Forest Carbon Trade in Malaysia: Early Assessment of Awareness, Knowledge, and Constraints among Forest Owners

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Forest carbon credit project developments throughout the world can contribute to nature-based solutions to mitigate climate change. With Malaysia's large forest endowment, a study was conducted to evaluate the awareness and knowledge among forest owners, and to identify the main constraints faced when venturing into forest carbon credit projects. A total of 75 companies in both forest plantations and natural forests were involved in the study. The results clearly suggest that knowledge and awareness of forest carbon credit projects is relatively low among forest owners. Hence, forest carbon credit projects development in the country is relatively slow and only a few projects have had serious development to the auction phase. The slow uptake of carbon projects is plagued by the low carbon credit price, lack of clarity in the national carbon policy, limited expertise and capability for project development, and the lack of financing mechanisms for project development. Forest owners prefer biomass production and timber production due to the higher economic returns. Against this background, policymakers as well as federal-state initiatives need to address the gaps with the forest carbon credit project development ecosystem, in order to facilitate and realize the full carbon sequestration potential of the country.

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INTRODUCTION

The Net Zero by 2030/2050 report by the IEA (2021) presented the various pathways of decarbonization to ensure climate change mitigation is realized. The notable pathways suggested included the use of renewable energy, energy efficiency, electrification, and plugging methane-leaks. However, carbon-capture-storage (CSU) technologies were listed way down among the least effective of the pathways to achieve the decarbonization goals within the given timeframe, especially due to its high cost and difficulty in implementation (Lefebvre *et al*. 2021). As the global economy rebounded after the Covid-19 pandemic, world energy prices touched record levels in many markets, bringing energy security concerns to the fore. In 2021, emissions rose by a record 1.9 Gt to reach 36.6 Gt. This was driven by extraordinarily rapid post-pandemic economic growth,

slow progress in improving energy intensity, and a surge in the global demand for coal, although renewables capacity additions scaled record heights. Against the background of these rather discouraging developments, the pathway detailed in the 'Net Zero Emissions by 2050' (NZE) scenario remains far from reach (Favero *et al.* 2020).

Despite the fact that CSU technologies have remained less attractive, forest related activities, especially reforestation and afforestation, which are considered emission removal mechanisms, appears to have picked up pace (World Bank 2023). This is owing to the fact that forested land is classified as a low-cost carbon-sink, from which, carbon credits can be traded in the global voluntary carbon market (VCM) or in the compliance carbon market (CCM).

CCMs are markets created by regulation or policy in specific local, national, or regional jurisdictions. These markets typically involve a cap and trade or Emissions Trading System (ETS), where each market participant is given a set quota of emissions that they may trade with other participants who are looking to exceed their quota. Within South East Asia, Vietnam has successfully used the ETS to become the first country in the region to raise significant funds from forest carbon trade (ITTO 2023). The Quang Nam region in Vietnam, with an area of 446 hectares of natural forest succeeded in developing the first forest carbon credit project in the country. VCMs are also used by entities to buy and sell carbon credits without a compliance purpose. These markets are often used by organisations or individuals to offset their carbon emissions voluntarily.

VCMs have seen rapid growth in the last decade as carbon offsets became an important component of climate change strategies worldwide. According to the IEA (2021), the VCM value grew by US$2 billion (RM9.3 billion) in 2021 compared to 2020, and it is anticipated to reach up to US$40 billion (RM186 billion) by 2030. The demand for carbon credits is driven by the governments and organizations worldwide, in their effort to reduce their carbon footprint. As part of the 2015 Paris Agreement, many countries agreed to cap global temperature increase to 2 °C by setting their nationally determined contributions (NDCs) towards greenhouse gas (GHG) emissions. On the other hand, private actors are increasing their climate engagement through the compliance carbon markets imposed by some jurisdictions, while others participate in the voluntary carbon markets (World Bank 2023).

Potential for Forest Carbon Trade in Malaysia

Malaysia's participation in carbon trading is not a new phenomenon. There have been several schemes involving carbon credits since the launch of the Clean Development Mechanism (CDM) under the Kyoto Protocol (MTIB 2022). As a reference point, Malaysia's first credit under the Verified Carbon Standard (Verra) was issued in 2013. Nevertheless, the idea of creating a national voluntary carbon market (VCM) is relatively recent. The first mention of such an initiative was reported by local media in September 2021, ahead of the COP26 conference in Glasgow, Scotland, by the Malaysian Ministry of Environment and Water (MEW)) following a cabinet meeting. As details of the VCM were announced in the Parliament in December 2021, it was announced that the market would be created by Bursa Malaysia, which also operates the country's stock, options and futures exchanges, and that the VCM would be compliant with the principles of Islamic financial law (also known as Shariah). This course of events led Bursa Malaysia to announce the launch of the VCM in December 2022 (Bursa Malaysia 2023), and the first auction on the "Bursa Carbon Exchange" took place in March 2023. During the auction all carbon credits on offer sold at the minimum reserve price, and Bursa Malaysia itself appears to have acted

as the buyer of last resort in accordance with the auction rules (Stek 2023). From a regulatory perspective, the VCM faced relatively few restrictions. The MEW has issued a 9-page guidance document, while the Securities Commission has reportedly issued a Letter of No Objection to the creation of the VCM by Bursa Malaysia (Bursa Malaysia 2023). Bursa Malaysia has stated that it will only accept the Verra standard of carbon emissions reductions on its VCM and has signed a Memorandum of Understanding with Verra to boost Malaysia's VCM ecosystem. Currently there is no Malaysian organization that can certify Verra credits, although SIRIM QAS, a company wholly-owned by the Ministry of Trade and Industry, held such a certification authorization in the past. A point of contention is the fact that Bursa Malaysia's four largest shareholders are also government-linked agencies, holding approximately 40% of the exchange's share capital. In this sense, both the VCM and the main verification provider (SIRIM QAS) are effectively state-controlled entities, which necessitates a relook at the ecosystem in order to enhance credibility (World Bank 2023).

The Bursa Carbon Exchange (BCX) offers two types of carbon contracts (Bursa Malaysia 2023). The Global Technology-Based Carbon-Contract (GTC) represents a standardized contract for the delivery of units issued by Verra, which features GHG reductions projects from sectors other than Agriculture, Forestry and Other Land Use (AFOLU) sector located outside of Malaysia. The other is the Global Nature-Based Plus Carbon Contracts (GNC+), which represents standardized contract for delivery of units issued by Verra, which features global nature-based GHG reductions project. This project demonstrates co-benefits from prevailing methodologies for Agriculture, Forestry and Other Land Use (AFOLU) sector (Table 1). The contracts come with climate, community, and biodiversity (CCB) affixed to the unit which indicates co-benefits of such projects. However, the GNC projects do not necessarily remove all the GHG emitted, suggesting that these projects are often used to reduce substantial amount of GHG but not eliminate it completely. Nevertheless, such projects are worth pursuing for their environmental and other co-benefits (Ratnasingam and Natkuncaran 2022).

