TECHNICAL EFFICIENCY AND RISK OF PINEAPPLE PRODUCTION AMONG SMALLHOLDERS IN JOHOR, MALAYSIA

By

MUHAMAD ZAHID BIN MUHAMAD

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of Doctor of Philosophy

February 2023

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DEDICATION

This thesis is dedicated to

My parents, my wife, my lovely kids, my parents-in-law, my family:

With love, respect and a bunch of memories
Indeed, we belong to Allah and indeed to Him we will return.

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Doctor of Philosophy

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Chairman : Professor Datuk Mad Nasir bin Shamsudin, PhD
Faculty : Agriculture

Pineapple is one of the most important crops in Malaysia and government recognizes its potential for exploitation. To that end, increasing pineapple production through improvement in its yield seems to be a reliable approach to achieve the Malaysia Pineapple Industry Board's agency yield target of 64 metric tonnes/ha in 2020. Efforts are being focused on Johor as the largest pineapple producing state (54%) in Malaysia which has the potential to achieve the yield target, with the government supporting smallholder production capacity. However, despite the various governmental support, pineapple production is hampered by the lower yield compared to the yield target. In 2020, average national pineapple yield was roughly 22.9 metric tonnes/ha. Since at a current technology, the yield is normally associated with the level of input use, the low pineapple yield was potentially caused by the technical inefficiency in the input use. The production inputs are essential to pineapple farming, which is likely to result in output variability (risk) and inefficiency. This indicates that the empirical models for measuring technical efficiency need to consider the element of production risk associated with inputs in pineapple production.

This research aims to shed light on the possible causes of pineapple production fluctuation being experienced by pineapple smallholders in Johor state in recent years. The gap between observed output and achievable output presents an opportunity for an increment in output which offers the inspiration for this study as it is concerned with examining the technical efficiency on pineapple production. The main objective of this study is to determine technical efficiency and production risk of smallholder pineapple production in Johor as two possible sources of the production variability. The specific objectives were to estimate the technical efficiency of smallholders' pineapple production; to analyse production risks with respect to the inputs levels of smallholders' pineapple production; and to determine influencing factors that affect the technical efficiency of smallholders' pineapple production. Data from a total of 290 randomly selected smallholder pineapple farms in Johor by using multistage sampling procedure. The research employed purposive sampling to select districts in Johor based on their relative importance in pineapple production and a systematic random sampling method to acquire random samples. The data for the study were collected from the pineapple smallholders in Johor from June till December 2021. The study employed stochastic frontier production function model (SFA) with flexible risk specification for parametric approach, and data envelopment analysis (DEA) for non-parametric approach without accounting for production risk in order to depict more holistic feature of pineapple farms efficiency in Johor.

For the first objective, technical efficiencies results of smallholder pineapple producers were compared between SFA and DEA techniques. Specifically, the average efficiency score of SFA was 68.1%, implying that the farmers in the study area were technically inefficient. On the other hand, the result of DEA technical efficiency score was 96.0%, also, implying that the pineapple farmers were technically inefficient. For the second objective, pineapple suckers were found to be risk reducing input while fertilisers and hormones were risk increasing inputs. By implication, it shows that risk-averse farmers are expected to use more suckers in the study area. The results also revealed that the mean output was positively influenced by suckers, fertiliser, agrochemicals, labour and hormone. For the third objective, several characteristics of farm operators such as demographics variables (farming experience); and institutional variables (extension contact and seminar participation); were found to have significant effects on the technical inefficiency of pineapple production in the study area.

The study concludes that the trans-log production function was the best fit for the data for estimation of farmers' technical efficiency as the analysis recorded that technical efficiency enhances the variability of pineapple production in the study area. The model estimates showed that production risk contributes considerably to the variability of pineapple production levels. Findings of this research show that output variability is primarily explained by technical inefficiency and production risk. It is recommended that relevant government agencies should ease the accessibility to extension visits, to hold seminars and promote the sharing of knowledge by experienced farmers, which could enlighten other farmers towards improving their production volumes. Furthermore, policy strategies aiming at improving technical efficiency should emphasise effective and efficient use of existing inputs among pineapple smallholders. The outcome of technical efficiency and production risk estimation have indicated the level of utilisation of the present technology used in the production process as well as rooms for improvement that can be translated to better income and livelihood among the smallholders.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

KECEKAPAN TEKNIKAL DAN RISIKO PENGELUARAN NENAS DI KALANGAN PEKEBUN KECIL DI JOHOR, MALAYSIA

Oleh

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Nanas merupakan salah satu tanaman terpenting di Malaysia dan kerajaan mengiktiraf potensinya untuk dieksploitasi. Dalam usaha untuk meningkatkan pengeluaran nanas, peningkatan hasil pengeluarannya merupakan pendekatan yang boleh diambil untuk mencapai sasaran hasil yang dtetapkan oleh Lembaga Perindustrian Nanas Malaysia iaitu sebanyak 64 tan metrik/ha pada tahun 2020. Usaha sedang ditumpukan kepada Johor sebagai negeri pengeluar nanas terbesar (54%) di Malaysia yang berpotensi mencapai sasaran hasil, melalui pelbagai sokongan kerajaan kerajaan dalam meningkatkan kapasiti pengeluaran pekebun kecil. Walau bagaimanapun, walaupun diberikan pelbagai sokongan kerajaan, pengeluaran nanas dihalang oleh hasil yang lebih rendah berbanding denga sasaran hasil. Pada tahun 2020, purata hasil nanas negara adalah kira-kira 22.9 tan metrik/ha. Pada kadar penggunaan input semasa, hasil biasanya dikaitkan dengan tahap penggunaan input, dan hasil nanas yang rendah berpotensi disebabkan oleh ketidakcekapan teknikal dalam penggunaan input.

Penyelidikan ini bertujuan untuk mencari punca turun naik pengeluaran nanas yang dialami oleh pekebun kecil nanas di negeri Johor sejak beberapa tahun kebelakangan ini. Jurang antara pengeluaran yang diperolehi dan sasaran pengeluaran menjadi tumpuan kajian kajian ini kerana ia berkaitan dengan mengkaji kecekapan teknikal pengeluaran nanas. Objektif utama kajian ini adalah untuk menentukan kecekapan teknikal dan risiko pengeluaran pengeluaran nanas pekebun kecil di Johor sebagai dua kemungkinan sumber kebolehubahan pengeluaran. Objektif khusus adalah untuk menganggar kecekapan teknikal pengeluaran nanas pekebun kecil; untuk menganalisis risiko pengeluaran berkenaan dengan tahap input pengeluaran nanas pekebun kecil; dan untuk menentukan faktor yang mempengaruhi yang kecekapan teknikal pengeluaran nanas pekebun kecil. Data daripada sejumlah 290 pekebun kecil nanas yang dipilih secara rawak di Johor telah dikumpul dan digunakan untuk analisa. Kajian ini menggunakan kaedah persampelan bertujuan untuk memilih daerah di Johor berdasarkan kepentingan relatif dalam pengeluaran nenas dan kaedah sampel rawak sistematik untuk

mendapatkan sampel rawak. Data kajian diperoleh daripada tinjauan yang dijalankan bagi tempoh musim penanaman nanas 2019/2020. Kajian ini menggunakan model fungsi pengeluaran sempadan stokastik (SFA) dengan spesifikasi risiko fleksibel untuk pendekatan parametrik, dan analisis penyampulan data (DEA) untuk pendekatan bukan parametrik tanpa mengambil kira risiko pengeluaran untuk menggambarkan ciri kecekapan ladang nanas yang lebih holistik di Johor.

Untuk objektif pertama, hasil kecekapan teknikal pengeluar nenas pekebun kecil telah dibandingkan antara teknik SFA dan DEA. Secara khusus, purata skor kecekapan SFA adalah 68.1%, menunjukkan bahawa petani di kawasan kajian tidak cekap secara teknikal. Sebaliknya, hasil skor kecekapan teknikal DEA adalah 96.0%, juga menunjukkan bahawa petani nenas tidak cekap secara teknikal. Untuk objektif kedua, sulur nanas telah didapati sebagai input yang mengurangkan risiko sementara baja dan hormon adalah input yang meningkatkan risiko. Secara implikasi, ia menunjukkan bahawa petani yang menghindari risiko disyorkan menggunakan lebih banyak sulur di kawasan kajian untuk mengurangkan risiko pengeluaran. Hasil kajian juga mendapati bahawa purata output dipengaruhi secara positif oleh sulur nanas, baja, agrokimia, buruh dan hormon. Untuk objektif ketiga, beberapa ciri-ciri pengusaha ladang seperti pembolehubah demografi (pengalaman bertani); dan pembolehubah institusi (hubungan dengan agen pengembangan dan penyertaan seminar); didapati mempunyai kesan yang signifikan terhadap ketidakcekapan teknikal pengeluaran nenas di kawasan kajian.

Kajian ini menyimpulkan bahawa fungsi pengeluaran trans-log adalah paling sesuai untuk data penilaian kecekapan teknikal petani kerana analisis menunjukkan bahawa kecekapan teknikal meningkatkan variasi pengeluaran nenas di kawasan kajian. Anggaran model menunjukkan bahawa risiko pengeluaran memberikan sumbangan yang signifikan kepada variasi pengeluaran nenas. Hasil kajian ini menunjukkan bahawa kebolehubahan output terutamanya dijelaskan oleh ketidakcekapan teknikal dan risiko pengeluaran. Agensi kerajaan yang berkaitan disyorkan memudahkan akses lawatan pengembangan, mengadakan seminar dan mempromosikan perkongsian pengetahuan oleh petani berpengalaman, yang boleh membantu petani lain dalam meningkatkan jumlah pengeluaran mereka. Selain itu, dasar dan strategi untuk meningkatkan kecekapan teknikal harus menekankan penggunaan input yang efektif dan cekap di kalangan pekebun kecil nanas. Hasil penilaian kecekapan teknikal dan risiko pengeluaran telah menunjukkan tahap penggunaan teknologi semasa yang digunakan dalam proses pengeluaran serta ruang untuk peningkatan yang boleh diterjemahkan menjadi pendapatan dan kehidupan yang lebih baik di kalangan pekebun kecil.

