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Assessing forest biomass and diversity of tree populations in Tekam Forest Reserve, Pahang, Malaysia

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Abstract. *Ruziman HH, Mohti A, Nik Ali NNBNA, Ismail A, Pardi F. 2024. Assessing forest biomass and diversity of tree populations in Tekam Forest Reserve, Pahang, Malaysia. Biodiversitas 25: 2821-2827.* Free Air CO_2 Enrichment (FACE) experiments are long-term monitoring projects to comprehend the response of forest ecosystems to future atmospheres with CO_2 enriched. Therefore, the research aims to determine the forest biomass and species diversity in the FACE system of Tekam Forest Reserve (TFR), Pahang, Malaysia. The sampling plots of 25 m × 20 m were established in TekamFACE as experimental plot and control plot in TFR. Allometric equation, Shannon-Wiener, and Evenness indices were used to estimate the standing biomass, carbon stock and species diversity, respectively. Tekam FACE system recorded total forest biomass of 54.38 ton/ha, contributed by 42.82 tons/ha of Above-Ground Biomass (AGB) and 11.56 tons/ha of Below-Ground Biomass (BGB). High carbon stock was also estimated at both forest plots with 27.19 tons/ha in TekamFACE and 17.35 tons/ha in control plot. These values indicated that the forest has high biomass, which can contribute to carbon sequestration that help mitigate the impacts of climate change. Further, this forest recorded high Species Diversity (H') and Species Evenness (E) at TekamFACE (H' = 4.04; E = 0.93) and control plot (H' = 3.53; E = 0.83). Overall, this research emphasized that forests with rich biodiversity have substantial carbon sequestration capacity for the adaptation of forest ecosystems to future atmospheric changes.

Keywords: Climate change, FACE, forest, species diversity, Tekam Forest Reserve

INTRODUCTION

Forest ecosystems are crucial in addressing climate change because trees compose approximately 50% of carbon in their dry weight, whereby the increased size of standing timber directly correlates with increases in inbound carbon during photosynthesis (Napaldet and Gomez 2018). The ecological role of forests is considered a carbon sink because forest trees can remove atmospheric carbon by storing carbon in their standing biomass. In tropical forests, about half of the carbon is stored in tree biomass, and the remaining half is in the forest soil. Large trees (≥70 cm) contain 39.1% of above-ground biomass, a major component of the total biomass in the forests, reflecting the functioning of tropical ecosystems as well as carbon storage (Bradford and Murphy 2019). The quantity of tree biomass per unit of land area constitutes the primary inventory data needed to understand the flow of materials and water through forest ecosystems (Bargali and Bargali 2016). This study becomes compounded if forest biomass is to be measured and analyzed in its proper context as a part of the production, the very basis of the functioning of ecosystems (Awasthi et al. 2022). Tree diversity is an important indicator for the sustainability of forest ecosystem (Ampoorter et al. 2020). In general, assessment on floristic composition at family, genus and species levels were conducted for the biodiversity aspect of a study area (Luna et al. 2020). The forest reserve is considered diverse if many species are recorded in the study area (Lundström et al. 2016). Forest diversity, distribution, and community status play a crucial role in preserving forest ecosystems, enhancing ecological benefits, and shaping future forest dynamics (Baboo et al. 2017; Karki et al. 2017). Understanding these aspects helps us gauge the species composition and diversity within forests (Bisht et al. 2024), which also provides valuable insights for forest conservation efforts (Joshi et al. 2023). However, across many regions, most of tropical Asia's forests are degraded and fragmented as a result of massive forest conversion for agriculture and other anthropogenic pressures (Ashton et al. 2014; Hansen et al. 2020). Further, deforestation consequently leads to the release of stored carbon and hence becomes the major contributor to human-caused climate change (Lawrence et al. 2022). As such, tropical forests are potentially susceptible to the existential threats of changing climate (Sodhi et al. 2004; Siyum et al. 2020) and identifying its hazardous effects is crucial for forest management and conservation plans.