Table 1. Types of Carbon Contracts

Project Category	Description	Examples
Global Technology-Based Carbon Contracts	Projects which prevent or reduce greenhouse gas emissions from entering the atmosphere	1.Energy efficiency projects 2. Renewable energy production 3. Electrification 4. Carbon Capture Utilisation and Storage (CCUS) not from nature-based projects 5. Direct Air Carbon Capture, (DACC)
Global Nature-Based Plus Carbon Contracts	Projects that remove greenhouse gases from the atmosphere	1. Reforestation 2. Afforestation 3. Bioenergy with Carbon Capture and Storage (BECCS) 4.Blue Carbon (especially from mangroves and coastal fauna) 5. Agricultural Practices

Source: Ratnasingam and Natkuncaran (2022) and Bursa Malaysia (2023)

However, for developing countries, such as Malaysia, a purely national perspective on carbon credits would lead to under-pricing of carbon value, given that the domestic supply of carbon offsets is relatively large compared to their emissions due to its large forest endowments (Sedjo 2001; JPSM 2022). Therefore, the export of such carbon credits is potentially lucrative for emerging economies, especially if they can obtain the much higher prices in compliance markets, as compared to the low prices for voluntary carbon credits (Rosales *et al.* 2021).

Carbon pricing is an essential policy tool to decarbonize the world economies, and through various instruments, carbon prices, such as ETS and carbon taxes, provide economic incentives to make climate-friendly changes in consumption, production, and investment (World Bank 2023). The introduction of the Carbon Border Adjustment Mechanism (CBAM) by the EU is an example of such a policy, which imposes a carbon levy on certain emission-intensive products originating outside the trading bloc. Although this policy has attracted much attention to the difference between the cost of emitting CO_2 in Europe and other countries, it is imperative to remember that carbon prices are essentially a product of their unique regulatory and economic environment (World Bank 2023).

Within the decarbonization pathways, renewable energy still dominates the global carbon market, representing about 45% of registered projects and account for 55% of credit issuances in 2022 (World Bank 2023). In line with the global trend, the Malaysian government launched the National Energy Transition Roadmap (NETR) in 2023, laying the framework to accelerate decarbonization initiatives, to facilitate the country's goal of achieving net-zero by 2050. The push towards renewable energy, electrification, energy efficiency, and electric vehicles, all of which aims to reduce dependence on fossil fuels, is fast gaining traction in the country through the provision of a set of tariffs and incentives to boost the transformation (NETR 2023).

Although the NETR also pays attention to nature-based activities, involving emissions reductions from agriculture and forestry, the rate of adoption of such projects appears to be slow, despite the carbon credits they produce often deliver co-benefits, *i.e.*, other socio-economic benefits aside from carbon reduction, which are valued by many buyers throughout the world. This may be attributed to the fact that nature-based carbon credits experienced the highest drop from as much as US$16 to below US$4 per ton within a decade, signalling the inherent challenges in issuing credits from such activities (World Bank 2023). Methodological challenges, particularly additionality, permanence, and leakage, as well as socio-economic challenges, including transaction, social, and opportunity costs, were identified as the major weak-points of nature-based carbon issuances. This is further compounded by the fact that the implementational challenges related to monitoring, reporting, and verification of the carbon credit can seriously impair the validity of the credit issuances (Stek *et al.* 2023).

Currently, three forest project types qualify to generate carbon offsets (Haya *et al.* 2023). These include, afforestation or reforestation (AF), avoided conversion (AC), and improved forest management (IFM). Each of these project types comes with its unique costs, benefits, and ways of accounting for carbon. Afforestation (AF), a vital environmental effort, revolves around reinstating tree cover on lands that were previously devoid of forests. These projects are fundamental in addressing deforestation, enhancing biodiversity, mitigating climate change, and contributing to ecosystem restoration. However, embarking on afforestation initiatives often incurs substantial costs due to the comprehensive processes involved, including land preparation, tree planting, maintenance,

innovation and technology, and long-term investment. Avoided conversion (AC) projects are crucial initiatives aimed at preventing the transformation of forested areas into non-forested landscapes. These projects, also called REDD+ (Reducing Emissions from Deforestation and Degradation), help fight climate change by safeguarding existing forest cover. But for this project to be considered eligible for carbon offset programs, project developers must substantiate that the land faces a substantial and imminent threat of conversion. IFM initiatives focus on optimizing the management practices of forested areas to enhance carbon sequestration, biodiversity, and overall ecosystem health. They aim to increase or maintain the carbon stored within forests, contributing to climate change mitigation efforts while ensuring sustainable use of forest resources.

In the study by Haya *et al.* (2023), it was reported that IFM projects have provided 193 million carbon offset credits since 2008. This accounts for 28% of the total credits from forest projects and 11% of all credits generated in the VCM. Well-designed and effectively executed forest carbon offsets can serve as incentives to reduce deforestation and forest degradation. They also aid in enhancing forest governance while promoting support for the rights of Indigenous peoples and local communities.

Despite the promising forest carbon ventures in parts of the world, issuing carbon emission offset credits from forests is challenging in Malaysia due to land ownership and management issues (Stek *et al.* 2023). Since Malaysia is a federation of states, the state governments are the main owners and managers of forested land, and they are therefore likely to become the main suppliers of nature-based carbon credits. However, there are a number of governance challenges surrounding land ownership that may complicate the supply of carbon credits. Although most forested land is managed by the Forestry Departments of the respective states, not all forested lands are necessarily owned by the state, and private owners, tribal people (through customary land rights), and the Malay rulers of certain states are also major owners of forested land (RESCU 2022).

Further, forested land in Malaysia can be gazetted as a Permanent Forest Reserve (PFR) by the federal government (West Malaysia only) and by state governments. The East Malaysian states of Sabah and Sarawak, which contain most of Malaysia's forested land area, have separate forestry legislation and policy, which is relatively autonomous from that of the federal government (JPSM 2022). Although the National Forestry Act of 1984 stipulates that PRFs are permanent, there have been occasional instances of PRFs being de-gazetted, including in Johor, Pahang, and Selangor, which has been reported in RESCU (2022). As land sales are a major revenue source for state governments, there is always a risk of forest reserve de-gazettement, although such moves also means that state governments are keen developers of carbon credits, which are considered a source of potential revenue (Stek *et al.* 2023). In this respect, many of Malaysian state governments are seen as large and eager sellers of nature-based carbon credits.

