hydroponic vegetable farm named "Agro Vege Farm" has become increasingly popular among people in Laos who visit the Paksong district, located in the southern province of Champasack. As a result, it has become one of the largest hydroponic farms in the country. The farm is a result of a Public-Private Partnership (PPP) between a foreign private company and the local government. The investment in Agro Vege Farm began in 2017 when the Laotian ambassador in Malaysia persuaded a Malaysian businessman, who owns Agrotech Pro Ltd., to invest in hydroponic farming in Champasack province. The company then contacted the Provincial Division of Agriculture and Forestry in Champasack to assess the potential investment. Following a meeting between the governor of Champasack and the owner of Agrotech Pro company in Malaysia, the company decided to invest in the Paksong district, Champasack province.

At present, the company cooperates with the Provincial Division of Agriculture and Forestry to develop a project area of about 40 hectares. The first phase of the project, which involved constructing infrastructure on 15 hectares, including 33 greenhouses for vegetable production, 1 greenhouse for quality control, 8 container dormitories, and 1 main dormitory, has been completed. The second phase of the project covers approximately 25 hectares. The investment made by Agrotech Pro in Laos is widely recognized as a significant contribution to the provision of clean vegetables for both domestic and foreign markets, the promotion of the local economy, and the creation of employment opportunities for local workers.

Agro Vege Farm is a collaborative effort between a foreign private investor and the local government. The Provincial Division of Agriculture and Forestry, representing Champasack province, provides the land while the foreign company invests in development. This partnership is mutually beneficial as the private sector can reduce its investment cost and streamline the document process while the public sector benefits from the company's technology, innovation, and expertise in ensuring efficient hydroponic farming. By working together, they can promote the local economy and create job opportunities.

Agro Vege Farm is not only a hydroponic farm but also a popular tourist destination. The Paksong district attracts thousands of tourists each year due to its pleasant weather, picturesque scenery, coffee plantations, and waterfalls. Agrotech Pro and the local government recognize the potential for profit in tourism, so they have integrated hydroponic farming with tourism to



create agritourism. In addition to vegetables, visitors can enjoy outdoor flower gardens, rose gardens, cacti, strawberries, and iconic buildings. The Agro Vege Farm restaurant offers fresh vegetables for visitors to eat and purchase.

The collaboration between the local government and Agrotech Pro company in hydroponic farming is highly beneficial to the local economy. The Agro Vege Farm provides job opportunities for around 180 local workers, and this number is expected to increase once the project extension is completed. Additionally, the farm produces nearly 200 varieties of vegetables for both domestic and foreign markets, reducing the need for imported vegetables. Furthermore, the Agro Vege Farm is not just a hydroponic farm; it serves as a demonstration farm where farmers can learn about innovation and technology in the agricultural sector.

Assessing the investment of Agrotech Pro in Laos is a challenging task since it is still in its early stages of development. However, the initial success of the partnership between Champasack province and the Malaysian company serves as an excellent example of Public-Private Partnership in the farming sector. Agrotech Pro's expertise, innovation, and technology in hydroponic farming have greatly contributed to the success of the project. The integration of farming and tourism at Agro Vege Farm is also a valuable lesson for farmers and entrepreneurs. It is crucial for the local government to continue to foster knowledge exchange with Agro Vege Farm. A mechanism should be established to facilitate the transfer of innovation and technology from Agro Vege Farm to Lao farmers

Conclusion

In the past decade, there has been notable progress in the use of innovation and technology in agriculture and rural development. Numerous potential innovations could be shared among farmers and production groups. LFN has the potential to serve as a national platform for information sharing and collaboration among cooperatives and production groups. CPC is an exemplary model for connecting domestic producers with foreign consumers. Saffron represents an innovation that reduces waste from coffee processing while also creating new products from coffee byproducts.

Although some innovations have potential, they have not yet been broadly implemented among farmers or production groups. For example, BRDF has created various formulas of animal feed that substantially reduce costs, but their use is limited. Similarly, two rice-growing techniques developed by a rice farmer model are only used in the Vientiane province.

Despite the numerous successful innovations, some struggle with various challenges such as insufficient investment, an unsuitable environment, or a limited market. The hydroponics vegetable, for example, requires significant investment and specialized knowledge and skills that may not be suitable for smallholder farmers.

Although many innovations and technology has already been invented, they have required policy implications as the following:

- To foster the creation of new and innovative agricultural technologies and practices, governments need to collaborate with the private sector in investing in research and development. This could involve providing financial support to research institutions and universities. Additionally, a joint research program could be established between universities and the private sector to combine theoretical and practical research methods.



