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Peat Land Oil Palm Farmers' Direct and Indirect Benefits from Good Agriculture Practices

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Abstract: With economically unsustainable metroxylon sagu (sago palms) found in peat lands, small scale farmers are gradually converting their land to oil palm cultivation. Good agriculture practices (GAP) were inculcated to peat land farmers to ensure that the environmental ecosystem is conserved and oil palm productivity is enhanced, along with the farmer's well-being. The present study examined the effect of GAP on farm performance and the perceived economic well-being of the peat land oil palm farmers. We interviewed randomly selected farmers with assistance from a locally trained native enumerator to complete the survey questionnaire. We conducted partial least square structural equation modeling (PLS-SEM) to incorporate direct and indirect benefits on farmers' economic well-being to estimate the significance of GAP. The empirical results show that GAP have direct positive effects on farm performance. Such practices lead to significant positive impacts on the economic well-being of peat land oil palm farmers. This solid evidence makes it much easier for small-scale farmers to convert from conventional farming to environmentally friendly farming, and ensures safe and healthy oil palm cultivation.

Keywords: farm performance; economic well-being; environmental sustainability; good agriculture practice; sustainable development

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1. Introduction

Peat lands are significant landscapes for the environment, economy, and public health. Peat lands cover an estimated area of 400 million hectares of the Earth's land surface, whereas tropical peat lands cover only 30–40 million hectares [1]. The soil found in peat lands is dominated by organic soil materials, with more than 50% in the upper layer of the soil [2,3]. The major typical problems with peat soil, especially deep peat, lie in its physical and chemical properties. Peat land ecosystems have various functions, especially for storm water retention, flood protection, water quality enhancement, freshwater fishery, food chain support, feeding grounds for marine fish, biodiversity, carbon storage, and climate mitigation [4–6]. Loss of biodiversity [7,8] and the contribution to global climate change through carbon emissions are the main concerns about peat land conversion [9–13]. Therefore, changes in peat land use and land cover affect the ability of landscapes to continue providing the high-quality ecosystems required for human health and well-being [14,15]. Some peat swamp areas have proven suitable for oil palm cultivation; whereas, some areas need to be conserved because of their unsuitability for agricultural development and high value for wildlife conservation [1]. In 2010, commercial plantations covered approximately 3.1 million hectares of the peat lands in Peninsular Malaysia, Sumatra, and Borneo. Estimates show that 6 to 9 million hectares may have been converted into plantations before 2020 [16]. Peat swamp areas are, not only a challenge to agronomy, but also contribute potential social and environmental impacts [17–20]. Empirical evidence on peat land conversion indicates positive socioeconomic impacts for local people, but also shows negative environmental impacts, such as reductions in water quantity and quality, decreases in forest cover, intensification in air pollution, soil erosion and destabilization, and risks to human health, due to peat fire, haze, and flooding [20–24].

The Malaysian government has committed to enhancing the income of farmers and increasing agricultural production through replanting, land consolidation, and rehabilitation, to increase rural job opportunities and to eradicate poverty [25–30]. Malaysia is the world's second largest palm oil producer; the country produced 31.8% of the total global production in 2015 [31]. The palm oil sector also contributed 5% of the country's exports (USD5.19 billion/MYR 21.4 billion for January–June 2016) [a] and 37.9% to the gross domestic product (GDP) of the agriculture sector in 2018 [32]. Areas with oil palm planted by independent farmers increased from 0.69 million hectares in 2012 to 0.93 million hectares in 2016 [31]. The shortage of suitable land for oil palm cultivation in Malaysia, especially in Sarawak, has pushed the expansion of oil palm into peat lands [33]. Approximately 44% of the total oil palm area in Sarawak is planted on peat land areas. Moreover, approximately 37% of the total 1.4-million-hectare peat land area in Sarawak is planted with oil palm [16]. In addition, 8% of peat swamp forests in Sarawak were lost between 2005 and 2010. Expansion of oil palm areas on peat lands in Sarawak is expected to reach approximately 600,000 hectares by 2020 [34]. Thus, a good irrigation system should be constructed to prevent flooding [35,36] and effective fertilization [37] should be implemented to maximize yields and mitigate possible negative impacts [38]. Konuma [39] and Luke [40] emphasized that peat land can be capitalized without compromising natural capital, including biodiversity and ecosystem services. A well-planned oil palm cultivation can minimize degradation zones of high conservation value or high carbon stock [8,13,16,41–43]. Since 2019, Malaysia has enforced the strict non-conversion of peat lands and enacted environmental oil palm cultivation rules on existing peat lands, in line with the national action plan for peat land development. The Malaysia Palm Oil Board (MPOB) is highly committed to strengthening the competitiveness of the palm oil industry and enhancing environmental ecosystems by inculcating good agricultural practices (GAP) [12,31,44]. The GAP for oil palm cultivation are "guidance covering field operations in the plantation to transportation of oil palm bunches to the collection center or mill in order to increase production efficiency and to ensure good quality and safe raw material of oil palm bunches or fresh fruit bunches (FFB) suitable for palm oil production", while also taking into account economic, social, and environmental sustainability (p. 2) [45]. GAP would inspire farmers to optimize resource utilization in a sustainable manner, which could not only affect oil palm yields, but also improve ecological systems [12,20,37,42,43,46,47]. As such, farmers need to observe ecological and agronomic practices in growing oil palm crops to maximize their economic benefits and improve the biodiversity of ecosystems. The GAP guideline elements, namely planting, fertilizing techniques, soil and water management, drainage systems, pest and disease control, harvesting and post-harvesting process, are inculcated to peat land oil palm farmers by MPOB extension officers [48]. Since 2011, the GAP has been introduced, transferred, monitored, and audited by MPOB's extension officers, as noted in Mansor et al. [49]. Therefore, this study aimed to examine the effect of GAP on farm performance and the economic well-being of peat land oil palm farmers. The direct and indirect effects of GAP on the economic well-being of small-scale peat land oil palm farmers were investigated in this study.