Forest Resources in Malaysia

As of 2022, the total area of PRF in Malaysia was reported to be 13.24 million ha, of which 4.9 million ha were in Sarawak, 4.8 million ha in Peninsular Malaysia, and Sabah with 3.54 million ha (MPIC 2023). The Federal Government of Malaysia enacted the National Forest Policy in 1978, and it was revised in 2021 (JPSM 2022), to ensure the adoption of Sustainable Forest Management (SFM) practices throughout all states in the country. With the SFM enforced, saw logs production from the natural forests was gradually reduced, and in order to fulfill the supply gap, forest plantations gained importance for saw logs production. As of 2022, Peninsular Malaysia has 137,000 ha of

forest plantations and Sabah approximately 360,000 ha, while Sarawak has so far planted 476,000 ha within 2,368,000 ha of LPF (license planted forests) concession areas, which covers 19% of the total surface area of Sarawak (Hii *et al.* 2017; JPSM 2022).

According to MTIB (2022), Malaysia produced about 5.3 million m^3 of industrial saw logs from its natural forests in 2022. Based on their being about 10% exported mainly from Sarawak, the balance was consumed domestically for the production of sawn timber, veneer, and plywood production. On the other hand, 3.5 million m^3 of plantation wood was harvested in 2022. Almost 58% of this was exported in the form of wood chips, particularly from Sabah and Sarawak. Consequently, the amount of saw logs produced does not fulfill the domestic industrial needs, which stands at 13.4 million m^3 per annum, resulting in a serious shortage of raw material supply, and inevitably, leading to significantly under-utilized capacity (*i.e.*, about 60%) across all sub-sectors of the wood products manufacturing industry. The total installed capacity in the wood products manufacturing industry is much higher, and therefore, the prevailing saw logs shortage leads to under-utilization of the processing capacity. It is thus no surprise that Malaysia is now a net importer of wood materials, and in 2022 the country imported 214,000 m^3 of sawn timber (MTIB 2022).

Endowed with a relatively large tract of natural forests, and now aggressively engaged in plantation forests establishment (Pearce *et al.* 2003), Malaysia is well positioned to capitalize on the rapidly growing global carbon credit market (MPIC 2023). In this context, forest stands, including both natural forests and forest plantations (referred to as 'green carbon') as well as mangroves (also known as 'blue carbon'), remain to be exploited for its carbon capture and storage (CCS) potential, as an economic means to raise funds, through the voluntary carbon market (VCM), as illustrated in Fig 1.

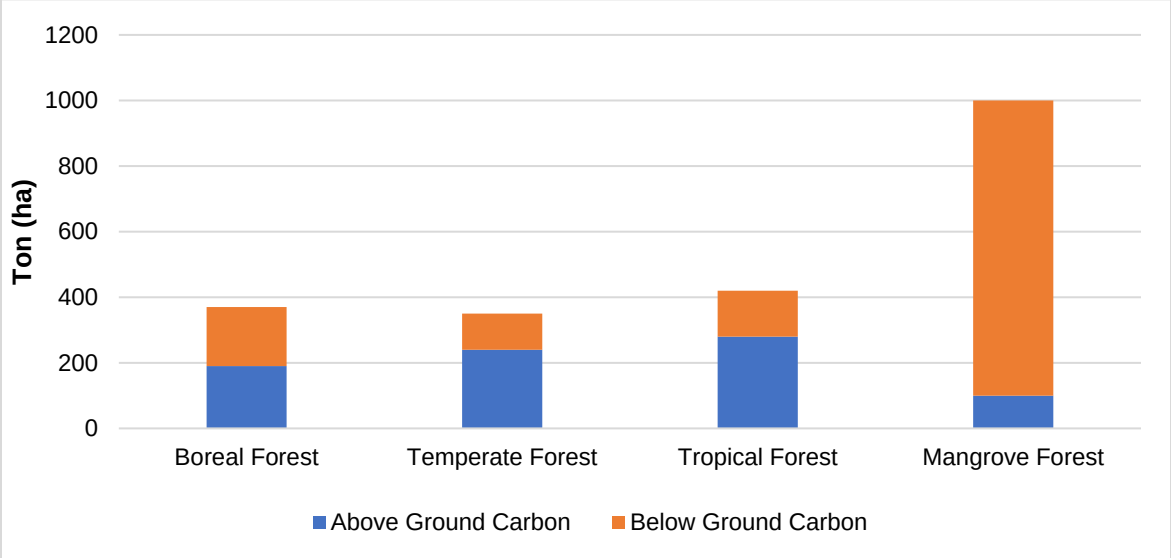

Fig. 1. Different Forest Ecosystem Carbon Storage (Ton/ha)
Source: Mukul *et al*. (2020).

Mangroves, tidal marshes, and seagrass meadows accumulate organic rich soils, often several meters deep, which provide long-term storage of organic carbon. Termed 'blue carbon' ecosystems (BCE), these habitats occupy only 0.2% of the global ocean area, but they are major contributors to marine sediment organic carbon. This is particularly true

for mangroves, as they store and sequester high amounts of C in both biomass and soils, usually up to five times more carbon than tropical upland forests. This is attributed to the high productivity of mangroves and their slow soil decomposition rates, which significantly boosts their ability to capture and store organic carbon (Chatting *et al.* 2022). In the case of Malaysia, however, mangrove ecosystems remain under threat by developmental projects. Current laws and enactments that serve to conserve this ecosystem are not sufficient, such that pursuing blue carbon projects may not be viable at this point in time. It is based on this, that forest carbon projects appear to be comparatively more attractive (RESCU 2022).

Against the background of the global 4Cs phenomena, *i.e.*, post-Covid-19 pandemic, climate change, conflicts, and currency fluctuation – the question of whether forest resources should be exploited for timber production, biomass production, or carbon capture and storage, as the desired option for economic returns, is increasingly gaining attention in the country. The geopolitical tension between Russia-Ukraine and the conflict in the Middle East continue to cast uncertainty over the global oil prices, which indirectly, leads to higher demand for other energy sources, especially biomass energy.

The objective of the study was to evaluate the perception of forest growers towards carbon-capture venture, as opposed to sawn timber or biomass production. The study also determined the level of knowledge and awareness of carbon-capture among forest owners, and to identify the constraints faced with forest carbon credit projects in the country. The findings of this study will provide insights into remedial measures that could be taken to encourage greater participation in forest carbon projects, which is deemed as an important carbon sequestration initiative both financially and socially.