- To promote the uptake of novel agricultural technologies and practices among farmers, the government should make it easier for them to access and use such innovations. This may involve providing tax incentives and other financial support mechanisms.
- To disseminate technology and innovation, there should be a platform for innovation and technology sharing. LFN has the potential to develop such a platform but requires some support from the government. Farmers need to acquire new skills and knowledge. Therefore, policymakers should allocate resources to education and training programs that equip farmers with the necessary skills to effectively adopt and utilize new technologies.
- It is crucial to pursue agricultural innovation in a manner that prioritizes environmental sustainability. Policymakers must take measures to ensure that the integration of new technologies and practices does not cause any harm to the environment or jeopardize the long-term sustainability of agricultural systems.
- Government sector should facilitate access to markets for farmers who adopt innovative technologies and practices. This could involve the development of policies that promote fair trade, reduce trade barriers, and encourage the adoption of sustainable agricultural practices.

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Appendix

Committee, Program agenda



Committee

Organizing Committee

No	Name	Department/Faculty	Institute
1	Dr. Orachos Napasintuwong	Department of Agricultural and Resource Economics, Faculty of Economics	Kasetsart University, Thailand
2	Dr. Theingi Myint	Department of Agricultural Economics	Yezin Agricultural University, Myanmar
3	Dr. Nguyen Phuong Le	Department of Agricultural Economics and Policies	Vietnam National University of Agriculture, Vietnam
4	Dr. Mark Buda	Department of Agribusiness and Bioresource Economics	Universiti Putra, Malaysia
5	Dr. Nitty Hirawaty Kamarulzaman	Department of Agribusiness and Bioresource Economics Faculty of Agriculture	Universiti Putra, Malaysia
6	Dr. Anita Rosli	Institute of Ecosystem Science Borneo	Universiti Putra Malaysia, Bintulu Campus, Sarawak, Malaysia
7	Dr. Vadsana Chanthanasinh	Faculty of Economics and Business Management	National University of Laos, Laos PDR
8	Dr. Sayvisene Boulom	Faculty of Agriculture	National University of Laos, Laos PDR
9	Dr. Julieta A. Delos Reyes	Department of Agricultural and Applied Economics	University of Philippines Los Banos, Philippines
10	Dr. Tony Irawan	Department of Economics, Faculty of Economics and Management	IPB University, Indonesia
11	Dr. Lukytawati Anggraeni Putra	Department of Economics, Faculty of Economics and Management	IPB University, Indonesia
12	Dr. Hajah Rose Abdullah	Faculty of Agriculture	Universiti Islam Sultan Sharif Ali, Brunei Darussalam
13	Dr. Jirawan Kitchaicharoen	Faculty of Agriculture	Chiangmai University, Thailand
14	Dr. Sirinya Phulkerd	Institute for Population and Social Research	Mahidol University, Thailand
15	Dr. Jongjit Rittirong	Institute for Population and Social Research	Mahidol University, Thailand
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3	Dr. Kampanat Vijitsrikamol	Department of Agricultural and Resource Economics, Faculty of Economics	Kasetsart University, Thailand
4	Dr. Uchook Duangbootsee	Department of Agricultural and Resource Economics, Faculty of Economics	Kasetsart University, Thailand
5	Dr. Juntip Seneerattanaprayul	Department of Agricultural and Resource Economics, Faculty of Economics	Kasetsart University, Thailand
6	Dr. Sophon Yamklin	Department of Agricultural and Resource Economics, Faculty of Economics	Kasetsart University, Thailand
7	Dr. Borworn Tanrattanaphong	Department of Agricultural and Resource Economics, Faculty of Economics	Kasetsart University, Thailand