2. Theory and Literature Review

2.1. Related Theory

Two main theories were used to discuss the adoption of GAP; namely, technology dissemination theory [50] and adult learning theory [51,52]. According to Rogers [50], a farmer decides to make full use of new technologies in farming practices for productivity enhancement and solving their problems [53,54]. With transformative learning theory [55], we expected that peat land farmers could gain new knowledge and practices to resolve challenges and sustain their future economic well-being. The benefits of good agricultural skills, attitude, knowledge, and practices [13,43,49,56,57], such as high productivity, added value, and resistant crops [54,58–60], were communicated to farmers. Transformative learning leads farmers to use past experiences as a guide for future actions, to be reflective, open to new perspectives, less defensive, and receptive to new ideas [55,61] for increasing productivity. Davis et al. [62] and Rustam [63] and Leitgeb et al. [64] suggested that farmers can learn in groups and collaborate on discovering and solving their agriculture problems.

2.2. Benefits in Farm Performance

A systematic literature review shows that environmental sustainability practices in oil palm cultivation enriched pollinator populations, which enhanced pollination [65]. Bee pollination improves the yield of most crop species, including oil palm crops [65,66]. Adequate weed management will protect the soil from erosion and provide a habitat for natural pests, while interacting with water and nutrient cycles [67]. An optimal yield is possible when oil palm trees are healthy [68]. Good drainage, which is needed to sustain oil palms in peat land, protects against the subsidence of soil, the potential deepening of future flood risks, and reduced oil palm growth [19]. Farm drainage systems, lanes, and farm roads should be well constructed and maintained. Groundwater should also be maintained to minimize peat subsidence [11,69,70], peat oxidation, and CO_2 emissions, as well as to drain out excess water for superior palm growth and production of fresh fruit bunches (FFB) [11,20,71]. The water level within drainage flows should be regulated frequently. Healthy oil palm trees are those not infected with parasites, pests, and diseases, such as fungus and Ganoderma; due to GAP in the selection of plant material, well-planned fertilization, pest control, and irrigation. Moreover, soil fertility needs to maintained to increased crop yields [26]. Previous research has shown that practicing good agricultural holistically increased agricultural yields. As a result, and as displayed in Figure 1, GAP are hypothesized to have a direct and positive effect on farm performance.