ACKNOWLEDGEMENTS

In the name of Allah, the Most Compassionate and the Most Merciful

I begin by expressing my gratitude to Almighty Allah SWT for granting me the health, strength, and passion to pursue my academic endeavours and complete my Ph.D. program. Through my faith, I have found solace and guidance during the challenges of my research journey. This accomplishment would not have been possible without the support of many individuals and institutions.

Firstly, I would like to extend my deepest appreciation to my supervisor, Professor Datuk Dr. Mad Nasir bin Shamsudin, for his invaluable guidance, wisdom, patience, and support throughout my research. His unwavering determination and passion have inspired me to be a great academician. His expertise, encouragement, and feedback have been instrumental in shaping the smooth progress of my research. Thank you for being patient with me and for providing me with the necessary tools and resources to succeed in this challenging journey.

I would also like to express my gratitude to my co-supervisors, Assoc. Prof. Dr Nitty Hirawaty binti Kamarulzaman and Assoc. Prof. Dr Nolila binti Mohd Nawi, for their generous suggestions, encouragement, and support. Additionally, I extend my special gratitude to my external co-supervisor, Dr. Jamaliah binti Laham from the Malaysian Pineapple Industry Board, who has assisted me significantly in all aspects of this research. I am also thankful to all the lecturers in the Department of Agribusiness and Bioresources Economics, Faculty of Agriculture, Universiti Putra Malaysia, for imparting their knowledge and expertise to me without reservation. Furthermore, I would like to extend my sincere appreciation to my PhD examiners for their valuable feedback and contributions to this research.

I am deeply grateful to the Ministry of Higher Education, and my employer, Universiti Teknologi MARA, for their support in completing this study. The contributions of these institutions were pivotal in ensuring that I had access to the necessary resources, facilities, and funding to carry out my research.

I extend my sincere thanks to all the respondents who participated in this study. Without their valuable inputs, this study would not have been possible. I am also grateful to all the staff in the Malaysian Pineapple Industry Board and the Department of Agriculture who have been patient and helpful in assisting me with my research.

Most importantly, I am extremely thankful to my family for their unwavering support and trust. I express my gratitude to my parents, Muhamad bin Mahmood and Che Rahmah binti Mustapha, for their love and support. I equally thank my late father-in-law, Hamdan bin Kasim, and mother-in-law, Aishah binti Osman, who have equally contributed and sacrificed a lot. My father-in-law passed away one day prior to my viva voce, but his support and contribution will always be remembered. The closest to my heart, who has always been my strong supporter, my soulmate, my dearest wife Nur Liyana binti Hamdan, thank you for everything. My sincere thanks also extend to my wonderful sons, Muhammad Aydan Rifqi and Muhammad Adlan, for their patience, kindness, and moral support during my study. Their unwavering support has been my source of strength throughout this challenging journey. My siblings have also provided invaluable support, encouragement, and love throughout my PhD journey. Their unwavering support has been my source of strength throughout this challenging journey.

I would also like to express my heartfelt thanks to my wife as well as my aunt, Zaidah binti Mustapha, who has been willing to be my guarantor throughout my PhD journey. Their unwavering support and generosity have been instrumental in helping me achieve my academic goals. Their belief in my abilities has given me the confidence to pursue this challenging journey. I am truly grateful for their love, encouragement, and unwavering support. Thank you for being an important part of my academic journey.

Finally, I would like to express my heartfelt gratitude to my dear friends who have been an integral part of my academic journey. Their continuous support, encouragement, and camaraderie have made this journey not only academically enriching but also personally fulfilling. Their shared experiences, struggles, and triumphs have helped me navigate through the challenges of pursuing a PhD. Their valuable insights, feedback, and constructive criticism have been instrumental in refining my research and enhancing the quality of my thesis. I am deeply grateful to all of them, including Harun, Shah Rol Hussain, Nik Rozana, Chanoknan Srilapat, Dr Yong, Dr Muhyiddin, Saida, Tarmizi, Dr Khairi, Dr Zuli, Dr Normadiyana, Dr Shaliza, Dr Nurul Jawahir, Farhan, Firdaus, Taufiq, Edzahar, Nazrin Sufi, and my fellow friends who have been a part of this journey. Thank you for your unwavering support and for making this academic pursuit a truly memorable and rewarding experience.

I believe that the journey towards a PhD degree is not merely a solitary pursuit, but it is a collaborative effort, where various individuals and institutions have played a pivotal role in helping me achieve my goals. During the course of my research, I have learned that true academic success is not only measured by the final output of the research, but also by the relationships formed along the way. The kindness, support, and encouragement from my family, friends, colleagues, and mentors have made a significant impact on my academic and personal growth.

As I move forward in my academic and professional journey, I will always cherish the knowledge, wisdom, and experiences gained during my PhD program. I am confident that the lessons learned and the relationships formed during this period will continue to shape my perspectives and contribute to my future endeavours.

Once again, I express my heartfelt gratitude to all those who have contributed to my research and supported me throughout my PhD journey. May Allah SWT bless you all with happiness, health, and success in your own pursuits.

This thesis was submitted to the Senate of the Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Doctor of Philosophy. The members of the Supervisory Committee were as follows:

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AE	Allocative Efficiency
BOT	Balance of Trade
Coeff.	Coefficients
CRS	Constant Return to Scale
DAN	National Agrofood Policy (*Dasar Agromakanan Negara*)
DEA	Data Envelopment Analysis
DEAP	Data Envelopment Analysis Programme
DMU	Decision Making Units
DOSM	Department of Statistics Malaysia
DPN	National Agriculture Policy (*Dasar Pertanian Negara*)
DRS	Decreasing Return to Scale
ECER	East Coast Economic Region
EE	Economic Efficiency
EPP	Entry Point Projects
EPU	Economic Planning Unit
FAOSTAT	Food and Agriculture Organisation Statistic
GAP	Good Agricultural Practices
GDP	Gross Domestic Product
GNI	Gross National Income
HVC	High Value Commodities
ICT	Information and Communication Technology
IRS	Increasing Return to Scale
MAFI	Ministry of Agriculture and Food Industries
MARDI	Malaysian Agricultural Research and Development Institute
MLE	Maximum Likelihood Estimator

MOF	Ministry of Finance
MP	Malaysia’s Plan
MPIB	Malaysian Pineapple Industry Board
NAFP	National Agrofood Policy
NAP	National Agricultural Policy
NBOS4	National Blue Ocean Strategy 4
NKEA	National Key Economic Area
OLS	Ordinary Least Square
PEMANDU	Performance Management and Delivery Unit
PRE	Economic Stimulus Package *(Pakej Rangsangan Ekonomi)*
R&D	Research and Development
RM	Ringgit Malaysia
RMK	Malaysia Plans (*Rancangan Malaysia*)
RTS	Return to Scale
SFA	Stochastic Frontier Analysis
TFNET	International Tropical Fruits Network
TE	Technical Efficiency
TI	Technical Inefficiency
USDA	United States Department of Agriculture
VRS	Variable Return to Scale

CHAPTER 1

INTRODUCTION

This chapter documents a general background of the pineapple industry in Malaysia to establish the context of this study. It is divided into sections, each of which details crucial component of the pineapple industry that is relevant to this study. The first section discusses the structure of the pineapple industry disaggregated under production and consumption. Discussions of issues and challenges associated with pineapple production are also included. These are proceeded by a statement of the research problem, the research questions, research objectives, the significance of the study, and an overview of the thesis structure are sequentially outlined.

1.1 Pineapple Industry in Malaysia

The agricultural industry contributes significantly to Malaysia's economic development by generating income and reducing poverty, particularly for those living in rural regions. Malaysia’s agriculture production sector is characterised by estate and smallholders sub-sectors, of which the former is heavily commercialised and typically controlled by publicly traded corporations, private businesses, and government land development organisations. The independent smallholders sub-sector on the other hand, is less commercialised and requires effective management by the authorities in order to ensure that all necessary farm inputs provided for efficient utilisation to generate optimum production. Since pineapple canning industry in Malaysia started in 1888, apart from producing and exporting industrial commodities like oil palm and rubber, the pineapple industry has been Malaysia's oldest agricultural sector (MPIB, 1988). The pineapple industry experienced a significant expansion in the years prior to World War II in 1941, after which it transitioned into a secondary crop (MPIB, 1988).

The pineapple industry plays a vital role in the Malaysian agrifood industry. Given its continued progress over the years, factored mainly by favourable production environment and supporting government policies, Malaysia has been able to develop a competitive advantage internationally (Mazdek et al., 2017). The Government has created numerous initiatives and frameworks through the Malaysian Pineapple Industry Board (MPIB) and the Ministry of Agriculture and Food Industries (MAFI) to facilitate the growth of the pineapple industry throughout the value chain in its efforts to develop a more productive and competitive agricultural sector, particularly from the Twelfth and Eleventh Malaysia Plan (Economic Planning Unit, 2021; 2015). The MPIB, a statutory body of MAFI, was established in 1957 in accordance with the *Ordinan Perusahaan Nanas 1957* (Revised 1990) and is responsible for managing and coordinating the Malaysian pineapple industry (MPIB, 2019c).