EXPERIMENTAL

Target Respondents

The target respondents for this study were primarily private forest owners, who have established forest plantations, as well as forest administrators and conservators of the respective state governments. The absence of published records on previous successful forest carbon projects in the country made it necessary to seek assistance of relevant government agencies to implement this exploratory study. To assess the willingness of forest owners to participate in carbon capture projects, the assistance of the Forest Plantation Development Sdn. Bhd. (FPDSB), a subsidiary of the Malaysian Timber Industry Board (MTIB), was obtained, as it was the only agency that maintained a record of private forest growers in the country. Due to data confidentiality, FPDSB had initially contacted all the 127 registered companies to seek their consent to participate in the study, but only 53 agreed to the request. To increase the number of respondents, the forest departments of the respective state governments in Peninsular Malaysia, Sabah, and Sarawak were contacted. Through this effort, another 23 companies were added, bringing the total sample size of the study to 75 companies. From the total of 75 respondent companies, 68% were involved in forest plantation trees, while 32% were involved with natural forest tree species.

To ensure data reliability and fair representation of the forest owners, only the companies with more than 5,000 hectares of forests and that had been in the business for at least 7 years were considered for the study. All the respondent forest owners had leased the land from the state governments for at least 45 years, with an option to extend for a

further period. Due to the sensitivity of the financial information of these respondent companies that cannot be disclosed, it was agreed that the questionnaire-survey used in the study, would exclude all questions related to socio-economic and other financial-related data, which are meant to be used for future strategic planning and policymaking for forest plantation development by the relevant agencies.

Survey Instrument and Implementation

The survey instrument used in this study was a structured questionnaire, which was prepared in two languages, *i.e.*, English and Malay. The questionnaire was designed after several discussions with stakeholders and experts from the Forest Department of Peninsular Malaysia (FDPM), Malaysia Forest Fund (MFF) and FPDSB. Some previous studies from other countries in the region were also referred to ensure the reliability of the study framework (Ni *et al.* 2016; FDPM 2020; Nunes *et al.* 2020; Osuri *et al.* 2020; Ratnasingam *et al.* 2020; Myint *et al.* 2021). The draft questionnaire was also discussed and reviewed with experts at Bursa Malaysia. Prior to the implementation of the survey, the draft questionnaire was pre-tested among 10 forest owners to ascertain its validity and improve it accordingly. The reliability of the questionnaire was validated through the Cronbach–alpha test, which gave a score of 0.71. Cronbach's alpha is a way of assessing reliability by comparing the amount of shared variance, or covariance, among the items making up an instrument to the amount of overall variance. If the questionnaire is reliable, there should be a great deal of covariance among the items relative to the variance.

The final structured questionnaire used had four parts. Part I of the questionnaire collected data on the demographic profile of the respondents, while Part II focused on their level of awareness and knowledge related to carbon capture projects. The questions were designed to capture a yes/no answer, as the questions posed were closed in nature, aiming to evaluate the respondent's agreement or disagreement to the statement. Part III focused on assessing their overall perception of forest for carbon capture, and the questions required an agree/disagree response. Part IV required the respondents to rank the various constraints (as major, minor, or not a constraint) faced by the respondents intending to be involved in carbon capture projects.

The survey was implemented over a period of 6 months. The respondent companies were initially contacted, notifying them of the implementation of the survey and other logistic matters. The questionnaire was then mailed to the target respondents, and a follow up telephone call was made four weeks later to check on the progress with the questionnaire, while reminding them return the filled questionnaire using the self-addressed, stamped envelope provided. Reminders were given again after two months if the questionnaire had not been returned. At the end of the 6 months, the return rate of the questionnaire was 100%, *i.e.*, all respondents had returned the questionnaire.

Analysis of Data

The data from the questionnaires were initially compiled and tabulated using Microsoft Excel software (Microsoft, version 2010, Las Vegas, NV, USA), as the data collected were substantial. The data were then analyzed using the Statistical Package for the Social Sciences (SPSS; IBM, version 25, New York, NY, USA). Frequency distributions and percentages of the responses were calculated for the tabulated data sets, and where appropriate, tables and graphical representations were prepared. Since the data obtained were nominal, the relationship between the various constraints that affected the respondents' decision to participate in forest carbon capture projects, were tested using the

Chi-square (χ^2) and Pearson Product Moment Correlation (PPMC) methods. These statistical tests are used to compare observed results with expected results and to determine whether a difference between observed data and expected data is due to chance, or if it is due to a relationship between the variables being studied. These tests were suitable for non-parametric data sets, which did not involve scaled measurements. Further, the results would provide useful insights in identifying the primary constraints that shaped the decision of forest growers to participate in carbon capture schemes.

RESULTS AND DISCUSSION

Demographic Characteristics of the Respondents

The demographic characteristics of the respondents who had participated in this study are shown in Table 2.

Table 2. Demographic Characteristics of Respondents

Characteristics	Response
Age group: 35–65 years	91%
less than 35 years old	8%
Average land holding	8,300 ha
Gender (Male)	100%
Experience in sector: >10 years	79%
5–9 years	21%
Education level: secondary	16%
tertiary (at least Diploma)	84%
Marital status: married	100%
bachelor/single	0%
Location: Peninsular Malaysia	68%
Sabah & Sarawak	32%

All the respondents surveyed in this study have sufficient experience as forest owners, although the majority indicated that they have been previously involved in the cultivation of agricultural crops, particularly rubber and palm oil. Interestingly, rubber, palm oil and tree crop cultivation are not deemed attractive to the tertiary educated workforce, as found in an earlier study by Ratnasingam (2019), which reported that the ageing 1st generation farmers are finding it difficult to entice the second and third generations to participate in such a tedious and low-income sector, and hence are heavily dependent on foreign contract workers (Ratnasingam and Ioras 2006). Inevitably, the apparent poor performance of smallholder farmers in rubber and palm oil cultivation is evidence by the challenges faced by the Rubber Industry Smallholders Development Authority (RISDA) and the Federal Land Development Authority (FELDA), the largest players in the rubber and palm oil sector respectively in the country. On the contrary, this study revealed that interests among tertiary educated workforce to participate in forest establishment sector is higher (84%) compared to the traditional crops such as rubber and palm oil, which possibly can be attributed to their greater concern for the climate change agenda (Ratnasingam *et al.* 2018). This may also be due to the 'graduate farmers scheme', introduced by the government to encourage tertiary educated workforce to participate in the agriculture sector. This scheme provides financial incentives to participants, which some have indicated to be attractive (Ratnasingam *et al.* 2018).