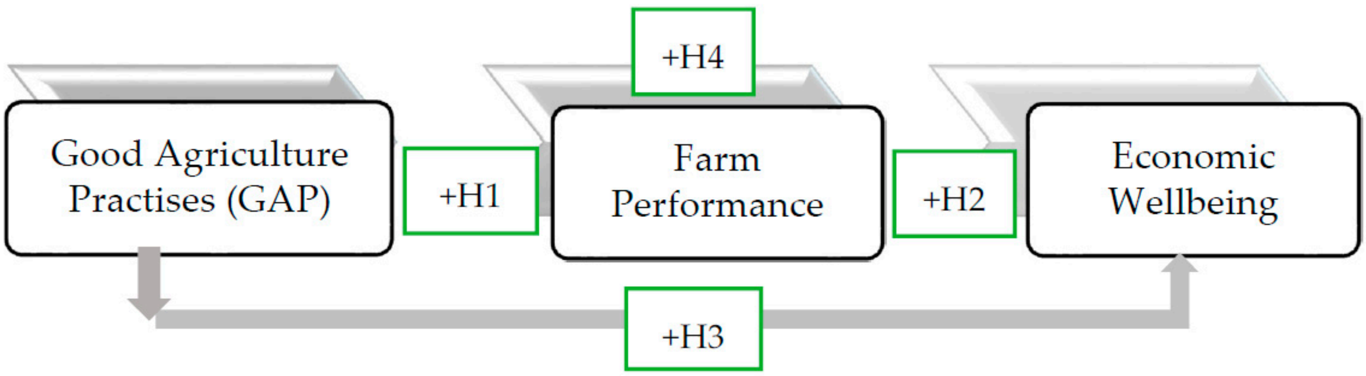

Figure 1. The GAP Linkages Framework.

2.3. Benefits for Farmers' Economic Well-Being

Oil palm plantations do not only provide farmers with permanent income but also job opportunities in rural areas. Planting oil palm in peatland areas can generate direct income for farmers if managed properly [22]. Ali and Sharif [72], and Waddington, White, and Anderson [68] found that the transfer of technology of environmentally friendly cultivation has affected crop performance and improved the well-being of farmers. With improved oil palm productivity, the quality of FFB leads to an increase in the income of farmers [25,31,73]. Empirical evidence from Indonesia shows that oil palm farmers with GAP enjoy higher yields than those who performed poorly [74,75]. Thus, high crop performance is associated with the high economic well-being of farmers [25,26]. If properly managed and enforced, sustainable oil palm cultivation can boost productivity [12,19,76,77]. Tilman et al. [78]; Feder, Murgai, and Quizon [79]; Woittiez et al. [76]; Awang Besar et al. [29]; and Nong et al. [80] suggested the transfer of technology to farmers through sustainable farm management practices, including reducing the productivity gap. A GAP is a set of norms and procedures developed to produce agricultural products in a sustainable manner [57,67,81]. Paramananthan [82] stated that oil palm productivity is also induced by environmental protection. Mariyono [83], and Yamazaki and Resosudarmo [84] showed that the use of integrated pest management leads to reliable productivity. Similarly, Mancini et al. [85], Obidzinski [21], and Saadun et al. [46] proved that agricultural extension programs that were aimed at increasing farmers' knowledge of environmental consciousness enhanced their productivity. Previous literature has demonstrated that GAP improved farm performance in terms of yield, sufficient nutrients, and the absence of diseases, pests, and parasites. We concluded that oil palm productivity has a significant and positive effect on per capita income. Farmers' economic well-being is enhanced by better farm performance, as shown in Figure 1, which generates sufficient income for their daily needs. As illustrated in Figure 1, good agricultural practices are hypothesized to have indirect and direct positive impacts on farmers' economic well-being. Thus, this study made the following hypotheses.

Hypothesis 1 (H1). *GAP have a direct and positive effect on farm performance (Farm Perf).*

Hypothesis 2 (H2). *Farm performance (Farm Perf) has a direct and positive effect on economic well-being (Econ Well).*

Hypothesis 3 (H3). *GAP have a direct and positive effect on economic well-being (Econ Well).*

Hypothesis 4 (H4). *GAP have an indirect and positive effect on economic well-being (Econ Well).*

3. Materials and Methods

3.1. Research Site, Population, and Sample Size

Dalat in the Mukah division was the research site of this study (in Appendix A). It is on the northwest coast of Sarawak in East Malaysia and covers an area of approximately 0.7 million hectares. This division is inhabited by 122,300 people, predominantly by the Melanau ethnic group, who comprise approximately 60% of the total Mukah population [86]. Only 5.6% of the total land of Sarawak is composed of low-lying peat. Since the 1880s, sago palm (Metroxylon sagu) has been the major commercial crop in this area and other parts of Sarawak [87]. Sago palm is classified as a high-energy-yielding crop, because it needs high infrastructure costs due to remoteness and caters mainly to a limited domestic demand [88]. Melling [33] found that the virgin peat swamp in this area is unsuitable for sago palm and causes stunted growth and a high mortality rate. Growing sago palm is also an economically unsustainable industry [89], because its maturity period is almost 10 years [90]. Such a long period can worsen poverty among farmers. Thus, farmers gradually convert their land to oil palm cultivation, which has become a source of permanent income and employment in this rural area. By 2016, approximately 43% of all farmers had planted oil palm on peat land area. The oil palms planted in peat soil area by farmers are mostly concentrated in the Matu (87.0%) and Daro (100%) districts in the Dalat area. On the basis of the calculations of Yamane (cited from Israel [91]), the minimum target sample size in this study was 200 peat land oil palm farmers in four villages. We randomly selected the independent farmers who planted oil palm in this peat land area. Based on the sample size, we generated random numbers and chose a peat land farmer who was registered with MPOB. Roscoe [92] stated that the applicable sample size for research is between 30 to 500 farmers, whereas Kwong [93] suggested a minimum sample size of 59 farmers, with three arrows pointing at latent variables. Hoyle and Gottfredson [94] suggested that a sample size of 100 to 200 farmers is a good start in path analysis. We conducted face-to-face interviews with independent oil palm farmers and were assisted by a locally trained enumerator [95] to complete the tested survey questionnaire. Fieldwork was conducted in August–October 2019. Finally, we obtained 78.5% (157) completed survey questionnaires that were reliable for further analysis.