The long-term responses of forests to atmospheric CO_2 enrichment have been complicated to determine experimentally given their canopy's large scale and complex structure (Norby et al. 2021). In Malaysia, Free Air CO_2 Enrichments (FACE) experiments in Universiti Kebangsaan Malaysia and Tekam Forest Reserve, Jerantut, are long-term monitoring projects to assess the impact of free air CO_2 enrichment on forest habitats. Following this achievement, there is broad optimism that forests should be considered a mitigation tool for global climate change. Further, only some studies focus on the forest biomass and diversity of tree populations in FACE plots, especially in TekamFACE, Pahang. The importance of fully understanding the forest biomass and diversity of tree populations is obviously needed so that comprehensive management and conservation action plan can be carried out to maintain the sustainability of the forest for future generations, especially in the changing climate. Hence, this research was conducted in TekamFACE with elevated CO_2 concentration and a control plot with ambient CO_2 concentration in Tekam Forest Reserve. This research aims to investigate the forest biomass and species diversity under elevated carbon dioxide in the FACE plot and under ambient CO_2 in a control plot at Tekam Forest Reserve, Pahang.

MATERIALS AND METHODS

Study area

Tekam Forest Reserve lies between 4° North and 102° 35' East, in the district of Jerantut, Pahang. The TekamFACE system was built in Compartment 84, Tekam Reserve Forest, Jerantut Pahang at coordinates 3°58'25.1" N and 102°35'28.5" E with a width of 228 ha.

In this study, the FACE plot in Tekam Reserve Forest, Jerantut, Pahang, is an infrastructure in the shape of a hexagon with a side of 6 meters and 12 meters of height that was built by the Forest Research Institute Malaysia (FRIM) in 2016. The primary function of the construction is to allow CO_2 gas to be released within the experimental plot at the desired level in the surrounding area. In general, the operational journey of the TekamFACE system begins with creating CO_2 gas in the panel control house's gas barrel. The discharge of CO_2 gas through the flow pipe into the FACE hexagon's air space. Then, the LAN/WiFi data transfer from the 4-in-1 sensor device. Thus, the data was stored on the PC using the EZ ICMS program and data monitoring via the Android phone. In this study, the FACE plot in Tekam Reserve Forest, Jerantut, Pahang is an infrastructure in the shape of a hexagon with a side of 6 meters and 12 meters of height that was built by Forest Research Institute Malaysia (FRIM) in 2016. The main function of the construction is to allow CO_2 gas to be released within the experimental plot at desired level in the surrounding area. In general, the operational journey of the TekamFACE system begins with the creation of CO_2 gas in the panel control house's gas barrel. The discharge of CO_2 gas through the flow pipe into the FACE hexagon's air space. Then, the LAN/WiFi transfer of data from the 4-in-1 sensor device. Thus, the data was stored on the PC using the EZ ICMS program and data monitoring via the android phone.

A typical forest environment has a monthly CO2 range of 495 ppm, a temperature of 29.9°C, a relative humidity of 84.2%, and a light intensity of 110 lux. Beginning in June 2018, the rise of CO_2 gas in the usual environment within the FACE hexagon will be ±125 ppm (Azian et al. 2021). The increases of CO_2 gases were released through a rubber pipeline and controlled by the sensor devices in the panel control house built around the experimental FACE plot (Azian et al. 2020). The 4-in-1 sensor devices have been installed in the FACE plot to measure the parameters of CO_2 (ppm), air humidity (%RH), light intensity (Lux), and temperature (°C) every 10 minutes for 24 hours every day.

Tree sampling

There were two plots of 25 m × 25 m quadrats constructed, which were equal to 0.0625 ha each located in the control plot and FACE plot. All trees with Diameter at Breast Height (DBH) of 5 cm and above were tagged and measured at 1.3 m above the ground. The quantity of each species in the FACE and control plots, the size of the trees, and a visual inspection of the well-being of the trees were used to help in identification of species. The identification of the specimens was referred to "The number of known plants species in the world and its annual increase", Dipterocarpaceae, Foresters' manual of Dipterocarps, and Pocket CheckList of Timber Trees (Wyatt-Smith and Kochummen 1952; Symington et al. 2004; Christenhusz and Byng 2016).