1.1.1 Production of Pineapple

1.1.1.1 Planted Area

Beyond serving as a food source, pineapples have an important economic function in Malaysia by providing farmers with access to a vital source of income and creating new job opportunities (Dardak, 2017). Although pineapple farms are common throughout Malaysia, over the years, there have been fluctuations in the area used for pineapple cultivation, as shown in Table 1.1. To guarantee a stable supply for the fresh and canned market, MPIB has planned and taken significant actions. In 1978, pineapple cultivations for estates and smallholders proliferated rapidly in West Johor's peat soil, supported by the West Johor Development Project (MPIB, 2018).

Table 1.1 : Planted Area, Total Production and Average Pineapple Yield in Malaysia, 1997-2020

Year	Planted Area (ha)	Production (mt)	Yield (mt/ha)
1997	7,580	119,825	15.81
1998	8,106	92,035	11.35
1999	7,271	82,571	11.36
2000	8,533	249,135	29.20
2001	9,980	288,938	28.95
2002	10,000	310,000	31.00
2003	10,000	320,000	32.00
2004	10,300	330,000	32.04
2005	14,145	356,000	25.17
2006	15,312	299,328	19.55
2007	15,586	316,219	20.29
2008	15,809	384,673	24.33
2009	15,457	357,654	23.14
2010	14,921	331,082	22.19
2011	15,650	309,330	19.77
2012	9,827	335,488	34.14
2013	10,317	352,638	34.18
2014	14,700	412,665	28.07
2015	13,149	452,020	34.38
2016	13,734	391,714	28.52
2017	16,654	434,812	26.11
2018	14,608	382,811	26.21
2019	15,849	373,022	23.54
2020	14,071	323,421	22.99

[Source: MPIB (2020b, 2019a, 2012)]

Since 2005, the industry has prioritised fresh pineapple over canning, attributable to strategic planning by MPIB. As a result, the pineapple planted area grew progressively until 2011. The overall area size increased by 50 per cent in 2014, reaching 14,700 hectares, though the number of pineapple plantations in Malaysia declined from 2011 to 2012. Following this, Malaysia's pineapple area grew by 21.2 per cent between 2016 and 2017. However, this growth was not maintained because there was an immediate decline of 12.3 per cent in 2018 and a further by 11 per cent decline in 2020. As of the year 2020, the area planted with pineapples was estimated to be 14,071 hectares.

There are some probable reasons behind this decline in the area planted. One reason is that smallholders typically cultivate pineapple as an intercrop with oil palm or rubber in plantation systems (Othman et al., 2011). Such as system could hinder constant cultivation, especially because these smallholder farmers sometimes favour the cultivation and management of oil palm and rubber versus pineapple, consequently causing a significant variation in the total planted area between 1990 to 2008 (Othman et al., 2011). The rise in the area from 2018 to 2019 relates to a number of states, including Sarawak, Pahang, and Selangor, which invested in the conversion of vacant land for pineapple croppings. This expansion in the pineapple area was aided by enhanced participation from the estate sector, which in turn was influenced by the local market's approval of the MD2 pineapple variety and high export demand for Malaysian fresh pineapple. Unfortunately, due to a competitive use of commodity crops such as oil palm, rubber, cocoa, pepper, and tobacco, the pineapple planted area decreased in 2020. Additionally, pineapple crops grown in conjunction with other crops have not been retained for the following cycle of cultivation (MPIB, 2020).

According to Table 1.2, Johor has the largest planting areas for pineapple (7,610.22 hectares), accounting for 54 per cent of all pineapple land areas in the nation (14,070.85 hectares) in 2020. The pineapple land allotted to other states and their proportions of the total areas is Sarawak (18 per cent), Sabah (7.5 per cent), Kedah (4.6 per cent), Pahang (4.5 per cent), Selangor (4 per cent), Perak (2 per cent), Pulau Pinang (1.7 per cent), Kelantan (1.6 per cent), Terengganu (1.0 per cent), Negeri Sembilan (0.52 per cent), Melaka (0.3 per cent) and Perlis (0.04 per cent).

Table 1.2 : Distribution of Pineapple Land Areas in Hectares in Malaysia, 2020

State	**Planted area (ha)**	**% of Total cultivated areas**
Johor	7,610.22	54.09
Sarawak	2,521.51	17.92
Sabah	1,055.30	7.50
Kedah	650.49	4.62
Pahang	632.75	4.50
Selangor	597.12	4.24
Perak	272.64	1.94
Pulau Pinang	235.84	1.68
Kelantan	225.20	1.60
Terengganu	144.30	1.03
Negeri Sembilan	72.30	0.51
Melaka	47.27	0.34
Perlis	5.91	0.04
Total	**14,070.85**	**100**

[Source: MPIB (2022b)]

Figure 1.1 depicts the country's fluctuating trend in the area under cultivation. Both the planted area and the output volume are negatively impacted by this shifting pattern. Although the nation's pineapple production was relatively stagnant from 2006 to 2011, it started to expand again in 2012 and continued to do so until 2018. Larger variability in pineapple yields have contributed in the fluctuations that have occurred in pineapple output over time (1999, 2006, 2011, and 2016). Recent data indicates that pineapple production continued to decline by 12 per cent in 2020 compared to production levels in 2019.

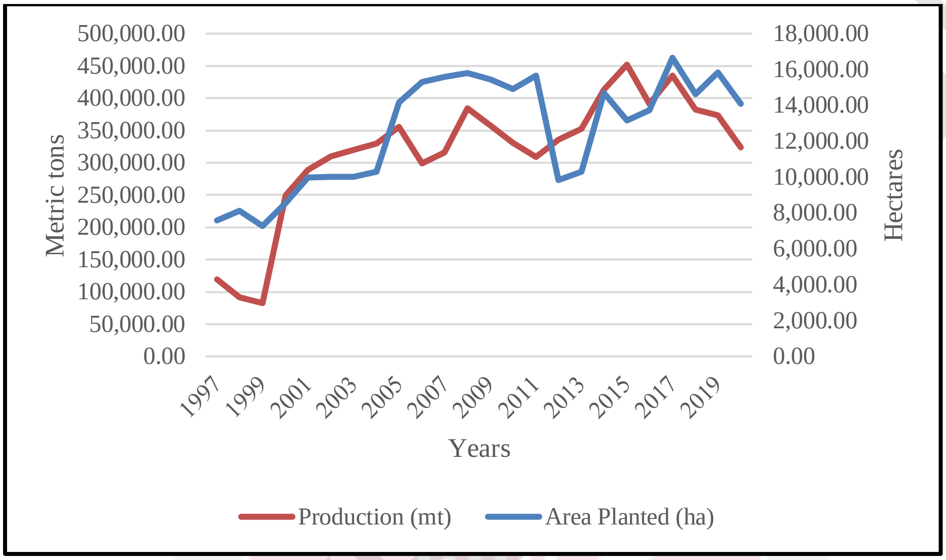

Figure 1.1 : Production (tons) and Area Planted (ha) in Malaysia, 1997-2020
[Source: MPIB (2012, 2019a, 2020b)]

1.1.1.2 Cultivars of Pineapple

In the late 1970s and 1980s, Masmerah variety was widely cultivated for canning (Chan, 2000). Later, this variety was obsolete as Gandul has become the main canning pineapple variety. This variety is from Singapore-Spanish group and has a good adaptability on peat soil and show good yields. The uniqueness of this variety for canned product is to its golden flesh colour attribute (Chan, 2000). This variety has been widely grown among estates and smallholders (MPIB, 2005, 1999). In 1996, Malaysian Agricultural Research and Development Institute (MARDI), the responsible authority for agricultural research and development, successfully created a new variety for the fresh market known as Josaphine, a blend of Johor Pineapple and Sarawak Pineapple, in recognition of the significance of pineapple to the nation (Zainol et al., 2018). The variety has successfully increased fresh pineapple exports to well-established markets like Singapore and has broadened the market reach of Middle Eastern nations. Because of its popularity, private industrial involvement in its cultivation has increased, as seen by the growth trend between 1990 and 2008 (Jaji et al., 2018). In 2008, MPIB successfully imported the premium MD2 variety suckers from the Philippines, which has dominated 70 per cent of the global pineapple market, with the assistance of the Ministry of Agriculture and the Johor Tropical Product Company (JTP) (MPIB, 2018). Since then, this variety has gained popularity in Malaysia, and as a result, community participation in the pineapple farming sector has expanded as a result of the industry's high revenue creation.

In general, several cultivars were launched in Malaysia to promote the market, including Nanas Johor, Masmerah, Gandul, Josapine, N36 and MD2 (MPIB, 2018). As indicated in Table 1.3, producers in Malaysia have planted and grown fourteen varieties of pineapple on a commercial basis, either on a small or large scale. These varieties are officially registered by the Department of Agriculture (DoA). The Plant Variety Department's suggested variety is AC9 (MD2) (DOA, 2021a). However, the five varieties which are popularly and commercially cultivated are AC1 (Moris), AC3 (Gandul), AC5 (Josapine), AC8 (N36) and AC9 (MD2).

Table 1.3 : Variety of Pineapples Registered by the DoA in Malaysia

No.	Variety Registration No.	Variety	Year Registered
1	AC1	Moris	2013
2	AC2	Sarawak	2013
3	AC3	Gandul	2013
4	AC4	Maspine	2013
5	AC5	Josapine	2013
6	AC6	Yankee	2013
7	AC7	Moris Gajah	2013
8	AC8	N36	2013
9	AC9	MD2	2013
10	AC10	View of Sunset	2017
11	AC11	Madu Kaca	2018
12	AC12	Keningau Diamond	2019
13	AC13	Cobek	2021
14	AC14	Crystal Honey	2022

[Source: DoA (2022; 2021b)]

1.1.1.3 Price of Pineapple

The main varieties on the market are Josapine, Moris, and MD2. Referring to Table 1.4, the farm price of Moris has been increasing since 2011 up until 2020. The average farm price of Moris is RM1.30/kg. The variety with the highest farm price is MD2 due to its high market demand. From 2011-2020, the farm price for MD2 has averaged RM2.98/kg, though it generally trends downward. The retail price, on the other hand, fluctuated between RM 3.40 and RM 3.90/kg, except in 2012, where MD2 is retailed at its highest of RM 7.00/kg. The retail price of the Moris variety has followed a relatively consistent increasing pattern throughout the years.