3.2. Instrument Design

The economic well-being of farmers involved in the conversion of peat land to oil palm plantations is investigated in this study. The economic well-being of peat land oil palm farmers is determined by GAP and mediated by farm performance. The most important measure in agronomic performance is oil palm yield, which depends on GAP. We measured GAP in peat land cultivation, primarily adopted from the Food and Agriculture Organization Good Agricultural Practices [24,46]. We combined the indicators on the basis of a diagnostic smallholder constructed by Woittiez et al. [96]. Then, we classified GAP systematically into six dimensions; namely, fertilization techniques, harvest and pruning techniques, drainage and transportation, parasite control and planting system, soil and water quality, and farm and financial management (in Table 1), as pursued by Choo and Abu-Bakar [2], and Woittiez et al. [76].

Table 1. Construct Reliability and Convergent Validity of the Model.

Latent Construct	Item	Outer Loading	Composite Reliability	AVE
Good Agriculture Practices (GAP) Dimension				
(a) Fertilization	Oil palm is fertilized sufficiently (F01).	0.896	0.948	0.822
	Oil palm is fertilized more than two times a year (F02).	0.909		
	Fertilizers are scattered in the circular area around the base of the oil palm (F03).	0.927		
	Fertilizers are scattered within a month of purchase or receipt (F04).	0.893		
(b) Harvest and Pruning	After pruning, the leaves are arranged tidily (HP01).	0.841	0.915	0.729
	Only mature, fresh fruit bunches (FFB) are harvested (HP03).	0.865		
	FFB stalks are cut short (HP04).	0.869		
	All loose fruits are collected (HP05).	0.840		
(c) Drainage System	Paths are well maintained (DS01).	0.891	0.907	0.709
	A drainage ditch is built where it is needed (DS02).	0.872		
	Drainage is well maintained to control water and flooding (DS03).	0.829		
	The water is always at a reasonable level (DS04).	0.771		
(d) Parasite and Cultivation	Oil palm is planted according to the standard system (PC01).	0.726	0.849	0.585
	Palm trees comply with the standard density system (PC02).	0.847		
	Palm trees are free of shrubs (PC03).	0.718		
	Oil palm plantation areas are grown with soft weeds (PC04).	0.761		
(e) Management and Finance	FFB are delivered on time to fruit dealers or millers (FM01).	0.881	0.851	0.741
	Crop or livestock integration is adopted (FM02).	0.840		
(f) Soil and Water	Lands are leveled or drained if they fall (SW01).	0.723	0.726	0.571
	Silt pits are constructed for sloping farms (SW02).	0.787		
Farm Performance (Farm-Perf)	Optimum oil palm fresh bunches are yielded (FPO1).	0.847	0.850	0.588
	Oil palms have no symptoms of nutrient deficiency (FPO2).	0.677		
	Oil palms are free from pests and parasites (FPO3).	0.724		
	Oil palms are free from Ganoderma and other infections (FPO4).	0.809		

Table 1. *Cont.*

Latent Construct	Item	Outer Loading	Composite Reliability	AVE
Economic Well-being (Econ-Well)	Income generated from oil palm cultivation is sufficient for a family's daily meals (EW01).	0.587	0.936	0.750
	Income generated from oil palm cultivation is sufficient for children's daily schooling expenses (EW02).	0.892		
	Income generated from oil palm cultivation is adequate for basic utilities (EW03).	0.948		
	Income generated from oil palm cultivation is sufficient for daily transportation costs (EW04).	0.921		
	Income generated from oil palm cultivation is adequate for detergent and toiletry expenses (EW05).	0.930		

Note: Sample (n) = 157.