Data analysis

The analysis involves tabulating all tree communities in Microsoft Excel according to their family, genus, and species level to describe the taxonomic composition in Tekam Forest Reserve. The estimation of total biomass, contributed by Above-Ground Biomass (AGB) as calculated by Chave et al. (2014) and Below-Ground Biomass (BGB).

$$AGB = 0.0559 \times (\text{Wood density} \times DBH^2 \times \text{Height})$$

After the biomass was determined, it was multiplied by 0.47 to determine the carbon content, which was then converted into a unit area (ton ha-1). Several ecological indices, including the Shannon-Weiner Diversity Index, the Evenness Index, and the Richness Index of Margalef, were used in this study to determine species diversity using PAST software (Hammer et al. 2001).

Shannon Diversity Index

$$H' = -\boldsymbol{\Sigma}\,(p_i)\,(\log 2\, p_i)$$

Where: p_i is the proportion of the species (n_i/N)

Evenness Index

$$E = \frac{H'}{\ln S}$$

Where:
H' : Shannon Diversity Index
S : Total number of species

The equation for maximum value of Shannon Index, H'_{max}:

$$H'_{max} = \ln S$$

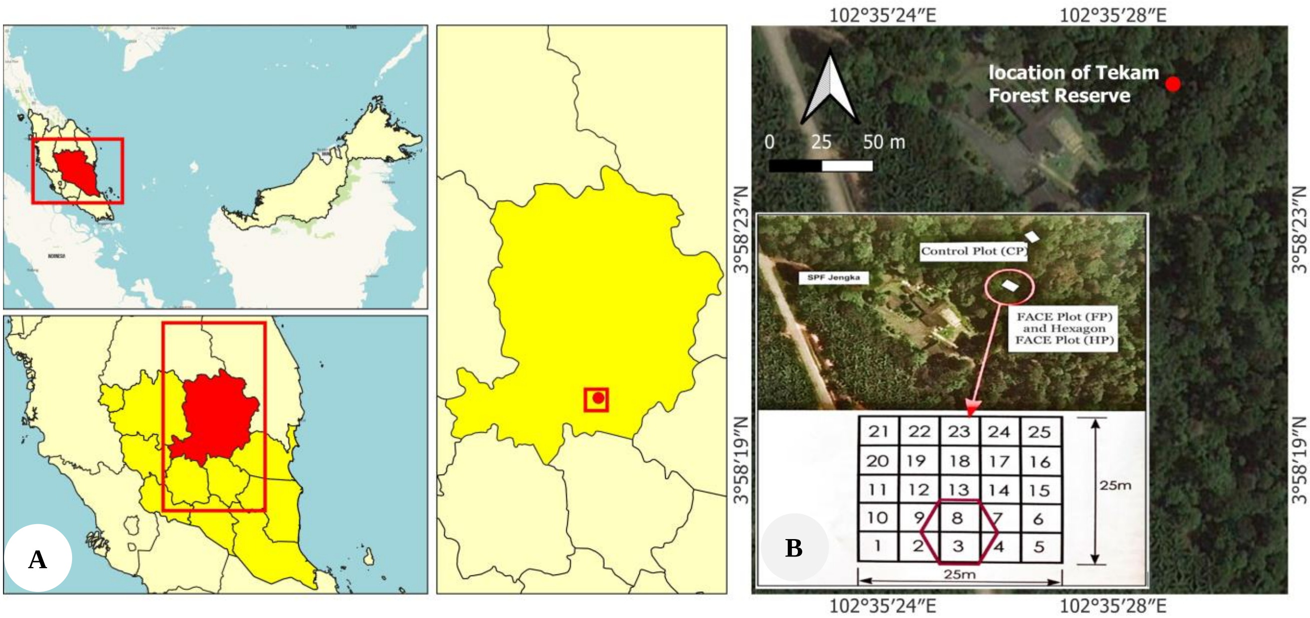

Figure 1. A. The location of Tekam Forest Reserve, Pahang; B. FACE Plot and Hexagon FACE subset plot design and position