Awareness and Knowledge of Forest Carbon Credit Projects

Table 3 shows that a majority (62%) of the respondents had not heard about forest carbon, while 38% acknowledged they were aware of forest carbon projects. In this respect, it is apparent that the low level of awareness and knowledge of forest carbon projects among the respondents suggests insufficient extension programs, to disseminate information about such forest carbon credit ventures. A similar finding was also reported in the study by Stek *et al.* (2023), who found that knowledge on forest carbon projects was still at an infancy among many forest administrators and conservators. The lack of information and model forest carbon projects appears to remain strong among respondents, which not only dissuades them from wanting to know more about such projects, but also imparts a high degree of skepticism among them on the credibility of such projects (Cambridge Zero Policy Forum 2021). In this context, it comes as no surprise that not many respondents have explored forest carbon projects, due to the difficulty and lack of clarity in forest carbon credit projects (Table 3). Although the need for forest certification either through the Pan-European Forest Certification Scheme (PEFC) or the Forest Stewardship Council (FSC) is prevalent among the respondents, as it is deemed to be a market-requirement (Diaz-Balteiro *et al.* 2017), the uncertain financial benefits to be gained from forest carbon credit projects appears to a dauting challenge for most respondents, which is parallel to the findings of the previous study by Behr *et al.* (2023).

Table 3. Level of Awareness and Knowledge of Forest Carbon

S/No.	Item	Yes (%)	No (%)
1	Have you heard about forest carbon?	38	62
2	Have you explored forest carbon ventures?	2	98
3	Would you switch your current forest area to a forest carbon scheme?	0	100
4	Do you think forest carbon scheme is more beneficial than forest for biomass or wood production?	4	96
5	Do you have difficulty in understanding forest carbon scheme?	93	7
6	Do you have easy access to information on forest carbon schemes?	0	100
7	Do you agree than forested areas are more environment-friendly than plantations of rubber and palm oil?	89	11
8	Do you have the knowledge and relevant expertise to venture in forest carbon schemes?	5	95
9	Are you aware that forest carbon schemes have a long gestation period?	94	6
10	Are you aware of the forest carbon schemes and policies by the government?	14	86
11	Are you aware that there are different forest carbon types?	3	97
12	Do you agree that forest certification is desirable if venturing into carbon schemes?	72	28
13	Do you know of any successful or model forest carbon scheme in the country?	0	100
14	Are the natural forests better for forest carbon compared to plantation forests?	73	27

Table 3 supports the narrative that forest establishment is deemed to be economically more viable for the production of biomass (*i.e.*, wood chips for biomass energy), and for wood production, rather than forest carbon to off-set climate change

emissions. The fact that Bursa Malaysia did not have much success with forest carbon credit projects since its exchange inception in 2022 suggest that uptake of such forest carbon credit projects is indeed slow and limited (Agarwal *et al.* 2022). Without clarity in methodology, standardization, and trade practices, forest carbon remains an elusive topic for exploration among forest growers and forest administrators. Further, the negative perception attributed to such forest carbon projects as being "scams" may also serve as deterrent for new potential participants in such schemes (Lefebvre *et al.* 2021). A case in point is the Sabah Nature Conservation Agreement (NCA), which was signed in October 2021 between the Sabah government and a Singapore-based carbon credit developer without consultation of local stakeholders, nor the national government, was declared as "legally impotent", further fueling speculations that carbon credit projects do not necessarily have the required transparency and credibility (RESCU 2022).

The above case in point underlines the fact that at the heart of Malaysia's forestry sector also lies a jurisdictional quagmire, wherein forest management is predominantly governed by state authorities rather than federal oversight. Historically, Peninsular Malaysia and Borneo (Sabah and Sarawak) have indigenous communities with deep connections to the land, but governments have permitted extensive growth of the logging industry with regional differences in practices, regulations, and environmental considerations. This decentralization of power poses a hurdle to the effective management and regulation of forests, particularly concerning carbon credit initiatives. In Malaysia, state authorities often rely heavily on logging as a source of income, presenting a significant barrier to prioritizing the protection or regeneration of forests conducive to carbon credit markets. The allure of immediate economic gains from timber extraction often overshadows the long-term benefits of preventing deforestation or reforesting previously logged areas. Consequently, allocating resources towards such initiatives becomes challenging, as it requires diverting attention from a lucrative industry deeply entrenched in local economies. Furthermore, Malaysia lacks a carbon tax system to set the price of carbon. The current dismal pricing of nature-based credits undermines the investment incentive for state authorities, as the potential returns may not offset the revenue generated from logging activities. Thus, the convergence of economic dependency on logging and the undervaluation of nature-based credits creates a formidable barrier to fostering meaningful conservation, let alone reforestation, which are necessary for carbon credit generation in Malaysia (Siew 2024).

Serious challenges also stem from the lack of uniformity in forest management practices across Malaysian states. Varying regulations, enforcement capabilities, and conservation priorities contribute to inconsistencies in carbon sequestration efforts. Without consistent protocols for measuring carbon stocks and emissions reductions from forests, the credibility and transparency of Malaysia's carbon credit projects will continue to be called into question as investors and international stakeholders demand verifiable data to ensure the legitimacy of carbon offsets.

Moreover, issues of land tenure and indigenous rights complicate the landscape of carbon credit generation in Malaysian forests. Indigenous communities, often stewards of the land for generations, hold customary rights over vast forested areas. Any carbon credit initiatives must prioritize the inclusion and empowerment of these communities, respecting their land rights and traditional knowledge. Failure to do so not only risks exacerbating socio-environmental injustices but also undermines the long-term sustainability of carbon sequestration initiatives (Siew 2024).

Against this background, this study reveals that the respondents' lack of knowledge and awareness appears to be the biggest stumbling block to entice them to participate in forest carbon projects. Despite the release of the National Guideline on the Voluntary Carbon Market Mechanisms by the Ministry of Environment and Water in 2022, information and knowledge of forest carbon credits has remained within the realms of government officials, rather than private stakeholders, as information dissemination has been limited. Inevitably, despite its large forest endowment, successful development of forest carbon credit projects remains difficult to be realized up to the present in the country.