Agricultural yield and income generated from agricultural production are often key indicators of a farms' well-being and economic performance [12,25,68,72,74,97–99]. Oil palm FFB (ton/ha) are the immediate products of oil palm farmers. These are then processed into crude palm oil and crude palm kernel oil by millers. An optimal yield is possible when oil palm trees are healthy. A healthy oil palm tree does not show any signs of major nutrient deficiency, such as yellow leaves, purple stems, orange spots, dry lower leaf blades, and wrinkled leaves. A healthy oil palm tree is also not infected with parasites, pests, or diseases, such as fungus and Ganoderma. Self-perception questions were used in this section, such as "Oil palms are free from pests and parasites". We used three-point Likert scales of possible answers to measure farm performance (1 = never, 2 = sometimes, and 3 = always).

Table 1 shows farmers' economic well-being measured in subjective measurements. The subjective economic well-being consists of farmers' perceptions of their earnings, finances, and wealth derived from oil palm cultivation. The earnings of oil palm farmers are highly dependent on yield and the price of oil palm fresh bunches. Income generated from oil palm sales [25,68,73,98,100] reflects the financial benefits enjoyed by farmers. We selected and adopted subjective well-being items on income sufficiency/adequacy and financial stability from previously established measurements [101–103]. The item responses in the economic well-being scale ranged from 1 = disagree to 3 = agree [104]. The farmers selected the Likert scale that best described them, such as "income generated from oil palm cultivation is sufficient for a family's daily meals".

3.3. Latent Variable Validity and Reliability

With 35 farmers participating in the pilot test, the study revealed that the Cronbach's alpha reliability coefficient (α) for economic well-being was 0.93, farm performance was 0.70, and the GAP was 0.90. The structured survey questionnaires were also based on actual data gathered for convergent validity (in Table 1), using partial least squares structural equation modeling analysis (PLS-SEM). This study used SmartPLS as a statistical analysis software to run PLS-SEM and evaluate the measurement quality and structural model. Hair, Ringle, and Sarstedt [105], and Kwong [93] proposed that composite reliability should be more than 0.70, whereas 0.60 is acceptable. By using PLS-SEM analysis [106,107], we identified the composite reliability for GAP, farm performance, and economic well-being of the oil palm farmers. Most of the outer loadings of the items were more than 0.70, which was considered good and reliable [105]. Only one item was less than 0.70 but higher than 0.40; nevertheless, it was acceptable [106]. A factor loading, which was greater than 0.50, was used as a criterion to select a statement in a factor [105]. Chin [108] pointed out that loads of at least 0.50 were acceptable. Average variance extracted (AVE) should be 0.50 or more [109]. Table 1 shows that the composite reliability and AVE were greater than 0.70 and 0.50, respectively, exceeded the minimum acceptable values, and proved good internal consistency for each latent construct [110].

Two methods can be used to determine discriminant validity [107,111–113]. In the first method, the AVE is examined. The AVE value must be greater than 0.50 [114]. In this study (Table 1), AVE was calculated to assess the discriminant validity of the eight latent constructs, which ranged from 0.57 to 0.82. These data showed that all values of AVE were above 0.50. Moreover, the square root of the AVE between each pair of factors was higher than the correlation projected between factors, thereby ratifying the discriminate validity. Alternatively, the square roots of AVE were compared with those of the other constructs below the diagonal in Table 2. These statistics suggest that each construct is stronger in its own measurement than in the measurement of another construct [106]. The statistics suggest that the elements of our measurements are reliable, internally consistent, and have discriminant validity. Table 2 shows the discriminant validity of the constructs. The comparison of cross-loadings in Table 3 shows that the loadings of an indicator are higher than the other loadings for its construct in the same column and row. Furthermore, the results indicate that discriminant validity exists among all the constructs on the basis of the loadings depicted in Table 2.

Table 2. Discriminant Validity Assessment of the Model.

	Drainage System	Economic Well-Being	Farm Performance	Fertilization	Harvest and pruning	Management and Finance	Parasite and Cultivation	Soil and Water	GAP
Drainage System	**0.842**								
Economic Well-being	0.134	**0.866**							
Farm Performance	0.260	0.306	**0.767**						
Fertilization	0.434	0.360	0.111	**0.906**					
Harvest and Pruning	0.636	0.160	0.163	0.441	**0.854**				
Management and Finance	0.314	0.186	0.012	0.523	0.339	**0.861**			
Parasite and Cultivation	0.725	0.154	0.243	0.640	0.731	0.308	**0.765**		
Soil and Water	0.538	0.039	0.276	0.301	0.326	0.110	0.523	**0.755**	
GAP	0.834	0.246	0.235	0.767	0.820	0.512	0.910	0.550	**0.652**

Note: Sample (n) = 157.