Table 1.4 : Farm Price and Retail Price of Main Pineapple Varieties, RM, 2011-2020

Year	Farm Price			Retail Price		
	Josapine	Moris	MD2	Josapine	Moris	MD2
	(RM/pcs)	(RM/pcs)	(RM/kg)	(RM/pcs)	(RM/pcs)	(RM/kg)
2011	1.60	1.05	3.40	3.30	2.40	4.50
2012	1.90	1.20	3.50	3.60	2.00	4.50
2013	1.80	1.00	2.90	3.80	2.20	4.30
2014	1.85	1.00	2.80	3.90	2.50	4.20
2015	1.80	1.10	2.80	4.00	2.50	4.20
2016	1.73	1.30	2.75	2.90	1.90	3.85
2017	1.73	1.30	2.96	2.90	2.00	4.00
2018	1.73	1.50	2.96	2.90	2.17	4.00
2019	1.80	1.50	2.96	3.00	3.00	6.00
2020	1.80	1.50	2.96	3.50	3.00	6.00
2021	1.80	1.50	2.40	3.50	3.00	7.00

[Source: MPIB (2023; 2016)]

1.1.1.4 Yield of Pineapple

There has been a varying pattern in pineapple yield from 2000 to 2020 due to several factors, as demonstrated in

Figure 1.2. These include policies established by the government mandate through Malaysia Plans. Specifically, the Eighth Malaysia Plan (8^{th}-MP), which ran from 2001 to 2005, followed by the Ninth Malaysia Plan (9^{th}-MP) from 2006 to 2010, the Tenth Malaysia Plan (10^{th}-MP) from 2011 to 2015, and the Eleventh Malaysia Plan (11^{th}-MP) from 2016 to 2020, each of which included a different crop as its primary focus (EPU, 2015; 2011; 2006; 2001).

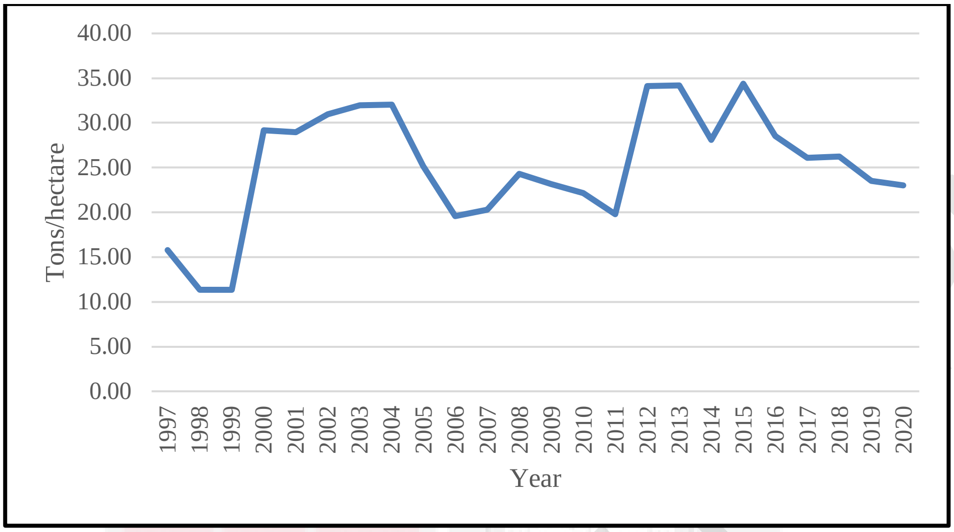

Figure 1.2 : Yield of Pineapple, 1997-2020
[Source: MPIB (2020b; 2019a; 2012)]

Pineapple cultivation has been selected as one of the eight locally grown fruits that are encouraged in the Third National Agricultural Policy Plan (DPN3), guided by the MAFI, which was effectively formulated from the Eighth Malaysia Plan period (2001 to 2005) (EPU, 2001; MAFI, 2010). Based on its commercial potential and value, the pineapple commodity was chosen to be developed in order to become a thriving industry at a more competitive, robust, and viable level in the domestic market as well as over a five-years period (2005 to 2010) in accordance with DPN3 goals (Hamid, 2010). From 2004 to 2010, smallholders' land area increased as a result of MAFI's strategic planning in the 8th MP, which was to increase the size of the pineapple area along with infrastructure, promoting the involvement of growers/entrepreneurs, and enhance more effective planting methods and product diversification. New regions are being established, productivity is increasing, and the issue of fruit shortages in factories is being addressed in the MPIB's long-term strategy (MPIB, 2016c). The Eleventh Malaysia Plan (11th MP) invested RM 104.25 million in the pineapple industry (EPU, 2015). The national budget has recently been increased to RM 137 million under the Twelfth Malaysia Plan (12th MP) (Hasan, 2022). With such funding, MPIB has been encouraging pineapple cultivation among farmers in an attempt to improve the income of pineapple smallholders.

1.1.2 Consumption of Pineapple

Pineapple is a popular indigenous fruit in Malaysia. Due to the relatively short production cycle which is 13 to 15 months, and depending on the pineapple variety planted, this crop is attainable and available year-round (Shamimi et al., 2017). The MAFI classifies pineapple as the principal fruit category and a High-Value Commodity

(HVC) since it has a lot of potentials to generate revenue for farmers and the nation (MAFI, 2021b).

Pineapples can be consumed in various forms such as fresh, canned, juiced or cooked. Young pineapple fruits are frequently used in religious ceremonies by the Chinese, especially during the festive season. Pineapple is commercially processed in Malaysia to produce canned pineapple and pineapple juice products. Additionally, pineapple can be used to create various foods with additional values, such as jam and pickles. The staples of the Malaysian pineapple industry include fresh pineapple items, canned pineapple, and pineapple juice (MPIB, 2020b).

1.1.2.1 Domestic Consumption

Fruit supply and demand are impacted by consumption trends in Malaysia (Dardak, 2017). Along with the quantity issue, pineapple consumption has advanced from speciality to mainstream. Because the domestic market is less competitive than the entry of pineapple from abroad, the local pineapple market has a favourable market space. This makes it possible for the local pineapple industry to seize control of the domestic pineapple market (DoA, 2001).

Uses of pineapple are increasing on a per capita basis due to factors including population growth and customer preferences (Abd-Halim, 2016) for natural-ingredients-based food items. For instance, as indicated in Table 1.5, the annual per capita consumption increased by two per cent, to 12.4 kg, between 2019 and 2018. According to Dardak (2017), the pineapple was Malaysia's second most popular fruit after bananas, and Malaysians consumed 10 kg of pineapple yearly.

Despite this, the consumption pattern per capita declined from 2015 to 2018 and then again in 2020. There has been a 27 per cent decrease in pineapple consumption per capita between 2015 (14.2) and 2018 (10.4). Although pineapple consumption per capita in Malaysia decreased, this trend was anticipated to be countered by the country's expanding population. Additionally, dietary patterns and income level changes are attributed to the decline in per-capita pineapple consumption (MPIB, 2020b). Today's health-conscious consumers are more focused on including fruits in their diets. The primary elements that influenced customer preferences for buying fruits were changes in lifestyle, income, and eating habits (Chen & Antonelli, 2020).

1.1.2.2 Export Demand

As indicated in Table 1.5, Malaysia's export trend generally encountered significant setbacks in her exports of pineapple from 2010 onwards. The decline in canned pineapple production by pineapple factories, which resulted from declining pineapple supply, is a major contributor to export volatility (Lin & Rahman, 2010). Another factor is the period's supply instability. This could be attributed to declining productivity among small-scale farmers, changing customer preferences, an emphasis on planting major commodities (such as oil palm and rubber), a reduction in pineapple farming, and macroeconomic instability. The declining trend in pineapple export is most notable from 2017 to 2020.

Table 1.5 : Consumption Per Capita, Domestic Consumption, Processed and Export Demand for Pineapple, 2010-2020

Year	Consumption per capita	Domestic		Processed		Export		Total
	kg/yr	mt	%	mt	%	mt	%	mt
2010	8.4	256,657	78	52,520	16	21,904	6	331,081
2011	10.71	235,054	76	56,117	18	18,160	6	309,331
2012	10.74	271,722	81	45,129	13	18,637	6	335,488
2013	11.84	298,296	85	36,762	10	17,580	5	352,638
2014	13.75	258,127	84	30,954	9	23,584	7	312,665
2015	14.2	403,569	89	28,171	6	20,279	5	452,019
2016	12.4	340,751	87	20,049	5	30,914	8	391,714
2017	12.1	423,260	91	17,399	4	21,116	5	461,775
2018	10.4	342,072	89	21,164	6	19,575	5	382,811
2019	12.4	340,003	91	15,167	4	17,852	5	373,022
2020	7.2	290,185	90	17,274	5	15,961	5	323,420

[Source: Department of Statistics Malaysia (2021); MPIB (2021b)]

As specified in Table 1.5, consumption per capita and domestic consumption exhibit inconsistent pattern. For example, in 2015, consumption per capita increased while domestic consumption decreased. This discrepancy could be due to various factors, including changes in population growth or shifts in demographic patterns. According to the United Nations, population growth rates can have a significant impact on consumption patterns, as higher population growth rates can lead to increased demand for goods and services (United Nations, 2019). The population of Malaysia has been growing steadily over the past few decades. According to data from the World Bank, the population of Malaysia increased from around 16.6 million in 1980 to approximately 32.9 million in 2020 (World Bank, 2021). This growth in population could be contributing to the divergent patterns observed in consumption per capita and domestic consumption in Table 1.5. This is supported by research conducted in Malaysia, which has found that population growth has been a key driver of increased demand for various agricultural products, including pineapple (Mohamed et al., 2018).