Margalef's Richness Index (D_{MG})

$$D_{MG} = \frac{(S-1)}{\log N}$$

Where:
S : Total number of species
N : Total number of individuals

RESULTS AND DISCUSSION

Taxonomic composition

The study recorded a total of 140 trees of 96 species from 70 genera and 38 families in Tekam Forest Reserve, Pahang. A total of 76 individuals of 61 species from 50 genera and 33 families were recorded in the Tekam FACE. In the control plot of the forest, a total of 63 individuals of 41 species from 34 genera and 22 families were recorded (Table 1). In terms of stand density, a total of 1,232 ind/ha were recorded in the FACE plot and 928 ind/ha in the control plot. Euphorbiaceae had the highest density at the TekamFACE and control plot with 128 ind/ha for each, respectively.

The results indicated that the TekamFACE plot has a significantly higher tree density compared to the control plot in the forest, primarily due to the unique hexagonal infrastructure of the FACE system. This system, designed to inject enriched carbon dioxide (CO_2) from a centralized control panel house into the experimental plot at precisely controlled levels, has been in operation for the past eight years (Azian et al. 2020). The hexagonal layout ensures uniform CO_2 dispersion, fostering an environment that enhances photosynthesis, growth rates, and overall biomass accumulation among the trees. Over time, this consistent CO_2 enrichment has likely stimulated higher tree recruitment, survival, and altered competitive dynamics, favoring species more responsive to elevated CO_2 levels (Ainsworth and Rogers 2007).

Euphorbiaceae was ranked as the most well represented family in the whole study area of Tekam Forest Reserve, Pahang. There were 7 species from this family that contributed to 11.5% of the total species, such as *Blumeodendron kurzii* (Hook.f.) J.J.Sm. ex Koord. & Valeton, *Drypetes cockburnii* Airy Shaw, *Elateriospermum tapos* Blume, *Epiprinus malayanus* Griff., *Mallotus cuneatus* Ridl, *Paracroton pendulus* (Hassk.) Miq., and *Pimelodendron griffithianum* (Müll.Arg.) Benth. ex Hook.f. The most abundant species recorded from this family was *P. griffithianum* or locally known as 'Perah ikan' tree. The species can be found in wet forest, secondary forest, semi-swamps and along logging roads or on hill slopes which tallies with its occurrence in the hill dipterocarp forest of Tekam. Similar observation of *P. griffthianum* was also recorded in other hill dipterocarp forests such as in Pahang National Park (Zani et al. 2018) and Lambir Hills National Park, Sarawak (Ahmad Fitri et al. 2017).

Species diversity

The Shannon-Weiner Diversity Index (H') calculated using PAST software, for the TekamFACE was 4.04 (H' max = 4.11) and in the control plot was 3.53 (H'max = 3.71) (Table 2). The diversity of the tree species in both forests was nearly similar. According to Magurran (1988), the value of H' usually lies between 1.5 and 3.5, although in exceptional cases, the value can exceed 4.5 and above. Therefore, the values found for the two types of forest were high. Additionally, species evenness also accounted as a measure of biodiversity to quantify the uniformity of the species distributions. Pielou Evenness index (J') is constrained between 0 and 1 (Beisel et al. 2003). The result showed that the study areas have high values, at 0.93 for TekamFACE and 0.83 for the control plot. This indicates that all tree species in the present study were equally abundant hence contributing to high evenness obtained.