Table 3. Item and Latent Construct Comparison of Cross-Loadings.

	Drainage System	Economic Well-Being	Fertilization	Management and Finance	Farm Permanence	Harvest and Pruning	Parasite and Cultivation	Soil and Water	GAP
DS01	**0.891**	0.137	0.425	0.244	0.294	0.516	0.716	0.478	0.754
DS02	**0.872**	0.053	0.412	0.219	0.125	0.609	0.748	0.503	0.778
DS03	**0.829**	0.268	0.310	0.291	0.294	0.559	0.481	0.406	0.657
DS04	**0.771**	−0.007	0.298	0.324	0.167	0.447	0.453	0.415	0.602
EW01	0.077	**0.587**	0.128	0.059	0.245	−0.012	0.031	0.089	0.077
EW02	0.167	**0.892**	0.342	0.207	0.278	0.183	0.154	0.106	0.264
EW03	0.068	**0.948**	0.306	0.164	0.297	0.157	0.113	−0.016	0.194
EW04	0.132	**0.921**	0.370	0.171	0.213	0.157	0.160	−0.023	0.242
EW05	0.126	**0.930**	0.369	0.174	0.288	0.165	0.181	0.018	0.252
F01	0.416	0.372	**0.896**	0.517	0.203	0.359	0.613	0.297	0.702
F02	0.431	0.237	**0.909**	0.463	0.130	0.401	0.580	0.291	0.707
F03	0.344	0.397	**0.927**	0.441	0.034	0.449	0.574	0.189	0.689
F04	0.381	0.300	**0.893**	0.475	0.033	0.392	0.550	0.315	0.681
FM01	0.345	0.174	0.395	**0.881**	0.069	0.344	0.266	0.179	0.469
FM02	0.186	0.144	0.514	**0.840**	−0.057	0.233	0.266	−0.001	0.409
FPO1	0.260	0.194	0.056	−0.085	**0.847**	0.159	0.223	0.228	0.200
FPO2	0.139	0.352	0.142	0.171	**0.677**	0.125	0.183	0.183	0.192
FPO3	0.140	0.157	0.024	−0.154	**0.724**	0.029	0.134	0.225	0.093
FPO4	0.267	0.119	0.063	−0.033	**0.809**	0.153	0.174	0.219	0.194
HP01	0.589	0.156	0.491	0.308	0.183	**0.841**	0.720	0.359	0.775
HP03	0.512	0.168	0.484	0.256	0.088	**0.865**	0.664	0.214	0.727

Table 3. *Cont.*

	Drainage System	Economic Well-Being	Fertilization	Management and Finance	Farm Permanence	Harvest and Pruning	Parasite and Cultivation	Soil and Water	GAP
HP04	0.592	0.084	0.232	0.270	0.128	**0.869**	0.583	0.301	0.666
HP05	0.465	0.133	0.260	0.327	0.155	**0.840**	0.497	0.227	0.608
PC01	0.498	0.128	0.369	−0.007	0.319	0.510	**0.726**	0.501	0.609
PC02	0.663	0.055	0.427	0.185	0.238	0.592	**0.847**	0.471	0.739
PC03	0.460	0.188	0.757	0.491	0.122	0.378	**0.718**	0.341	0.705
PC04	0.587	0.107	0.394	0.246	0.081	0.746	**0.761**	0.302	0.719
SW01	0.390	−0.056	0.148	0.195	-0.005	0.295	0.332	**0.723**	0.392
SW02	0.422	0.106	0.299	−0.016	0.400	0.203	0.453	**0.787**	0.439

Note: Sample (n) = 157.

3.4. Model Verification

The PLS-SEM was used as a statistical technique for estimating the cause-and-effect relationship models using latent variables [97,107]. A combination of multiple regression and PLS-SEM is ideal for data analysis to assess the structural effect GAP of peat land oil palm plantations on the economic well-being of farmers. We used the Smart PLS statistical software to take advantage of cross-sectional data [93,115] to identify the direct and indirect effects of GAP on the oil palm farmers' economic well-being. Smart PLS, which was developed in Java, is an appropriate software to the analyze data, as suggested by Hair et al. [106], Hair Jr et al. [115], and Hair, Hult, and Ringle [107].