In particular, the urbanization of Malaysia has been a key factor in driving population growth and increasing demand for food products. The World Bank reports that Malaysia's urban population increased from approximately 10 million in 1990 to over 24 million in 2020, representing a significant shift in demographic patterns (World Bank, 2021). This urbanization has been accompanied by changes in lifestyle and eating habits, which could be contributing to the fluctuating patterns observed in pineapple consumption in Table 1.5.

Another possible factor to consider is changes in consumer preferences or behaviors. Research has shown that consumer preferences can fluctuate over time, leading to changes in the demand for specific goods and services (Ferrier et al., 2017). For example, if consumers become more health-conscious and seek out healthier snack options, this could lead to a decrease in pineapple consumption if it is perceived as less healthy compared to other fruits.

Additionally, the role of exports in driving overall pineapple demand cannot be overlooked. The stability of exports despite fluctuations in domestic consumption suggests that global demand and supply chains could be influencing overall trends in pineapple consumption. This is supported by research indicating that changes in global market conditions, such as shifts in demand or changes in trade agreements, can impact the agricultural industry and affect consumer choices (Barrett, 2019). Various factors could be contributing to the contradictory patterns observed in consumption per capita and domestic consumption in Table 1.5, including changes in population growth, consumer preferences, and global demand. Besides, the urbanization of Malaysia has been a key factor in driving population growth and increasing demand for food products, which could be influencing consumption patterns.

Considering that the export value of pineapple is expected to increase progressively, the Malaysian government has recognised pineapple as a new source of wealth for the nation in Malaysia's Budget Planning 2018 due to its potential (Othman, 2017). This came as Singapore accounted for 62.5 per cent of pineapple export in 2018 (MPIB, 2020b). Additionally, Malaysia has an excellent potential to surpass other countries as the world's top producers of fresh pineapples with a focus on exporting pineapple to the Middle East and China (BERNAMA, 2019). According to a report by the MPIB (2021b), Singapore (63.9 per cent), Egypt (13.8 per cent), the United Arab Emirates (8.2 per cent), China (6.9 per cent), Japan (3.9 per cent), and Saudi Arabia (0.8 per cent) are Malaysia's top export of pineapple destinations.

1.1.3 Producers of Pineapple

Most pineapple-producing nations rely mostly on smallholders and estates for pineapple production. The following section elaborates on the pineapple production system that is common among the estate and smallholder producers in Malaysia.

1.1.3.1 Estates

The Johore Pineapple Committee, which was founded to safeguard the pineapple industry, launched pineapple farming as estate in 1947 (MPIB, 2018). At the time, however, estate establishment was only permitted for businesses with canning factories and required at least 1,500 acres of planted pineapple estate. Since 2000, the focus on the pineapple industry has increasingly shifted from canning to fresh pineapple (Chan, 2000). Based on the survey report conducted by MPIB in 2015 (MPIB, 2015), Syarikat Peninsular Plantation Sdn Bhd was the only pineapple plantation estate with a canned processing facility. As of 2014, companies running as Private Limited Company (*Syarikat Sdn Bhd*) recorded the largest planting area with 5,514.10 hectares involving 39 company operators (MPIB, 2015). Employing the definition by MPIB, estates covering more than 40.47 hectares (100 acres) of pineapple cultivation or when pineapple cultivation is permitted and under valid ownership. The trend of hectarage by the estates was relatively stagnant from 2000 to 2011, while the yield reported by the estates showed a declining pattern between 2000 and 2011, which has since rebounded (Table 1.6).

Table 1.6 : Planted Area, Production, and Yield by Estates, 2000-2015

Year	Planted Area (ha)	Production (mt)	Yield (mt/ha)
2000	2,023	60,990	30.15
2001	2,023	57,310	28.33
2002	2,023	61,725	30.51
2003	2,023	64,254	31.76
2004	2,023	60,529	29.92
2005	2,428	66,191	27.26
2006	2,428	70,948	29.22
2007	2,428	57,498	23.68
2008	2,428	57,216	23.57
2009	2,428	55,794	22.98
2010	2,428	48,257	19.88
2011	2,752	52,052	18.91
2012	6,000	213,102	35.52
2013	3,506	202,998	57.90
2014	4,852	269,024	55.45
2015	10,064	278,699	27.69

[Source: MPIB (2015)]

1.1.3.2 Smallholders

According to the MPIB's definition (MPIB, 2021b), smallholders are those who cultivate pineapple on an area of less than 40.47 hectares (100 acres) where such cultivation is lawful and subject to legal ownership. A substantial amount of pineapple planted area was contributed by smallholder farmers where they control over 47 per cent of the country's pineapple production area (Salim, 2015). As of 2015, smallholders cultivated and managed approximately 4,636 hectares. Therefore, smallholders play a crucial role in the pineapple supply chain.

From 2000 to 2015, smallholder production in Malaysia was shaped like a bell curve (Table 1.7). Since 2009, the size of the pineapple planted area has decreased, mainly among smallholder farmers, who have reduced their planting acreage. One of the factors contributing to the reduction in planted land in this region is the switch of pineapple producers to the cultivation of oil palm (Jaji et al., 2018). Ageing and a shortage of new workers to replace ageing farmers are also among the causes of the decline in the number of pineapple farms. According to the MPIB's annual survey (MPIB, 2015), the middle-aged group between the ages of 41 and 60, accounting for 57.2 per cent of all smallholders in the pineapple business in 2014, followed by those 61 and older, who made up 25 per cent of all smallholders. The smallholders’ pineapple planted area, production and yield trend from 2000 to 2015 is displayed in Table 1.7.

Table 1.7 : Planted Area, Production, and Yield by Smallholders, 2000-2015

Year	Planted Area (ha)	Production (mt)	Yield (mt/ha)
2000	5,248	188,145	36.00
2001	6,510	231,628	36.00
2002	7,957	248,275	31.00
2003	7,977	255,746	32.00
2004	7,977	269,471	34.00
2005	7,872	273,809	34.78
2006	8,214	228,380	27.80
2007	9,253	258,721	27.96
2008	9,650	327,457	33.93
2009	9,953	301,860	30.33
2010	9,572	282,824	29.55
2011	8,726	257,279	29.48
2012	6,045	122,386	20.25
2013	6,320	149,640	23.68
2014	5,464	143,641	26.29
2015	4,636	173,320	37.39

[Source: MPIB (2015)]

The average pineapple yield by Malaysia's smallholder sector increased from 2012 to 2015, going from 20.25 mt/ha to 37.39 mt/ha. Nonetheless, the yield recorded a fluctuating trend. One possible cause of the fluctuating trend could be linked to the smallholder farmers changing their preference for planting more lucrative crops like oil palm on the peat soil that had previously been home to pineapples (Jaji et al., 2018). Oil palm planting is low risk, easily managed, and provides a significant return due to favourable demand by the international market. Over the years, the productivity of the smallholders has been unsteady, and thus, affecting their income. One of the main causes of this unsteady productivity is ineffective farm management which results in inefficient production by the smallholder sector (MPIB, 2019b).

According to Al-hassan (2008), improved technical efficiency would enable farmers to employ farm resources more effectively and give the course the necessary adjustment over time to achieve the production of sustainable crops like pineapples. If there was a lack of efficiency, agricultural output could not be raised without using more farm inputs. Therefore, efficiency measurement is a crucial tool for calculating the potential advantages of adopting better farm practises in agricultural production at a given level of inputs (Laha & Kuri, 2011; Armagan, 2008; Rahman, 2003; Tauer, 2001).

1.1.4 Pineapple Industry in Johor

With a planted area of 7,6210.2 hectares in 2020, Johor is regarded as the centre of the pineapple industry in Malaysia (Table 1.8). Pineapple cultivation in Johor is favoured by its abundant peat fields, and Joseph et al. (1974) noted that pineapple growing on peat soil had historically been practised in Malaysia. Bartholomew et al. (2003) emphasised that pineapple has a good adaptation to peat soils. Due to pineapple's adaptability to peat, peat has historically been considered ideal for pineapple production, and this is also the case today. This supports Selamat's (1997) findings that pineapple grown on peat soils has minimal disease issues, particularly those related to the nematodes because the soil has a low pH.

Table 1.8 : Planted Area, Production, and Yield of Pineapple, Johor, 2008-2020

Year	Planted Area (ha)	Production (mt)	Yield (mt/ha)
2008	9,268.0	275,154.0	29.7
2009	9,528.0	223,120.0	23.4
2010	8,806.0	197,825.0	22.5
2011	8,692.0	187,025.0	21.5
2012	9,093.0	202,183.0	22.2
2013	5,515.7	267,913.1	48.6
2014	5,790.3	231,613.2	40.0
2015	10,064.0	329,954.2	32.8
2016	8,934.5	273,949.5	30.7
2017	8,729.7	294,265.1	33.7
2018	9,727.5	276,242.3	28.4
2019	8,554.1	252,478.7	29.5
2020	7,610.2	212,129.6	27.9

[Source: DoA (2017); MPIB (2021b, 2016a, 2012)]

Knowing that pineapple is a significant fruit crop for Malaysia and particularly Johor, commercial pineapple farming has been practised extensively, and the amount of land planted has shown promise over time. The average production of pineapples in the state of Johor increased from 275,154 metric tonnes in 2008 to 276,242 metric tonnes in 2018. The amount of land that was cultivated did not increase much during this time. However, the state's productivity recorded 48.57 mt/ha and 40 mt/ha in 2013 and 2014, respectively. This, in spite of the fluctuating trend in productivity, demonstrated the state's capability of producing the targeted yield of 45 mt/ha set forth in MPIB's strategic planning (MPIB, 2016c).