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1	Dr. Uchook Duangbootsee	Productivity and Efficiency Analysis, Land Policy, Consumer Choice and Behavior	Kasetsart University, Thailand
2	Dr. Nopasom Siphurmsukskul	Environmental Policy, Environmental Valuation, Recreation and Tourism, Pollution	Kasetsart University, Thailand
3	Dr. Sophon Yamklin	Agribusiness Entrepreneur, Business Model Innovation, Qualitative Research	Kasetsart University, Thailand
4	Dr. Theingi Myint	Agricultural marketing and value chain, Economic Impact Assessment and Household food system	Yezin Agricultural University, Myanmar
5	Dr. Yu Yu Tun	Price and market analysis Agricultural Production and efficiency analysis	Yezin Agricultural University, Myanmar
6	Dr. Nguyen Phuong Le	Agricultural economics, Rural development, Agricultural policy analysis, Rural livelihood, Gender	Vietnam National University of Agriculture, Vietnam
7	Dr. Le Thi Thanh Loan	Agricultural economics, Rural development, Agricultural policy analysis, Waste management	Vietnam National University of Agriculture, Vietnam
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9	Dr. Nguyen Thi Hai Ninh	Resources and Environmental Economics, Environmental Policy, Environmental Valuation, BCA	Vietnam National University of Agriculture, Vietnam
10	Dr. Nitty Hirawaty Kamarulzaman	Agribusiness Supply Chain Management	Universiti Putra Malaysia, Malaysia
11	Dr. Nurul Nadia Ramli	Agricultural and Resource Economics	Universiti Putra Malaysia, Malaysia
12	Dr. Muhammad Mu'az Mahmud	Agribusiness Strategic Management	Universiti Putra Malaysia, Malaysia
13	Dr. Norhariani Mohd Nor	Animal Health Economics	Universiti Putra Malaysia, Malaysia



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17	Dr. Piya Wongpit	Trade and finance	National University of Laos, Laos PDR
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22	Asst. Prof. Paul Joseph B. Ramirez	Economics	University of Philippines, Los Banos, Philippines
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27	Dr. Ahmed Osumanu Haruna	Food security, sustainability, climate change	Universiti Islam Sultan Sharif Ali, Brunei Darussalam
28	Dr. Ahmed Jalal Khan Chowdhury	Ecological Aquaculture,	Universiti Islam Sultan Sharif Ali, Brunei Darussalam



Technical Committee

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		Aquatic Resource Management, Food Security, Climate Change and Environmental Sustainability	
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33	Dr. Jongjit Rittirong	Agricultural and food systems, demography	Mahidol University, Thailand
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35	Assoc. Prof. Le Khuong Ninh	Economics and Finance	Can Tho University, Vietnam
36	Assoc. Prof. Khong Tien Dung	Agricultural and Resource Economics	Can Tho University, Vietnam



Program agenda

Date/time	Activity/Speaker	Facilitator/moderator	Location
Thursday, April 18, 2024			
08.00-08.50	Registration	Ms. Kiratikan Sadakorn Mr. Denver Buenaseda	EC5205
08.50	Opening Ceremony		
08.50-09.00	Opening by MC	Dr. Uchook Duangbootsee	EC5205
09.00-09.10	Report from Organizing Committee	Dr. Orachos Napisintuwong	EC5205
09.10-09.30	Welcome speech of Dean of Faculty of Economics, Kasetsart University Welcome speech by President of Kasetsart University	Dr. Visit Limsombunchai Dr. Chongrak Wachrinrat	EC5205
09.30-09.50	Invited Speakers Dr. Glenn B. Gregorio, Southeast Asian Regional Center for Graduate Study and Research in Agriculture (SEARCA) Center Director	Moderator: Dr. Orachos Napisintuwong Kasetsart University	EC5205
09.50-10.10	The role of universities in agricultural research and training towards sustainable agri-food system development in Southeast Asia		
10.10-10.30	Dr. Piti Srisangnam, ASEAN Foundation Executive Director The role of ASEAN Foundation in supporting education and community building towards sustainable agri-food system development in Southeast Asia Dr. Jongsoo Shin, Director of ASEAN-CGIAR Innovate for Food and Nutrition Security Regional Program ASEAN-CGIAR regional program for Innovations and Sustainable Development of ASEAN Agri-Food Systems		
10.30-10.50	Coffee Break		
10.50-11.20	Keynote Speaker Dr. Witsanu Attavanich, Associate Professor, Department of Economics, Faculty of Economics, Kasetsart University Climate change and climate resilience agriculture in Thailand	Moderator: Mr. Bates Bathan Kasetsart University	EC5205