4. Results and Discussion

4.1. Oil Palm Smallholder Profile

We predominantly used percentages to describe peat land farmers' background and farm characteristics. Almost half of independent oil palm farmers have their own land, followed by 24.2% with mortgaged land, 18.3% with heritage land, and 7.8% with other types of land ownership (in Appendix B). Half of peat land oil palm farmers do not have any formal education, 19.7% only reached primary school, and 15.3% reached lower secondary school. Only 7.0% of farmers are high school graduates, 1.3% are diploma holders, and 1.3% are degree holders. Only 14.0% of the peat land oil palm farmers were less than 39 years old, more than half (55.5%) were 40–59 years old, and the rest (30.6%) were more than 61 years old. With limited oil palm land and small-scale production, 66.7% of farmers earn a monthly cash income between MYR 501 to MYR 1500, and 13.0% earn MYR 1501 to MYR 2500. Only 15.2% of farmers earn less than a MYR 500 of monthly cash income generated from oil palm cultivation.

4.2. Adoption of GAP

Adequate oil palm fertilization (M = 2.261; SD = 0.545), more than two times a year (M = 2.248: SD = 0.539), was moderately performed by peat land oil palm farmers (in Appendix B). In terms of harvest and pruning techniques, most farmers comply with the pruning techniques, harvesting only mature, short FFB stacks and collecting loose FFB. Farm drainage systems (M = 2.503; SD = 0.526), lanes, and farm roads (M = 2.478; SD = 0.538) are well constructed and maintained. However, the water level within drainage flows is less regulated than normal (M = 2.248; SD = 0.476). Mud pits (silt pits) are seldom (M = 1.866; SD = 0.680) built, because most of farmland in this area is not sloping. A healthy oil palm tree does not show any signs of major nutrient deficiency symptoms, such yellow leaves, purple stems, orange spots, dry lower leaf blades, or wrinkled leaves. With the oil palm density planting system (120–150 palms per hectare), the yield becomes relatively high [65]. Peat land farmers planted according to standard oil palm planting systems and complied with the prescribed density of oil palm trees. Farmers planted according to oil palm planting systems (M = 2.694; SD = 0.489), leveling the farmland (M = 2.580; SD = 0.611) and complying with the density of oil palm trees (M = 2.529; SD = 0.526).

However, peat land oil palm farmers do not integrate crops or livestock into their farms (M = 1.834; SD = 0.6186) to diversify their income. On average, oil palm farmers in this study area have 3.64 hectares. With the latest agricultural innovations and strengthened indigenous knowledge, local farmers are able to optimize their sustainable cultivation and management practices [53,68,116–118]. Farmers need to be trained further to solve their cultivation challenges in a sustainable manner [53,68,79,119,120].

4.3. Effects on Farm Performance and Farmers' Economic Well-Being

Smart PLS 3.0 was used to examine the structural model and hypothesis [107]. The path estimates and t-statistics were calculated for the hypothetical relationships by using an algorithm and bootstrapping technique with a resampling of 5000. The structural model (Figure 2) shows the relation between one variable and another variable with beta (β) and R-squared (R^2) values. The results showed that the R^2 for farm performance was 0.05, and the R^2 for farmers' economic well-being was 0.13. The R^2 value of economic well-being of farmers could be explained or influenced by 13.0% of the independent variables (GAP and farm performance), and the rest were influenced by other factors outside this model. In general, a combination of adequate rainfall, sunshine, ideal soil conditions, good weed management, fertilization, irrigation, pre-harvest and post-harvesting, and pest and disease control would result in optimal growth and yield of oil palms [19,65,73]. Oil palm plantations in these areas have soft weeds and are free of shrubs, which led to positive effects. The results showed that GAP (β = 0.23, $p < 0.01$) had a significantly positive and direct effect on farm performance, as predicted in H1.