1.2 Issues and Challenges in Pineapple Production

Despite the pineapple industry's significant growth and development, a number of concerns have been identified that could affect its progress. A significant portion of the smallholder pineapple industry has experienced production challenges. The production of pineapples is plagued by yield fluctuations that may result from input inefficiency problems, differences in farmers' socio-economic backgrounds, and production risks related to inputs.

In 2020, the governing agency predicted that it would be able to produce 707,960 mt of pineapple, as stated in the MPIB Strategic Planning in 2021–2025 report (MPIB, 2019c). However, the production of pineapple fell 54 per cent short of the projected target in 2020, totalling only 323,421 mt (Table 1.9). The MPIB stated that the production target for pineapple appears to have not even been met in Malaysia.

Table 1.9 : MPIB Production Target Versus Production Achieved, 2018-2023

Year	2018	2019	2020	2021	2022	2023
Production Target ('000 mt)	526	139	707	821	952	1105
Production Achieved ('000 mt)	382	373	323	n/a	n/a	n/a

[Source: MPIB (2019c).] Note: n/a= not available

According to the MPIB Annual Report for 2020, Malaysia has a productivity rate of 22.99 mt/ha. The output of Malaysian pineapple is also found to be inferior to that of other ASEAN nations that produce pineapple. The Food and Agriculture Organisation (FAO)(2020) reported that the productivity of pineapple production in the Philippines and Indonesia are higher at 40.42 mt/ha and 127.29 mt/ha, respectively, and this is supported by Mohamad et al. (2022). Despite the 2020 MPIB Annual Report clearly stating that Malaysia's target for pineapple productivity is to attain 45 to 64 metric tons/ha, Malaysia's productivity figures were below the national target. This has limited Malaysia's ability to become a significant pineapple exporter (MPIB, 2019a). The previous Director General of MPIB, Mr Sahdan Salim, further underlined that the output of smallholders faces difficulties due to low productivity and inadequate returns on investment during the Pineapple Industry Seminar in 2015. He stressed the smallholders' low production and how most pineapple smallholders met subpar application inputs (Salim, 2015). The technical inefficiency can serve as a reflection of the most likely reason the target was not met. Therefore, Malaysian pineapple's low productivity suggests that pineapple production is inefficient.

Furthermore, the proposition is supported by the fluctuations in production over the years, where Malaysian pineapple production declined between 2009 and 2012 and between 2016 and 2019 onwards. As mentioned earlier on, the director general's emphasis on the smallholders' improper application of inputs and that 44 per cent of pineapple smallholders did not use the recommended agricultural methods (Salim, 2015). Efficiency and productivity are indeed closely related. Given the significance of the connection, it is important to investigate the efficiency of the pineapple growers in Johor, considering that it has the largest area dedicated to pineapple cultivation and is home to the vast majority of pineapple producers. Looking into the pineapple production trend in Johor by comparing the production from 2018, there has been an almost 100,000 mt decline in 2020. However, as supported by Suhaimi and Fatah (2019), the majority of these farmers are unable to achieve their desired level of productivity and, consequently, profitability.

Threats to pineapple production in Malaysia include weeds, pests, and diseases, improper input application, a lack of labour and seed supplies, and labour-intensive management approaches (Tahiruddin, 2019; Suhaimi & Fatah, 2019; Idris et al., 2013). This was further corroborated by Heng's (2019) findings that, in order to grow pineapples productively, inputs should be managed effectively. This includes using the right fertiliser, eliminating weeds, and using the right planting materials.

Numerous studies have stressed the importance of ensuring that farms are run effectively and cautiously in order to achieve the desired output and subsequently contribute to the export market (Rahim & Othman, 2019; Idris et al., 2013). The shortage of labour and manpower presents a challenge for the farmers' pineapple cultivation, according to International Tropical Fruits Network (TFNET) (2019). The smallholders have relied on the family members as possible and available labour in order to address the problems with acquiring labour for cultivation operations. Idris et al. (2013) provided evidence to support the claim that smallholder pineapple growers of pineapples relied on family labour, particularly for harvesting activities, with villagers and children also involved in assisting the farmers. This is done to prevent damages associated with harvest delays on agricultural products. Family labour was discovered to be crucial in other developing nations, particularly during the peak of the crop season (Balogun et al., 2018; Idris et al., 2013).

Aside from labour shortage, ITFN (2019) advised that research be conducted with an emphasis on determining the right fertiliser dosage, correct planting density, and optimum amount of watering. Each smallholder's goal is to produce fruits of high quality that meet consumer demands and adhere to specifications. Another emphasis also includes making optimal use of the land and inputs. With respect to fertiliser application, studies conducted in developing nations, such as Ghana, Nigeria, and Columbia, found that fertiliser substantially impacted the productivity of pineapples (Ofori-Appiah et al., 2022; Balogun et al., 2018; Adegbite & Adeoye, 2015; Trujillo & Iglesias, 2013). An appropriate amount of fertiliser input is necessary for the efficient production of pineapples. Unfortunately, a labour shortage may suggest an unbalanced distribution of fertiliser input on each tree (Abbas et al., 2021; Abbas, 2019; Lin & Rahman, 2010). More than 90 per cent of pineapple growers in Johor used less fertiliser than was required (Lin & Rahman, 2010). According to the researchers, although 3.7 mt/ha of fertiliser was the expected rate of application, the farmers actually applied less. This shows that less fertiliser was used on the crops than was recommended, which was also supported by the study conducted by Rahim and Othman (2019) and Moïse et al. (2022).

The planting density of pineapple cultivations, i.e. the number of plants per unit area, as indicated by planting materials or suckers, also had an impact on pineapple production. This was supported by the efficiency studies on pineapple by Ofori-Appiah et al. (2022), Balogun et al. (2018), Adegbite and Adeoye (2015), and Trujillo and Iglesias (2013). TFNet (2019) also noted that one of the issues encountered by smallholder farmers is their inability to obtain sufficient high-quality suckers for planting, which has a negative impact on their ability to meet the ideal planting conditions for pineapples. Farmers occasionally did not adhere to the variety-based suggested planting distance, which led to lower plant densities than expected on most fields. According to research by Lin and Rahman (2010), 66 per cent of growers did not apply fungicide onto planting materials as recommended by MPIB; others using a variety of techniques for treating planting materials.

In terms of hormonal input application, there are instances where farmers do not apply hormones according to the correct planting schedule, thereby disrupting the farm's harvesting schedule (Hartinee et al., 2021; Lin & Rahman, 2010). A group of researchers discovered that farmers frequently fail to use appropriate hormonal blends for pineapple cultivation (Hosnan, 2022; Abbas et al., 2021; Lin & Rahman, 2010). There have been instances where farmers did not follow the recommended ratio and used it without measuring as required (Abbas et al., 2021), creating issues with production growth. This should be avoided because it is unfavourable and raises farmers' production costs.

Pests and disease management is another critical aspect of pineapple farming because they have the potential to reduce yield and quality. According to Hosnan (2017b), if weeds are not properly controlled, pineapple yields can be reduced by 25 per cent to 30 per cent, which can eventually lead to pest attacks and diseases on pineapple plants. The presence of thick grass and continuous rain may causee an attack of Bacterial Heart Rot (BHR) disease (Hosnan, 2017b). According to Musa (2019) and Sapak et al. (2021), some of the common diseases occurring in pineapple farms include pathogenic induced black rot caused by *Phytophtora spp.* and *Dickeya spp.* In the event of an outbreak, farmers should be aware of the information available on controlling the outbreak with the use of appropriate pesticides and fungicides, in addition to good management practises. According to Lin and Rahman (2010), 48 per cent of farmers took no action to remediate their farms for pests and diseases. This was supported by studies on pineapple production in other developing countries (Ofori-Appiah, 2021; Balogun et al. 2018; Adegbite, 2015; Trujilo & Iglesias, 2013).

The efficiency of pineapple producers varies depending on the different amounts of inputs used (Ofori-Appiah et al., 2022; Idris et al., 2013). The majority of pineapple efficiency studies concurred that farmer inefficiency and production risk factors are responsible for the gap that occurred when actual output fell short of potential output. Given a particular technology, input consumption is expected to enhance the production process and produce the best results possible. However, a gap in output levels is the outcome from the absence of specific inputs and the incorrect use of inputs.

Inefficiency is the central argument of this thesis. A substantial body of evidence implies that one of the ways to boost production is to use available resources efficiently (Anang et al., 2020; Abate et al., 2019). Studies have also shown a strong and persistent connection between inefficient input usage and developing nations, where farmers frequently make inefficient decisions and underutilise production resources and technologies (Ahmadzai, 2017; Bravo-Ureta et al., 2017, 2007). Low productivity performance among the smallholders' production of pineapples may be caused by inefficient input utilisation. On the other hand, increased output combined with appropriate input application can increase pineapple production. To remove these obstacles within this industry, practical and targeted actions are needed. Nonetheless, little research has adequately considered the presence of production risk, even though it is well-known that economic units make decision-making often involve risk and uncertainty.

1.2.1 Production Risks Associated with Inputs Use

Small-scale farmers typically experience output uncertainty and unpredictability, particularly in developing nations (Kaka et al., 2020; Kara et al., 2019b; Mishra et al., 2019a; Amuakwa-Mensah et al., 2018). In addition to elements that are beyond the control of the farmers, such as input and product pricing, other factors that can be controlled include changing the level of input utilisation (e.g., seed, fertiliser, herbicides and pesticides). Concerning output variability, agricultural production, including pineapple farming in Malaysia, may be impacted by these same issues. Numerous studies in agriculture have observed that output variability, or production risk, is assessed by the variance of output while focusing on the specification that permits inputs to be either risk-increasing or risk-decreasing (Kara et al., 2019a; Alam et al., 2019; Amuakwa-Mensah et al., 2018; Ogundari & Akinbogun, 2010; Fufa & Hassan, 2003).