Table 1. List of taxonomic composition in the two forest plots at Tekam Forest Reserve, Pahang

Family	Control			FACE			Total
	Genus	Sp.	Ind.	Genus	Sp.	Ind.	
Alangiaceae	1	1	1	-	-	-	1
Anacardiaceae	1	1	1	-	-	-	1
Annonaceae	2	3	3	3	3	5	8
Apocynaceae	-	-	-	1	1	1	1
Araceae	1	2	8	-	-	-	8
Burseraceae	2	4	8	2	2	2	10
Combretaceae	-	-	-	1	1	1	1
Dilleniaceae	-	-	-	1	1	1	1
Dipterocarpaceae	1	2	6	2	5	7	13
Ebenaceae	-	-	-	1	1	1	1
Elaeocarpaceae	-	-	-	1	1	1	1
Euphorbiaceae	4	4	9	5	5	8	17
Fabaceae	4	4	4	2	2	3	7
Fagaceae	1	1	1	1	1	1	2
Flacourtiaceae	1	1	1	-	-	-	1
Hypericaceae	-	-	-	1	1	1	1
Lamiaceae	-	-	-	1	1	1	1
Lauraceae	-	-	-	1	3	3	3
Lecythidaceae	-	-	-	1	1	2	2
Melastomataceae	-	-	-	1	1	3	3
Meliaceae	2	2	2	1	1	1	3
Memecylaceae	1	1	1	1	1	1	2
Moraceae	1	1	1	2	2	2	3
Myristicaceae	3	4	4	2	4	5	9
Myrtaceae	1	1	1	1	2	2	3
Olacaceae	1	1	3	1	1	2	5
Palmae	-	-	-	1	1	1	1
Phyllanthaceae	1	2	3	4	6	6	9
Polygalaceae	1	1	1	1	1	1	2
Rubiaceae	2	2	2	2	2	2	4
Rutaceae	-	-	-	2	2	2	2
Sapindaceae	1	1	1	1	2	3	4
Sapotaceae	-	-	-	1	1	1	1
Sterculiaceae	-	-	-	2	2	2	2
Styracaceae	-	-	-	1	1	1	1
Thymelaeaceae	-	-	-	1	1	1	1
Ulmaceae	1	1	1	1	1	2	3
Violaceae	1	1	1	-	--	-	1
Grand total	34	41	63	50	61	76	140

High value of Shannon Diversity Index (H') represents the species rich ecosystem meanwhile an ecosystem with low value H' will have a low species diversity (Faezah et al. 2013; Spellerberg and Fedor 2003). As a comparison in other forests with similar sampling size, Norashikin et al. (2015) revealed that Gunung Basor Forest Reserve was the most diverse with index value of H' = 4.46, followed by Bukit Bakar Forest Reserve and Gunung Stong Tengah Forest Reserve with H' index values of 4.42 and 3.42, respectively. Hence, the results showed that Shannon diversity indexes in various forest habitats were high, depicting the characteristics of tropical forests in Malaysia that harbor high species diversity.

TekamFACE had a slightly higher Margalef Index (13.81) than control plot (9.66) because of a larger number of individuals/species (77 trees; 61 species) as compared to the control plot (63 trees, 41 species). These findings were in accordance with Magurran (1988) who stated that Margalef Index is correlated with the sample sizes such as the number of individuals. Similar observations were also demonstrated in all study sites by Nik Norafida et al. (2013) where the forests recorded high species richness of the Margalef Index. Among all study sites, Bukit Bauk Forest Reserve recorded many trees (1474 trees) thus contributing to the highest index value of 45.92. Meanwhile Lesong Forest Reserve with 1364 trees showed Margalef's Index value of 39.90 and Gunung Belumut Forest Reserve with its index value of 37.80 because of 1297 trees.