Perception Among Respondents towards Forest Carbon Credit Projects

Table 4 shows that most respondents agree with the perception that a forest carbon credit project can be regarded as a rather difficult venture and that it does not yield the desired financial benefit. Furthermore, they also perceive that forest carbon credit projects as a business venture takes too long a time to be realized, and its profits are uncertain. A similar sentiment was echoed by the respondents in the sense that as of now, no successful ventures of such a nature-based carbon off-set solution have been reported in the country (Kelly *et al.* 2017). Although a majority of the respondents agree that forest carbon credit projects constitute a low-cost climate change mitigating solution (Behr *et al.* 2023) that should be pursued, the respondents have rather mixed perception regarding forest plantation, due to its' monoculture composition, is indeed a better option for forest carbon credit projects compared to natural forest. The respondents also believe that forest plantations contribute to biodiversity loss, as forest plantations are mainly monocultures, and in addition they have been shown to be a less efficient carbon storage sink compared to the natural forests (Rahman *et al.* 2021). Most respondents did not agree that forest carbon credit projects would give good return on investment (ROI), a concept which they are very familiar with as the term is widely used during their discussions with financial institutions, as well as growers of rubber and palm oil (Ratnasingam 2020). The concept of return on investment (ROI) is the ratio of money gained or lost on an investment relative to the cost of the investment appears to be well appreciated among the respondents. The ROI concept allows the respondents to analyze and compare investments to identify the best alternative for their situation, and forest growers are more aware of the different costs associated with owning and operating a forested area meant for biomass and wood production, rather than for forest carbon, due to the lack of information and guidelines (Grafton *et al.* 2021).

Although the respondents perceive forest carbon credit projects to be difficult, they also concur that the existing policies, guidelines, and prevailing ecosystem do not necessarily encourage forest carbon credit projects, as reported previously in the study by Azmi & Associates (2023). The fact that land tenure and ownership of forested land are also primarily in the hand of the respective state governments is also seen as a deterrent for increased private participation, in long-term forest carbon credit projects.

As reported previously by von Hedemann *et al.* (2020) and Fouqueray *et al.* (2021), forest owners were also well aware of the fact that forest carbon credit projects cannot be successful should the forested area be relatively small; rather, areas of at least 50,000 hectares would be necessary to assure *viability* of such projects over a long period of time of at least 45 years. In this respect, the potential for forest carbon credit projects on smaller forested area becomes attractive only if it is offered in tandem with other co-benefits, such as eco-tourism, biodiversity conservation, renewable energy generation (*i.e.*, solar farm), as well socio-economic development of aboriginal communities to ensure sufficient

multiple income-streams to ensure success (Rahman *et al*. 2021). In this respect, this study shares similar findings to that of the study by Altamirano-Fernandez *et al.* (2023), which clearly stated that the certification of forests should be mandated to alle*via*te some of the risks associated with biodiversity loss, before forest carbon credit ventures are pursued, together with other co-benefits.

Table 4. Perception of Respondents towards Forest Carbon Ventures

S/No.	Respondents' Perception	Agree (%)	Disagree (%)
1	Management of forest for carbon is difficult.	89	11
2	Forest is a high carbon sink.	96	4
3	Natural forests are a better carbon sink compared for forest plantations	93	7
4	Forest carbon is an effective low-cost nature-based climate change mitigating solution	71	29
5	The long-term investment in forest carbon is profitable	16	84
6	Private forests can be easily established in the country.	28	72
7	Forested areas provide better return when focused on biomass and timber production rather than carbon	89	11
8	Forest plantation for biomass production is the most financially attractive option	86	14
9	Return on investment (ROI) in forest carbon is high.	4	96
10	Forest carbon is a *viable* economic sector in the country	2	98
11	There is favorable policy supporting the forest carbon schemes	19	81
12	Forest carbon with co-benefits from eco-tourism and socioeconomic development of aboriginal communities is highly attractive	63	38

Constraints to Forest Carbon Credit Projects

Table 5 shows the important constraints faced by forest growers when exploring forest carbon credit projects. The top five constraints identified are (1) higher economic returns from biomass or wood production, (2) uncertainty in carbon pricing, (3) lack of clarity in carbon trade policy, (4) lack of successful forest carbon credit projects, and (5) insufficient knowledge and expertise. Other factors identified as also having a negative influence on the decision to participate in forest carbon credit projects include unclear state forest policy in terms of carbon credit, poor ecosystem supportive of forest carbon credit projects, land tenure issues, long-term investment or gestation period, lack of standards and methodology, immature carbon credit market, availability of other easier options for decarbonization through technology-based solutions, lack of rules-based market for carbon trading, and the limited appreciation of environmental conservation in the society. These factors have also been identified in the report by the World Bank (2023) and Zhang *et al*. (2024). In essence, the constraints underline the many challenges faced when exploring forest carbon credit projects. There are other options, particularly forest for wood production and forest for biomass production, which has a large market both domestically and globally, which is not only lucrative but also easier to manage. Inevitably, the evidence from this study suggests that the viability of forest carbon credit projects in the country still has a long way to go.

Forest carbon credit purchasers come from an array of backgrounds. In VCMs, the buyers are usually organizations with a target offset for GHG emissions from their operations, which indirectly seek to positively impact the climate. VCMs are driven

primarily by sales-side of the carbon markets, and the success of VCMs is dependent on maintaining integrity and transparency of markets and the credits traded. In this context, standards (*i.e*., Gold and Verra), registries, and auditors are responsible to ensure the legitimacy of the carbon credit traded. The standards must define the methodology while also maintaining a carbon credit registry. Further, the processes should provide accreditation to auditors and validators, who are solely responsible to evaluate and verify the forest carbon projects, which at the present time remains challenging (Stek *et al.* 2023).

Table 5. Constraints Faced in Forest Carbon Ventures

Constraints	Major	Minor	Not a Constraint
Higher economic return from biomass and wood production	87%	4%	9%
Uncertainty in carbon pricing	84%	12%	4%
Land tenure system	75%	17%	8%
Lack of clarity in carbon trade policy	82%	16%	2%
No successful carbon ventures	80%	16%	4%
Insufficient knowledge and expertise	80%	13%	7%
Unclear state forestry policy	61%	29%	10%
Poor ecosystem (*i.e.* market conditions) for carbon ventures	60%	31%	9%
Long gestation period	68%	24%	8%
Unverifiable standards and methodology	63%	22%	15%
Immature market for forest carbon	54%	33%	13%
Availability of easier options for decarbonization through technology-based solutions	61%	20%	19%
Lack of rules-based market for carbon trading	67%	23%	10%
Limited appreciation of environmental conservation within society	52%	36%	12%
Limited financing mechanism for forest carbon ventures	73%	22%	5%

Despite these constraints, some proponents of carbon tax argue that the implementation of carbon tax regime in the domestic market will facilitate greater participation in forest carbon off-set projects (van Kooten *et al.* 1995; Butler *et al.* 2009). However, the government's reluctance under the prevailing challenging economic situation and raised inflation within the domestic market, suggest that a carbon tax implementation in the near future in the country remains unlikely (KPMG 2021).