It is commonly suggested that small-scale farmers are risk-averse (Bala et al., 2019; Alam et al., 2019; Ahsan, 2011). They also use an input bundle that differs from the economically optimal, utilising a higher proportion of risk-reducing inputs and a smaller proportion of risk-increasing inputs than a profit-maximizing producer. The decision-makers attitude towards risk will determine the extent to which they are exposed to risk outcomes or events. These obstacles also impede farmers from achieving their full potential yield.

Farmers, who are often risk-averse, will attempt to reduce the risks associated with production by selecting inputs (Alam et al., 2019; Sarker et al., 2016). However, the level of output variation (production risk) can be affected by inputs in one of two ways which is either increasing it or decreasing it (Kumbhakar, 2002; Just & Pope, 1978). Therefore, an economic analysis of the relationship between input use and output variation would be beneficial for policy makers involved in risk management in the pineapple industry as well as farmers by increasing their understanding of the risk consequences of their input selections.

If a farmer's decision to produce is greatly influenced by production risk, this could have a considerable impact on the farmer's technical efficiency performance (Alam et al., 2019; Picazo-Tadeo & Wall, 2011; Bokusheva & Hockmann, 2006). The pineapple farming industry exhibits a wide range of diversity in its production trend. The production inputs are essential to pineapple farming, which is likely to result in output variability (risk) and inefficiency. This indicates that the empirical models for measuring technical efficiency need to consider the element of production risk associated with inputs in pineapple production. An in-depth research should be conducted in order to expand and improve this farming system in a way that is both economically sound and environmentally sustainable.

Therefore, it is crucial to enhance the efficiency of the resources used in pineapple production. The goal of this work is to suggest ways to increase pineapple output through an efficient approach in a sustainable way. The presence of risk in the environment where the crop is grown affects producers' decision-making, as well as their choice of how to allocate inputs and, as a result, the supply of the crop. Production risk related to inputs is pervasive and has significant effects on agricultural operations. It is crucial to analyse how risk impacts a farmer's decision regarding input allocation and how it also influences the farmer's efforts to achieve technical efficiency. There is a critical need to measure the output variability in pineapple farms in Johor, given the rising prevalence of agricultural studies that have included production risk in input uses, particularly in developing countries and have demonstrated the importance of this aspect (Kaka et al., 2020; Kara et al., 2019b; Onumah et al., 2018). Given the government's objectives to increase pineapple production, it is therefore important to look into how production risks affect pineapple production.

1.2.2 Socio-Economic and Institutional Variables Affecting Production

Studies on efficiency estimation have shown that there is a gap in agricultural productivity, with actual output frequently falling short of potential output. Certain socio-economic inefficiencies, such as experience, participation in farming seminars, association membership, and extension assistance, might be used to explain another contributing element of efficiency estimations (Rahim & Othman, 2019; Idris et al., 2013). The lack of expertise and unpreparedness of the new smallholders was brought up by pineapple producers during a conference held in Malaysia in 2019 (TFNet, 2019). Due to this, farmers failed to realise the expected return on investment for their crops.

The previous Director General of MPIB, Mr Anim Hosnan, concurred that a lack of networking and cooperation among the supply chain participants, including the growers, wholesalers, processing facilities, and pertinent governmental authorities, are among the problems impeding the pineapple industry (Hosnan, 2018). According to incidents and reports, several pineapple farmers were reported to have been unsuccessful in growing pineapple farms as a result of working on the fields alone (Hosnan, 2018). Due to poor and insufficient communications, according to the Director General of MPIB, farmers who work alone are unlikely able to obtain the necessary information.

1.2.3 Government Support to Smallholders Pineapple Smallholders

Given the economic potential of pineapple production, the government intervened through MPIB and provided assistance through various projects and assistance, such as *Projek Pengukuhan Tanaman Nanas* (Berita RTM, 2022). This programme aims to balance market supply and demand, ensure the sustainability of pineapple production, and reduce production costs so that pineapple growers, particularly small-scale producers, generate substantial income. The implementation mechanism provides small-scale businesses with planting materials or agricultural inputs valued at up to RM 2,250 per acre, with a restriction of 15 acres per participant (MPIB, 2019c). Since independence, numerous programmes and initiatives have been launched to improve the productivity of these farmers and transform the pineapple industry. The policy environment of Malaysia's pineapple industry is discussed in the following section in light of the government's initiatives to increase smallholders' pineapple production.

1.3 Policy Environment of Pineapple Industry in Malaysia

Examining the policy documents that offer the intended statement and methods provides an insight into the evolution of the Malaysian pineapple policy. There is a lengthy history of government intervention in the Malaysian pineapple industry. The 1950s saw the beginning of Malaysia's product of canned pineapple for the world market (MPIB, 2008). Despite several modifications in the structure of the major regulating body of the pineapple industry, MPIB, the government's support for the pineapple industry has been maintained. Both Malaysia Plans and the National Agricultural Policy (NAPs) indicate the government's support for the pineapple industry. Increasing farmers' income, attaining marketing efficiency, and accomplishing the aim of self-sufficiency are among the general objectives of these government policies (Abd-Halim, 2016).

The government, through MAFI, have developed and implemented strategies and programmes for pineapple growing since Malaysia gained its independence in 1957. After independence, two development plans, the First Malaya Plan (1MP) (1956–60) and the Second Malaysia Plan (2MP) (1961–65), marked the beginning of the shift in the emphasis on development (Malaya, 1957 and 1961). The fundamentals—infrastructure development and institutional support to enhance rural and farming communities—were the focus of the sector's revamping in the rural and agricultural areas. *Lembaga Perusahaan Nanas Tanah Melayu*, which took the position of the Johor-based Pineapple Joint Industrial Council, was established in 1957 as a result of the widespread and significant economic importance of pineapple production (MPIB, 1988). In order to ensure that the industry's flow and development are organised through the functions mentioned by regulating and coordinating production, processing, and marketing, and quality assurance, the MPIB is responsible for regulating and developing the national pineapple industry through the regulations it enacts.

In the 1970s, The Pineapple Replanting Scheme and the Half Price Assistance Scheme for smallholders were established under the Pineapple Industrial Regulations (Financial Assistance for Replanting) of 1971. The policies were invested in the peat land in accordance with the policy of the Johor State Government at the time to develop peatlands with pineapple crops due to the concentration of pineapple smallholders in Johor (MPIB, 2018). In order to give a far more "all-encompassing" policy approach to agricultural development, the National Agricultural Policy (NAP) was introduced in 1984. The NAP was created to ensure an even and consistent pace of growth in the agriculture industry, including pineapple crop in comparison to other economic sectors (EPU, 1984).

The *Ordinan Perusahaan Nanas 1957,* also known as the *Akta Perindustrian Nanas* Malaysia 1957 (Semakan 1990), was amended in 1990 during the same period as Malaysia was moving towards industrialization (MPIB, 2018). In 1992, the New National Agricultural Policy II (also known as NAP II) was created to remedy the flaws in the first NAP. The new NAP II's goal was to maximise income through the most effective use of available resources in production. Later, the third National Agricultural Policy (1998–2010) was developed to restore agriculture in the context of the new global economic order, where globalisation is the norm and trade liberalisation is accelerating (Malaysia, 1999). The NAP III focuses on innovative methods to boost production and competitiveness, strengthen connections with other industries, explore uncharted territory, and sustainably conserve and utilise natural resources.

Malaysia started on a new route of development in 2010 with the Economic Transformation Program (ETP) in order to obtain a high income by 2020. According to the strategy, the pineapple crop has been included in the agricultural national key economic areas (NKEAs) under Entry Point Project 7 (EPP7), which has great growth potential (PEMANDU, 2016). The Malaysian government has recognised pineapple as a new source of wealth for the nation in Malaysia's Budget Planning 2018 (Othman, 2017) and therefore has highlighted pineapple's potential in improving farmers' income. This was in line with Malaysia's aim to enhance the export volume of pineapple to Middle Eastern nations, including Turkey, Iran, Saudi Arabia and Egypt, which have gradually shown increasing demand. Furthermore, Malaysia's pineapple industry, through MPIB, conducted rigorous and extensive efforts to increase the pineapple planting area, notably for the MD2 and Josapine varieties (MPIB, 2019a). The government also has provided financial supports to involve youth in agriculture through Young Agropreneur Program by MAFI within this period alongside other relevant government agencies including Agrobank and National Business Group Economic Fund (TEKUN). In a bid to also accomplish the objective, MPIB rolled out various projects on pineapple production from 2016 to 2020 under Eleventh Malaysia Plan. Among the projects that were established included *Projek Pengukuhan Tanaman Nanas, Projek Penanaman Nanas untuk Pasaran Premium, Projek Integrasi Tanaman Nanas* and *Projek Kluster Pengeluaran Nanas di Sarawak* (MPIB, 2019c).

The National Agrofood Policy 2021–2030 (NAP 2.0) was developed to support the aspirations and future direction of the country's agro-food sector, which is more sustainable, resilient, and heavily technology-driven. With the intervention of NAP 2.0, the agro-food industry, including pineapple, would also be able to maintain its competitiveness, helping to advance national economic growth, human welfare, and environmental sustainability. These objectives follow the Sustainable Development Agenda 2030's guiding principles (SDG 2030). The country's pineapple industry would be further strengthened by the NAP 2.0, which was established to promote the growth and modernisation of the agro-food and food security industries under the MAFI. The NAP 2.0 highlighted the high demand for pineapple as one of the HVC would fluctuate more than it would be volatile for staple commodities (MAFI, 2021b). The government took multiple measures to address the issue by offering smallholders various forms of aid and incentives with the goal of increasing pineapple production over the years. Given the critical importance of pineapple to both urban and rural family units, pineapple production has long been considered a need in Malaysia. The country has enacted a slew of policies aimed at bolstering and expanding domestic output. The main goals of this support were to boost smallholders' incomes and the economy's contribution from pineapple production (MPIB, 2019c).