Biomass and carbon stock estimation

Forest biomass is considered as one of the parameters to describe the productivity of the forest. This is because trees compose 50% carbon in their standing timber hence contributing to the total forest biomass. This value represented by the Above-Ground Biomass (AGB) and Below-Ground Biomass (BGB). Total biomass of trees in TekamFACE was estimated at 54.37 t/ha. From this amount, a total of 42.82 t/ha was contributed by Above-Ground Biomass (AGB) and 11.56 t/ha of Below-Ground Biomass (BGB). Meanwhile in the control plot, the total biomass was estimated at 34.70 t/ha, represented by 27.33 t/ha of AGB and 7.37 t/ha of BGB. Nevertheless, there was no significant difference between the biomass of experimental TekamFACE and control plots ($p>0.05$). TekamFACE recorded more tree biomass or carbon density which may be influenced by the development of FACE system that injected elevated carbon dioxide into the plot. Thus, all trees in the FACE plot sequester more atmospheric carbon and the carbon were stored in their standing tree timber. These values also indicated that forests as a potential means of carbon sequestration thus can be considered as mitigation factor for climate change. The carbon sequestration rate in Malaysia is notably high, primarily attributed to the rapid plant growth within the region (Elbasiouny et al. 2022). High carbon stock was also estimated at both forest plots with 27.19 t/ha in TekamFACE and 17.35 t/ha in control plot. These values indicated that the forest has high biomass which can contribute to carbon sequestration that help mitigate the impacts of climate change (Raihan et al. 2021).

Family-wise, Dipterocarpaceae showed the highest total biomass with 31.41 t/ha in TekamFACE and 20.32 t/ha in control plot, respectively (Table 3). This family alone represent 50% of the total biomass and carbon stock estimated in the forest and this is possible because most dipterocarp trees are generally large and have greater DBH thus contributing to high tree biomass recorded (Richard et al. 2023). These findings showed that DBH is one of the most contributing factors that influence tree biomass value in a forest, as recorded in Pahang National Park (Zani et al. 2018) and Gunung Stong Tengah Forest Reserve, Kelantan (Norashikin et al. 2015).

Figure 2 shows that the coefficient of determination in Regression (R2) result between DBH and Carbon Stock (CS) which is Basuki et al. (2009) = 0.8915, Chave et al. (2014) = 0.7937; Kenzo et al. (2009) = 0.9015; and Kato et al. (1978) which is 0.8761. The scatter plot graph shows there is relationship between DBH with carbon stock based on tree species even using different equations. The regression values for all equations showed that there is a strong correlation coefficient between DBH and CS, thus this showed that higher DBH value thus the higher the carbon stock estimation. Additionally, species density also plays a role in increasing carbon stock, but its influence is dependent on tree size and species composition. Dense stands with numerous small trees may have less biomass compared to stands with fewer, but larger, trees. This indicates that large trees contribute significantly to higher carbon storage.

Conservation status and endemism

All species in the study plots were compared with the IUCN list to evaluate the conservation status. Overall, 48 species out of 96 species in the study area were listed in Red List of Threatened Species (Table 4). These species were rated in six different threat categories: (1) low risk, (2) vulnerable, (3) endangered and (4) critically endangered. 39 species were listed as lower risk, two species with data deficient, three species as vulnerable (*Aglaia oligophylla* Miq., *Nephelium costatum* Hiern, *Dipterocarpus baudii* Korth.), one species as endangered (*Shorea ovalis* (Korth.) Blume) and another three species as critically endangered species (*Aquilaria malaccensis* Lam., *Dipterocarpus cornutus* Dyer, *Shorea lepidota* (Korth.) Blume). All the endangered and critically endangered species listed were from the family of Dipterocarpaceae.

Dipterocarpaceae had the most significant percentage of threatened species because of its high economic value and dominating the international timber trade, especially in Southeast Asia (Khoo et al. 2023). Of all genera in *Dipterocarpaceae, Shorea* or its local name as Meranti recorded 100 threatened species of the total endangered species in IUCN Red List. This study also revealed three endangered *Dipterocarps* consisting of two *Shorea* species, namely *Shorea lepidota* and *S. ovalis* and one species of *Dipterocarpus cornutus*. Meranti trees have a slow growth rate and a long recovery time, which causes their population numbers to be drastically reduced (Purwaningsih and Kintaman 2018). Also, the presence of forest disturbances such as large-scale illegal logging, forest fires, and conversion of land contribute to their scarcity (Chua et al. 2022). Furthermore, Yong et al. (2021) listed 91 taxa of dipterocarps in Peninsular Malaysia under the threatened category of the IUCN Red List 2021. The largest number of threatened species in one family indicated that the family needs more attention in conservation (Siti Mariam and Jivitra 2019). This also shows the importance of the investigation on the conservation status of the tree species for the forest management activities.