The chi-square analysis revealed that a significant relationship exists between poor economic returns, lack of financing mechanism, poor market structure for carbon trade, and the lack of knowledge and expertise, *versus* the decision to participate in carbon credit projects (Table 6). It is therefore apparent that economic return is the primary consideration for forest carbon credit projects, and when comparing forest for carbon against forest for biomass and wood production, the latter appears to be more profitable amidst the global economic challenges driven primarily by the high global energy prices (Augusto and Boca 2022). It may also be argued that the realization of forest for biomass is often at 6 to 7 years rotation, while forest for wood production may be realized within 15 years. On the contrary, forest carbon credit projects may take up to five years for implementation and may yield the necessary profits over much longer periods, compared to biomass production (Ratnasingam and Natkuncaran 2022).

The result of the Pearson Product Moment Correlation (PPMC) between the constraints is highlighted in Table 6, and the poor economic return have the strongest

impact on the decision of forest growers not to pursue forest carbon credit projects, as reflected by the significant correlation (r = 0.479, p = 0.03). The PPMC test was conducted on the four significant factors identified after the chi-square test (*i.e.* poor economic returns, lack of financing mechanism, poor market structure for carbon trade, and the lack of knowledge and expertise, and the decision to participate in carbon credit projects. Therefore, this study conclusively shows that for forest carbon credit projects to be successfully developed and implemented, the constraints related to low economic return, lack of financing mechanism, poor market structure for carbon trade, and lack of knowledge and expertise, must be addressed. Similar findings were also reported by Mukul *et al.* (2021) and Agarwal *et al.* (2022) in their reports, which emphasized the need for appropriate economic returns, sufficient knowledge, and local capabilities, and scaled up financing to facilitate greater forest carbon ventures.

Table 6. Chi-square Analysis of Constraints and Impact on Decision Making to Establish Forest Plantations

Variables	x^2-Value	p-Value	Impact on Decision Making to Pursue Forest Carbon	Pearson Product Moment Correlation (r Value)
Poor economic returns	26.038	0.030	S	0.479
Uncertainty in carbon pricing	3.631	0.326	NS	-
Lack of clarity in carbon trade policy	21.013	0.044	S	0.321
Lack of financing mechanism	15.472	0.047	S	0.358
No successful carbon ventures	0.865	0.968	NS	-
Land tenure system	1.476	0.211	NS	-
Insufficient knowledge and expertise	18.073	0.045	S	0.318
Long gestation period	3.443	0.583	NS	-
S = ($p \leq 0.05$), S = significant, NS = not significant.				

Implications of Study

Malaysia has committed to achieving climate neutrality and to cut greenhouse-gas (GHG) intensity against its gross domestic product (GDP) by 45 percent by 2030 compared with 2005 levels. In order to achieve this goal, the government has implemented several policy measures, such as the National Energy Transition Roadmap (NETR) and the New Industrial Master Plan 2030 (NIMP), which lays down a set of guidelines and action plans to facilitate the shift towards climate neutrality. According to Malaysia's third biennial update report to the United Nations Framework Convention on Climate Change (UNFCCC), the country's annual emissions in 2020 amounted to 334 metric megatons of CO_2 equivalent (MtCO2e). Malaysia's forests play a significant role in mitigating climate impact, sequestering an estimated 259 $MtCO_2e$ a year, through measures such as legally designating reserved forests and protected areas including national parks and wildlife sanctuaries (Adebayo *et al.* 2020). Given the importance of forest-based sequestration in Malaysia, the country would need to maximize efforts to avoid deforestation and sustainably manage land use to meet its climate goals.

Malaysia could expand carbon sequestration in forests and the natural environment beyond current levels through an array of measures. These include restoring degraded forests, mangroves, and peatlands and increasing the amount of carbon sequestered per

hectare of land through better land management practices. In this respect, Malaysia has been ranked 7th in the world in share of potential low-cost nature-based solutions, with a 40 $MtCO_2e$ emission crediting potential (Agarwal *et al.* 2022). These include avoiding deforestation contributing 26 $MtCO_2e$, peatland restoration providing an additional 11 $MtCO_2e$, natural forest management contributing 2 $MtCO_2e$, and another 1 $MtCO_2e$ from reforestation activities.

Despite the promising scenario, Malaysia trails other Southeast Asian countries in carbon credit issuances, which necessitates the rapid mobilization of carbon projects ecosystem by addressing the gaps identified in this study, in order to exploit the globally growing demand for carbon credits. Although Malaysia has had a few carbon projects under the clean development mechanism (CDM) in the past, new entrances are limited due to the nascent market challenges related to up-front carbon financing (Wright *et al.* 2000).

Table 7 reveals that under prevailing circumstances, forest carbon credit projects are comparatively less attractive financially, compared to forest for biomass and wood production. The poor economic return of forest carbon credit projects serves as a strong deterrent for new entrances, especially among forest growers, who prefer to capitalize on the huge global demand for biomass for energy and pulp/paper industry (Donnison *et al.* 2020). It is estimated that in 2022, almost 14 million m^3 of wood chips were exported from the country, suggesting that this huge volume of biomass may deprive the domestic wood-based panel producers of the necessary supply for their operations (MTIB 2022).

Table 7. Comparative Economic Benefits of Forest Carbon

Forest for	Average Area (ha)	Average Yield per ha/year	Average Price per Unit (RM)	Average Income per ha (RM)
*Biomass	10,000	400 m^3/ha	180 per ton	39,600
*Wood	10,000	250 m^3/ha	120 per m^3	30,000
Carbon	50,000	100 metric tons/ha	25 per metric ton	2,500 per year
Data Source: Ratnasingam and Natkuncaran 2022. RM = Ringgit Malaysia. * Biomass at 7 years rotation, while wood at 12 years rotation. Carbon credit was calculated over a period of 45 years, which is typical for the lowland forest cover in the country.				

Table 8 provides the cost–benefit analysis of the various business options for forested areas in the country. At the current rate, it is apparent that the economic returns from forest carbon credit is not comparable to that of forest for biomass, and forest for wood production.