In general, the majority of the strategies were established primarily to raise the productivity of smallholders and estates and to raise the economic contribution of pineapple. Malaysia's ability to compete in the pineapple business has the potential to be fully utilised. The Malaysian government has been putting forth initiatives specifically designed to boost productivity in an effort to improve pineapple production, income and livelihood of the smallholders.

1.4 Problem Statement

The importance of the pineapple industry in Malaysia's agriculture sector and its overall economic development has been recognised for years. The high export potential of pineapple in Malaysia has elevated the country's position as an important pineapple producer in the global market. As an important producer of pineapple on the global stage, it is necessary for the country to explore, to the fullest, its pineapple industry potential so as to strengthen its domestic market as well as increase the revenue from export markets. Although there is market potential in terms of domestic consumption, the greatest potential still appears to be in promoting fruit exports. This shows that pineapple smallholder producers play a vital role in the pineapple industry. These farmers have helped shape the pineapple industry into an attractive business entity, evidenced by its high market value both locally and internationally. While the pineapple industry has made some progress in terms of growth domestically and in the export market, it has been confronted with the problem of production decline in recent years as it was recorded that there was a 26% decline from 2017 till 2020 (MPIB, 2020; 2019a) . The implication is that Malaysia's pineapple contribution to the global market has been affected negatively, thus, diminishing its global competitiveness. This production decline can be attributed to many factors and signals probable production challenges.

Over the last decades, pineapple production has attracted investment from farmers for both domestic consumption and the export market. The state of Johor, being endowed with a favourable environment for pineapple production, makes it a thrust area which attracts a continuous stream of programmes/policies implemented in the past, resulting in a steady production trend for decades. This income opportunity has helped in improving the livelihoods of the farmers for generations. Small-scale farmers frequently endure unpredictable and unclear output, especially in developing countries (Kaka et al., 2020; Kara et al., 2019b; Mishra et al., 2019a; Amuakwa-Mensah et al., 2018). Other aspects that can be managed, in addition to those beyond of the farmers' control like input and product pricing, include modifying the rate of input utilisation (e.g., seed, fertiliser, herbicides and pesticides). With regards to output variability, these same problems might have an effect on Malaysian pineapple smallholders. Numerous research in agriculture have found that the variation of output, or production risk, is measured while focusing on the specification that allows inputs to be either risk-increasing or risk-decreasing (Kara et al., 2019a; Alam et al., 2019; Amuakwa-Mensah et al., 2018; Ogundari & Akinbogun, 2010; Fufa & Hassan, 2003).

Recognising the fact that the pineapple industry has the potential to contribute immensely to the Malaysian economy as a whole has stimulated the government to strengthen its domestic market as well as seek new export markets. As a strategy, the government has implemented numerous policies and strategies towards improving the country's pineapple production volumes. There are multiple ways to improve pineapple production, such as expansion in cultivated areas, increase in cropping intensity, technological change and improvement in technical efficiency. However, some of these options do not seem feasible in the short run: area expansion and cropping intensity seem to be a challenge considering the intercropping cultivation system practice of pineapple in Johor, while technological change may require a long-term process in addition to huge funding and investment. Therefore, the only feasible short-term option will be to improve technical efficiency.

Policy makers and agricultural economists have always emphasised the crucial role of efficiency in fostering agricultural productivity. This is because improvements in technical efficiency are an important policy objective as it constitutes a major facilitator of overall productivity growth. Production of agricultural commodities is a complex process and a function of limited multiple inputs. Furthermore, the production process does not depend on individual resources solely but on the combinations of different inputs as well as management practices that ultimately determine total productivity. Therefore, the success of any farm producer depends on identifying the best production system and on their ability to combine these limited resources appropriately. Considering the pineapple production system as a whole, the differences across farms in the use of various factors of production at various levels and in various combinations influence changes in pineapple yields. This means that increase in production is possible mainly through improvement in productivity of the crop that could be achieved by efficient utilisation of available resources.

To estimate technical efficiency, a conventional stochastic frontier model is typically used. However, it does not sufficiently take into account production risk, which is a crucial component of production. It is, in fact, crucial to consider the possibility that risk aversion may influence the decision between production strategies when assessing the success of pineapple production. This is because risk aversion could have an impact on the producing output that is actually realised. Furthermore, it is vital to consider socio-economic and managerial aspects that could increase output while assessing pineapple production. Technical efficiency estimates will be inaccurate if production risk is not factored into the equation. Therefore, a thorough analysis of the input-output relationship, production risk, and technical inefficiency degree for pineapple production is necessary.

The decline in production volumes confronting the pineapple industry in recent years has, therefore, prompted research efforts on production efficiency and production risk of pineapple smallholders. Such investigation is vital at both the national level and at the producer level: at the national level, examining efficiency can guide resource utilisation and may lead to significant resource savings, which has important implications for policy formulations. Similarly, at the producer level, such information can help them focus on any necessary adjustments within their operations and, as a result, improve their productivity. In this context, assessment of the existing level of technical efficiency and production risk in pineapple production assumes paramount importance. The outcome of the technical efficiency evaluation will indicate the level of utilisation of the present technology used in the production process, as well as the possibilities for improvement. Estimates of the input component productivities in relation to pineapple output will demonstrate how input and output are related. The change in output if all factor inputs are changed in the long run by the same percentage is also shown by the estimated scale elasticity of production. With the assistance of these estimations, policymakers can choose the best possible inputs, which will boost their outputs. Therefore, this study aims to determine the technical efficiency and production risk of smallholders pineapple production in Johor considering Johor is the largest pineapple producing state in Malaysia.

1.5 Research Questions

Based on the problem statement aforementioned, the following research questions need to be answered:

a. What is the technical efficiency level of pineapple smallholder farmers?

b. What are the production risks with respect to the inputs used by pineapple smallholder farmers?

c. What are the factors affecting the technical efficiency of pineapple smallholder farmers?

1.6 Objectives of the Study

The general objective of this study is to determine the technical efficiency and production risk of smallholders pineapple production in Johor. The specific objectives of the study are:

a. to estimate technical efficiency of smallholder pineapple production;

b. to analyse production risks with respect to inputs of smallholder pineapple production;

c. to determine influencing factors affecting technical efficiency of pineapple smallholders' production.

1.7 Significance of the Study

This research will assist pineapple farmers in increasing their revenue, yield, and resource efficiency. This would aid in the overall growth of the agriculture industry and the country. Examining the efficiency of the pineapple smallholders would therefore serve as a guide in identifying areas of policy strategy targets. An increase in pineapple industry output is thought to provide the required growth in revenue through the export of the fruit.

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The presence of risks in the production environment, such as the occurrence of pests and diseases and changes in the costs of inputs and outputs, affect farmers' decisions on the allocation of inputs and, as a result, the supply of output. The degree to which farmers are ready to incur this risk substantially influences how well they can manage it. The findings of the production risk component will clarify how various inputs affect output variance. The variability of the output may be increased by some input parameters while it may not be by others. The allocation decision of inputs depends on this knowledge.

The causes of pineapple production variability may be because many smallholders lack a clear understanding of the optimum distribution of variable inputs and/or because many of the smallholders lack the technical efficiency necessary to operate the production technologies. Consequently, it is anticipated that identifying areas of inefficiency and factors related to input risk in pineapple farming will aid in determining the gap between actual and potential production. For farmers as well as policy makers, addressing the causes of inefficiency and production risk is crucial. There is, however, hardly a farm-level research that addresses either risk or both at once when it comes to pineapple cultivation in Malaysia. This research on pineapple farming in Malaysia is the first to examine how input utilisation and ineffective pineapple production affecting production variability.

The results will be able to offer policy recommendations that can enhance the planning and monitoring system used by the industry's regulatory bodies, particularly MAFI and MPIB, to effectively increase production and, consequently, the farmers' farm income. The study would also give decision-makers the knowledge they need to set up initiatives that will help Malaysia's pineapple production potential. The study's contribution will be to further the discussion about ways to raise the profitability of the pineapple smallholder sector in Malaysia. The study and its findings will benefit the government and relevant development agencies, in the hope of improving the lives of rural pineapple smallholders. The outcome of this study will also contribute to the literature on the improvement of technical efficiency in the pineapple production industry and also the risk mitigation in the pineapple production process.

1.8 Organisation of Thesis

This thesis is structured into five chapters. Chapter one dwells on the introduction of the study, where the emphasis was on the overview of Malaysia’s pineapple industry with emphasis on the aspects of its production system, policies and market dynamics. It also included the problem statement, objectives and significance of the study. Chapter two accommodates a review of approaches for efficiency measurements, the importance of incorporating production risk in a stochastic frontier model and empirical studies on efficiency applications of the different approaches in efficiency analysis. It also highlights agricultural policies and programs in Malaysia with respect to the pineapple industry.

Chapter three focused on the theoretical framework, conceptual framework for pineapple production efficiency, methods of analysis, and empirical analysis for estimating technical efficiency and production risk and hypothesis tests. It also comprised of the study area, sources and methods of data collection, validation of an instrument for data collection, sampling techniques and a priori expectation of the signs of the variables and the analytical techniques. Chapter four documents the results and discussion concerning each objective, summary statistics of the output and input variables, a description of the demographic characteristics of the respondents, hypotheses that were tested, estimates of the marginal output risk, the inefficiency model estimates and the estimates of inefficiency. The summary, implications of the study for policy, recommendations for policy implications, limitations and suggestions for future study and conclusion are in the last chapter, followed by the references and appendices.

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