A checklist of endemic trees compiled by Ng et al. (2010) for Peninsular Malaysia included a total of 2830 tree species from 532 genera and 100 families, of which 746 species (24.6%) are endemic. Of the total number of endemic trees, only nine species were endemic in the study area. Nine species namely *Baccaurea polyneura* Hook.f., *Drypetes cockburnii*, *Casearia clarkei* King, *Bridelia pustulata* Hook.f., *Licuala pahangensis* Furtado, *Alangium ridleyi* King, *Aporosa penangensis* (Ridl.) Airy Shaw, *Syzygium castaneum* (Merr.) Merr. & L.M.Perry, *Nephelium costatum* were recorded as endemic species in this study area (Table 5). This showed that tree communities in the study area have widespread distribution, which is not restricted to certain areas. High endemism was recorded in both Peninsular Malaysia due to the differences in the microclimate, physiography, and soil properties. In addition, Omar et al. (2020) concluded that the topography of Peninsular Malaysia formed by a mountainous spine (Banjaran Titiwangsa) is the reason for the endemic status of many species in the peninsula. The occurrence of endemic species in the forests played a crucial role in the structure and composition of tree communities, as well as reflecting the uniqueness of the forests (Brambach et al. 2017).

Table 2. Species diversity in the forest plots at Tekam Forest Reserve, Pahang

Locations	Shannon Diversity Index (H')	Evenness (E)	Margalef Index (D_{MG})
TekamFACE (this study site)	4.04	0.93	13.81
Control plot (this study site)	3.53	0.83	9.66
Gunung Belumut Recreational Forest	4.82	0.85	21.37
Gunung Basor Forest Reserve	4.46	0.97	17.52

Table 3. List of five leading families in the biomass estimation in the study area

Location	Family	AGB (t/ha)	BGB (t/ha)	TB (t/ha)
TekamFACE	Dipterocarpaceae	24.74	6.68	31.41
	Burseraceae	3.63	0.98	4.62
	Fabaceae	2.73	0.74	3.46
	Annonaceae	1.94	0.52	2.46
	Rutaceae	1.25	0.34	1.58
Control plot	Dipterocarpaceae	16.00	4.32	20.32
	Fagaceae	3.68	0.99	4.67
	Olacaceae	1.91	0.51	2.42
	Araceae	1.85	0.50	2.35
	Euphorbiaceae	1.07	0.29	1.36

Table 4. The numbers of tree species listed under the IUCN Red List category in the study plots of TFR, Pahang

IUCN Red List category	Total no. of species	Percentage of species
CR	3	3%
EN	1	1%
VU	3	3%
DD	2	3%
LC	39	35%