Table 8. Cost-benefit Analysis of Forest Carbon versus Biomass Production and Wood Production on a 25 Year Rotation

Forest Option	Establishment Cost (RM/ha)	Maintenance Cost until Harvest (RM/ha)	Potential Income (RM/year)	Net Present Value (RM)	B/C Ratio
Wood Production	8200	3650	800	51,000	6.3
Biomass Production	4200	1250	650	27,000	8.9
Forest Carbon	14,000	8,450	2,500	22,400	3.9
Forest Carbon with co-benefits	31,000	10,300	4,300	28,000	4.7
Data Sources: Cuong *et al.* 2020; Donnison *et al.* 2020; Ratnasingam *et al.* 2021; Ratnasingam and Natkuncaran 2022. RM = Ringgit Malaysia. B/C = Benefit/Cost					

Unless there is a significant change in the economic returns, there is little evidence that forest growers would explore the possibility of venturing into forest carbon credit projects. The concept of potential income relates to the possibility of sales of produce per month, granting that all conditions enable the forest owners to achieve the output. However, the output is not only affected by soil condition, topography, market demand conditions, pest risks, but also the fluctuating prices in the global market place (Cubbage *et al.* 2022; Cuong *et al.* 2020). In the case of forest for biomass production, the economic returns are higher due to the shorter rotation, compared to forest for wood production (Anderson *et al.* 2013; Bleyer *et al.* 2016; Favero *et al.* 2020). On the other hand, forest for carbon requires a long-term conservation approach, which may be intertwined with co-benefits such as eco-tourism and socioeconomic development of aboriginal communities, which may be more attractive to some international carbon credit buyers over the longer term. Nevertheless, under the present situation, the uncertainty with the value-streams of such an option, and the associated lack of initial financing remain as major obstacles (Agarwal *et al.* 2022; Stek *et al.* 2023).

The global carbon credit price of USD 5.0 per metric ton, at the present, is relatively low for most private forest owners to venture into forest carbon credit projects (Pan *et al.* 2022; World Bank 2023). On the other hand, public forests, which in Malaysia are owned and managed by the respective states, do not necessarily ensure longevity. This is because de-gazettement of forest remains a thorny issue. Forest area conversion for other purposes continues to be reported (Probst *et al.* 2023). Whether it is a matter of green-carbon (*i.e.*, carbon from forests) or blue-carbon (*i.e.*, carbon from oceans and coastal vegetations, including mangroves), there is an urgent need for policymakers to address the prevailing gaps that appears to restraint forest carbon credit project developments (Thompson and Hansen 2012; Smith *et al.* 2000). These include the harmonizing the design of voluntary and compliance carbon markets in the country, defined rules and guidelines for carbon project development, scale-up carbon financing to facilitate carbon projects with other co-benefits, and establish local capabilities in terms of project development, validation and verification bodies (Guitart and Rodriguez 2010; Bukoski *et al.* 2022). These gaps must be addressed sooner than later, as a fair, orderly, rules-based market will be crucial for

aggregating supply and demand and providing effective price discovery to companies and carbon project developers. Partnerships with global entities, such as established carbon standards (*i.e.*, Verra and Gold), can also ensure the design of Malaysia's voluntary carbon market incorporates lessons learned and best practices from other carbon markets. Further, the compliance carbon markets that allow a limited number of carbon credits that meet specific quality criteria can also accelerate the growth of an ecosystem of service providers to support the development and scaling of emission-reduction projects and activities (Leach and Scoones 2013; KPMG 2021).

In certain jurisdictions, there are interactions between compliance and voluntary carbon markets, whereby carbon credits from the voluntary markets are permitted to be used as part of the carbon reduction requirements in the compliance market (Pan *et al.* 2023). These markets have helped put a price on carbon and have helped to channel funds to finance projects that mitigate climate change through the buying and selling of carbon credits (Favero *et al.* 2023; World Bank 2023). In line with growing awareness of climate action, voluntary carbon markets (VCM) play an important role to support financing for projects and solutions that reduce, remove or avoid greenhouse gas (GHG) emissions. Participation in the VCM will allow companies to offset their carbon emission footprint and meet their voluntary climate goals. Perhaps this is an avenue that could be adopted by policymakers in the country, in order to accelerate the development of carbon credit projects.

One highly contentious issue is embedded in Malaysia's constitution, which stipulates that land use is a state matter, and therefore individual states can pursue their own strategies to allocate land and resources for carbon projects (RESCU 2022). In order to allay any fears and increase transparency, the first step will be for state and federal governments to coordinate closely on policies to encourage and facilitate nature-based solution projects with leading global organizations and local developers. This coordination would create clarity for market participants and facilitate the pooling of expertise and resources across the various states (Gren and Aklilu 2016; van Kooten and Johnston 2016; Kim *et al.* 2018).

Despite the challenges, Malaysia does possess inherent strengths that can be harnessed to unlock the carbon credit potential of its forestry sector. Malaysia has demonstrated a commitment to sustainable forest management through initiatives such as the Malaysian Timber Certification Scheme (MTCS), the Heart of Borneo (HoB) conservation initiatives, and the recently established Malaysia Forest Fund (MFF), which is mandated to explore the establishment of a Forestry Carbon Offset Protocol (Siew 2024).

Since carbon projects can take up to five years from initiation to the first issuance of carbon credits, urgency in addressing these gaps is absolutely crucial so that the carbon markets can scale in time to make meaningful contributions to Malaysia's 2030 carbon targets. In view of the country's forest endowments, Malaysia has an opportunity to not just meet its 2030 climate targets but also support the world through additional carbon sequestration. In this respect, the forest carbon markets could be one of the key enablers to help Malaysia do so.

CONCLUSIONS

1. The development of forest carbon credit projects in Malaysia has been limited due to several factors, such as the prevailing low carbon credit price, poor market structure

for carbon trading, the lack of expertise and capability, and the limited financing mechanism for carbon credit projects development.

2. Plantation forest owners are keen to exploit their forests for biomass production and timber production, which can be attributed to the higher return on investment, as well as the shorter gestation period. The higher demand for biomass worldwide is also a strong encouragement for such efforts.
3. Malaysia needs to improve its carbon credit market structure in order to facilitate interchangeability between the voluntary carbon market (VCM) and compliance carbon market (CCM) to facilitate the growth of its carbon credit market, while allowing it to increase its carbon sequestration.
4. Potential forest carbon credit projects in the country are more likely to come from natural forests, meant for conservation purposes to avoid any encroachment. In this respect, many state governments are highly motivated to exploit such natural forests site gazettes as permanent forest reserves for carbon credit ventures, as a source of income for the state.
5. Malaysia should adopt a multifaceted approach to navigate the complexities of jurisdictional governance and unlock the full potential of its forestry sector for carbon credit generation. Such an approach should aim to improve the coordination and collaboration between state and federal authorities to harmonize forest management regulatory framework, develop standardized forest carbon accounting methodologies. It should also foster meaningful engagement with indigenous communities to ensure the equitable distribution of benefits and protection of customary land rights. These efforts can be expected to indirectly enhance the social integrity of projects but also to strengthen their resilience to external pressures.

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