Program agenda

Date/time	Activity/Speaker	Facilitator/moderator	Location
11.20-11.30	Transition time		
11.30-11.50	Signing of LOI between 11 ASEAN Universities		EC5205
11.50-12.00	Photo Session		
12.00-13.30	Lunch Break		EC5726
13.30-16.00	Track 1: Towards sustainable production	Moderator: Dr. Pham Le Thong, Can Tho University	EC5302
	Track 2: Resilience of food system	Moderator: Dr. Lukytawati Anggraeni Putra, IPB University	EC5205
Friday, April 19, 2024			
08.30-09.00	Registration	Ms. Kiratikan Sadakorn Ms. Moh Moh	
09.00-9.30	Keynote Speaker Dr. Tuyen Huynh, Research Team Leader, Food Environment and Consumer Behavior in Asia and Alliance Bioversity-International Center for Tropical Agriculture (CIAT) Transformation toward sustainability: Experiences in food systems and healthy diets work in Vietnam	Moderator: Dr. Uchook Duangbootsee Kasetsart University	EC5205
9.30-12.00	Track 3: Coping with vulnerability and risk	Moderator: Dr. Mark Buda, Universiti Putra Malaysia	EC5305
	Track 4: Natural resource and nature positive system transformation	Moderator: Dr. Piya Wongpit, National University of Laos	EC5205
12.00-13.00	Lunch Break		EC5726
13.00-14.30	Track 5: Consumer behavior	Moderator: Dr. Theingi Myint, Yezin Agricultural University	EC5302
13.00-14.30	Track 6: Agribusiness and sustainable management	Moderator: Dr. Hajah Rose Abdullah, Universiti Islam Sultan Sharif Ali	EC5205
14.30-15.00	Coffee Break		
15.00-16.30	Track 7: Food and nutrition security	Moderator: Dr. Nguyen Phuong Le, Vietnam	EC5302



Program agenda

Date/time	Activity/Speaker	Facilitator/moderator	Location
		National University of Agriculture	
15.00-16.30	Track 8: Sustainable food consumption	Moderator: Dr. Julieta Delos Reyes, University of Philippines Los Banos	EC5205
16.30-16.45	Best paper award announcement Awards presented by Dr. Petipong Pungbun Na Ayudhya, President of the Agricultural Economics Society of Thailand Under Royal Patronage EC5205	Moderator: Dr. Nopasom Sinphurmsukskul, Kasetsart University	EC5205



Program agenda

Track 1: Towards sustainable production Moderator: Dr. Pham Le Thong, Can Tho University

EC5302

Eddy Silamat	Economic efficiency of using production factors in people's coffee plantation business using a strip system and grafting in Bengkulu Province	Department of Resource and Environmental Economics	IPB University
Mark Buda	Cost-Efficiency of Small and Semi-Commercial Broiler Farms in Peninsular Malaysia	Department of Agribusiness and Bioresource Economics	Universiti Putra Malaysia
Ei Thandar Lin	Economic Analysis of Direct Seeded Rice Production in Zeyarthiri Township, Nay Pyi Taw	Department of Agricultural Economics	Yezin Agricultural University
Erwin E Torres	Technical and Economic Analysis of Technological Progress in the Pili (Canarium ovatum, Engl.) Industry in the Bicol Region, Philippines	Department of Agriculture and Applied Economics	University of Philippines Los Banos

Track 2: Resilience of food system Moderator: Dr. Lukytawati Anggraeni Putra, IPB University

EC5205

Deni Lubis	Determinants of food waste behaviors on Muslim generation z in Padang city, Indonesia	Faculty of Economics and Management	IPB University
Reymond Denver Q. Buenaseda	Determinants of Using Cold Storage Technology: Insights from Onion Farmers in Bongabon and San Jose City, Nueva Ecija, Philippines	Department of Agricultural and Resource Economics	Kasetsart University
Muhd Afif Rusydi Hj Muhd Kartolo	The Potential of Vertical Farming in Brunei Darussalam	Faculty of Agriculture	Universiti Islam Sultan Sharif Ali



Program agenda

Abigail T. Lat	An Assessment of the Economic Effect of Value Adding Activities in the Production and Marketing System of Salt in Ilocos Norte, Philippines: The Case of Pagnasahan Norte Agas Asin Association	Department of Agribusiness Management and Entrepreneurship	University of Philippines Los Banos
Track 3: Coping with vulnerability and risk Moderator: Dr. Mark Buda, Universiti Putra Malaysia EC5302			
Xiong Zheng	Structural Price Fluctuation Caused by Oil Price Variation in China's Mutton and Beef Market	Department of Social Science and Management, Faculty of Humanities, Management and Science	Universiti Putra Malaysia
Bates M. Bathan	Spatial Price Transmission in the Retail Rice Markets of the Philippines	Department of Agricultural and Resource Economics	Kasetsart University
Rhemaneeeta Allan	Cointegration Analysis of the World's Black Pepper Export Market among Major Producers	Institute of Ecosystem Science Borneo	Universiti Putra Malaysia
Le Van De	Attitudes toward Risk and Optimal use of Inputs in Maize Production in the Mekong Delta, Vietnam	Faculty of Rural Development	Can Tho University
Track 4: Natural resource and nature positive system transformation Moderator: Dr. Piya Wongpit, National University of Laos EC5205			
Aye Yamone Htwe	Study on Marketable Rice Varieties, Strength, Weakness of Rice Marketing and Value Added Products in Nay Pyi Taw Union Territory, Myanmar	Department of Agricultural Economics	Yezin University