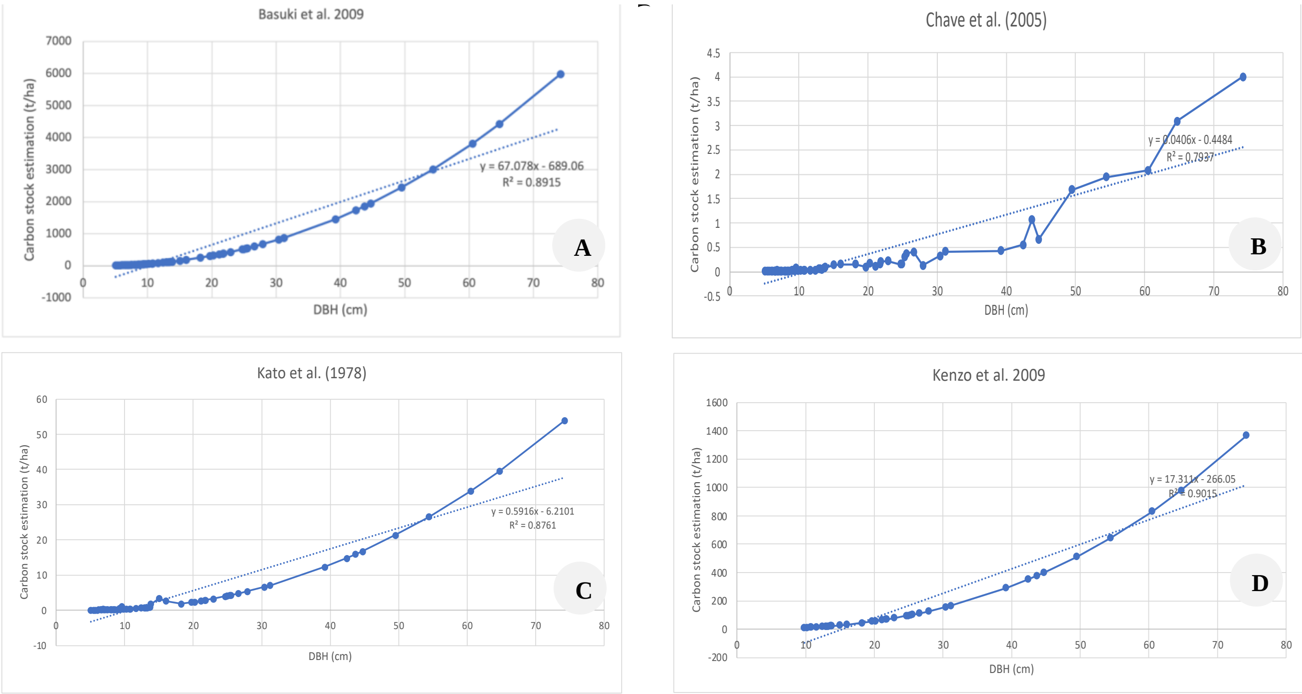

Figure 2. Regression graph for the relationship of carbon stock estimated and DBH at Tekam Forest Reserve, Pahang. Note: A. Basuki et al. (2009); B. Chave et al. (2014); C. Kato et al. (1978); D. Kenzo et al. (2009)

Table 5. Endemic species in Peninsular Malaysia that were found in Tekam Forest Reserve, Pahang

Family	Species	Location
Phyllanthaceae	*Baccaurea polyneura*	Pk, Ml
Euphorbiaceae	*Drypetes cockburnii*	Ph, Jh.
Flacourtiaceae	*Casearia clarkei*	Pk, Ph, Sl, Jh
	Bridelia pustulata	Pk, Ph, Sl, Ml, Jh, Sp
Palmae	*Licuala pahangensis*	Ph
Alangiaceae	*Alangium ridleyi*	Kd, Pn, Tg, Pk, Ph, Sl, NS, Ml
Euphorbiaceae	*Aporosa penangensis*	Peninsular Malaysia lowland forest; Pk, Jh
Myrtaceae	*Syzygium castaneum*	
Sapindaceae	*Nephelium costatum*	Pk, Ph, Sl, NS, Ml

Note: Jh: Johor; Kd: Kedah; Ml: Melaka; NS: Negeri Sembilan; Ph: Pahang; Pn: Penang; Pk: Perak; Sl: Selangor; Tg: Terengganu

In conclusion, this study shows that TekamFACE has a rich biodiversity with high carbon sequestration capacity based on their tree biomass and carbon stock. Thus, it is said that TekamFACE or any other Face system has the potential to be a valuable climate change mitigation tool. It could assist tropical forests in absorbing more carbon dioxide from the atmosphere by increasing CO_2 levels in their vicinity. This would help to reduce the risk of global warming and delay the rate of climate change. In the future, it is recommended to have a large sampling area for more reliable results and to represent species diversity, better investigating the relationship between edaphic factors, the impact of elevated CO_2 on forest structure after ten years, and tree species composition is also suggested. More findings are needed to research the face system for increased CO_2 levels around Malaysian tropical forests.

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