Program agenda

Lukytawati Anggraeni	The Impact of Climate Change on Indonesian Rice and Coffee Sectors	Department of Economics, Faculty of Economics and Management	IPB University
Daniza Mae C. Oco	Valuation of Reef Tourism: A Preliminary Review and Lessons Learned for a Study in the Philippines	Department of Agriculture and Applied Economics	University of Philippines Los Banos
Wini Rismawati	Economic Valuation of Water Provisioning Services in the Recharge Area of Ciburial Spring, Bogor Regency	Resource and Environmental Economics	IPB University
Track 5: Consumer behavior Moderator: Dr. Theingi Myint, Yezin Agricultural University			EC5302
Htet Marlar Aye	Per Capita Fish Consumption in Nay Pyi Taw Union Territory, Myanmar	Department of Agricultural Economics	Yezin Agricultural University
Chan Myae Lwin	Healthy Rice Consumption Behaviour in Nay Pyi Taw, Myanmar	Department of Agricultural and Resource Economics	Kasetsart University
Muhammad Mu'az Bin Mahmud	Consumers' perceptions towards purchasing organic food in Klang valley, Malaysia	Faculty of Agriculture	Universiti Putra Malaysia
Vu Viet Trung	Consumers' Self-Provisioning of Vegetables in Urban Vietnam and Maslow's Hierarchy of Needs	Department of Agricultural Economics	Vietnam National University of Agriculture



Program agenda

Track 6: Agribusiness and sustainable management Moderator: Dr. Hajah Rose Abdullah, Universiti Islam Sultan Sharif Ali EC5205

Yan Lin Aung	SWOT Analysis of Myanmar Indigenous Chicken (MIC) Enterprises in Nay Pyi Taw, Myanmar	Department of Agricultural Economics	Yezin Agricultural University
Nguyen Thi Hai Ninh	Factors Influencing Access to Formal Credit by Pottery Households: Case Study in Bat Trang Village, Hanoi, Vietnam	Faculty of Economics and Rural Development	Vietnam National University of Agriculture
Hani Ariffin	Bio-fertilizers from Food Wastes for Sustainable Agriculture in Brunei Darussalam	Faculty of Agriculture	Universiti Islam Sultan Sharif Ali
Oraphan Pradit	Social Return on Investment of Chiang Mai's Urban Pesticide-free Vegetable Production System Development Project	Department of Agricultural Economy and Development	Chiang Mai University
Le Thi Thanh Loan	Investigating factors influencing scores of the sustainable rice platform (SRP) standard in rice cultivation: A case study in an Giang Province, Vietnam	Faculty of Economics and Rural Development	Vietnam National University of Agriculture

Track 7: Food and nutrition security Moderator: Dr. Nguyen Phuong Le, Vietnam National University of Agriculture EC5302

Dian Verawati Panjaitan	Women as headed and its impact on household food security	Department of Economics	IPB University
Khaysy Srithilat	Food and Nutrition Security Vulnerability to the Don Sahong Hydropower Dam	Faculty of Economics and Business Management	National University of Laos



Program agenda

Quennie Ann B. Durian	Household Food Security, Diet Diversity, and Nutritional Status of Preschool Children (36 to 59 Months) of Fishing Households from the Seven Lakes in San Pablo City, Laguna, Philippines	Institute of Human Nutrition and Food	University of Philippines Los Banos

Track 8: Food system and innovation Moderator: Dr. Julieta Delos Reyes, University of Philippines Los Banos EC5205

Thi Thi Soe	Drinking Water and Beverage Intake after COVID-19: Case Study in Nay Pyi Taw Council Area, Myanmar	Department of Agricultural Economics	Yezin Agricultural University
Piya Wongpit	Innovation Models in Agriculture and Rural Development in the Lao PDR	Faculty of Economics and Business Management	National University of Laos
Tran Thi Nhu Ngoc	Multifunctionality of Farming Systems: A Case Study in Hanoi Peri- urban, Vietnam	Department of Agricultural Economics and Policy	Vietnam National University of Agriculture

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