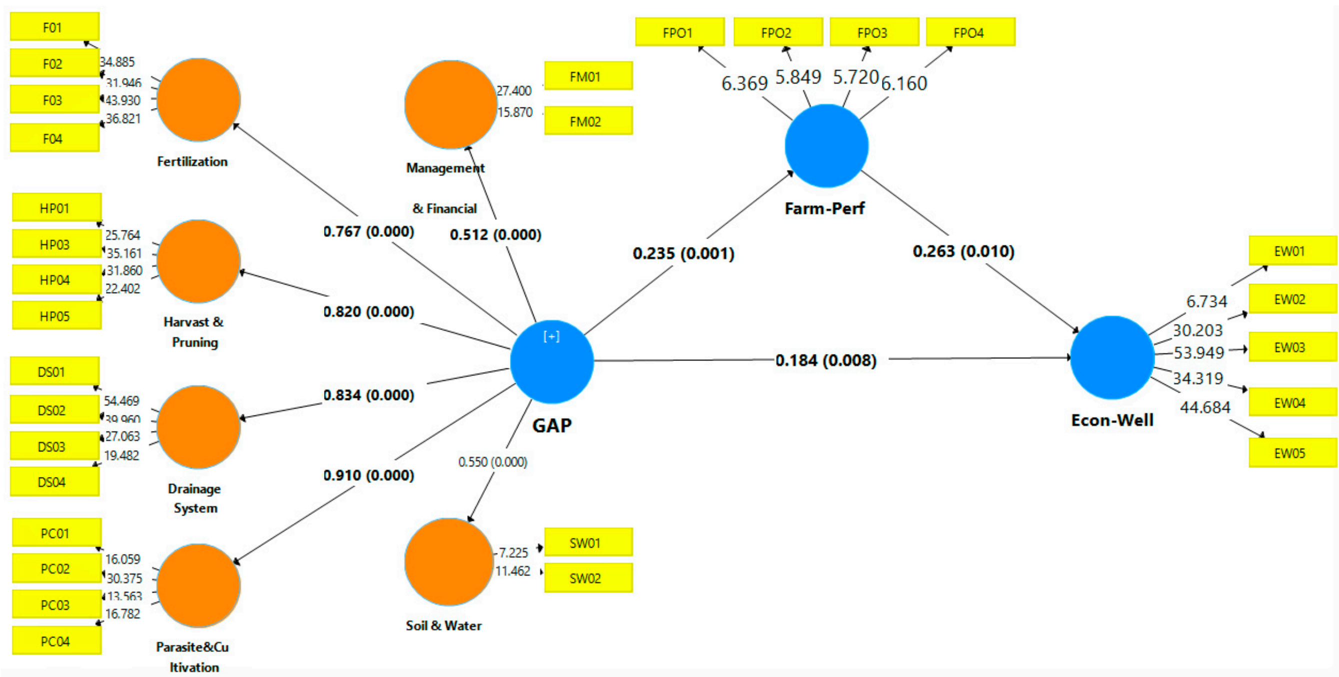

Figure 2. Measurement Model, the Effect of GAP.

We found that farm performance has a positive and direct significant effect on peat land farmers' economic well-being. The results are consistent with H2, that farm performance (β = 0.26, $p < 0.01$) was positively related to farmers' economic well-being. However, the integration of crop and livestock (in Appendix B) is typically practiced less often by peat land farmers, which could increase weed control and the productivity of oil palms [121,122]. Similarly, crop and livestock integration in oil palm plantations generates additional income and employment [99,100,123].

4.4. Direct and Indirect Effects on Farmers' Economic Well-Being

On the basis of the above literature and framework, we tested the hypothesis (H3) that GAP have a positive and direct significant effect on farmers' economic well-being, and (H4) that GAP have a positive and indirect significant effect on farmers' economic well-being. Figure 2 shows that GAP (β = 0.18, $p < 0.01$) is positively and directly related to farmers' economic well-being. Furthermore, GAP is significantly indirect related to the economic well-being (β = 0.06, $p < 0.05$) of peat land oil palm farmers and is mediated by crop performance. This result strengthened the findings of Cole and Fernando [124], and Mkanthama et al. [125], that eco-healthy agricultural practices, such as nutrient management, seed selection, and weed management, improved productivity. In line with Qaim et al. [12], Luke et. al. [40], Uning et al. [42], Santika et al. [126], and Heylen et al. [127] we confirmed that GAP are associated with diminished poverty among farmers.

Table 4 shows that the total effects of GAP on farm performance and the economic well-being of peat land oil palm smallholders can be classified as complementary mediation. This finding implied that all paths in the model have a strong effect on farmer's economic well-being, as shown in Figure 2 and Table 4. This finding confirmed previous works [26,66,68,76], with consistency in the results. Healthy oil palm trees lead to high productivity and high-quality FFB. Thus, optimal yield will lead to a positive impact on the income of farmers [31,74,75]. Similarly, farm performance has a significant impact on the well-being of peat land oil palm farmers. Peat land oil palm farmers' economic well-being is also significantly and directly affected by GAP. GAP in peat land oil palm plantations has indirect impacts on economic well-being and is mediated by crop performance.

Table 4. Summary of The Hypothesis Test.

Path Correlation	Hypothesis	Coefficients	t Statistics	*p* Values	Decision
Direct effect					
Good Agriculture Practice (GAP)→Farm Performance (Farm Perf)	H1	0.235 **	3.453	0.001	Supported
Farm performance (Farm Perf)→Economic Well-being (Econ Well)	H3	0.263 **	2.570	0.010	Supported
Good Sustainable Practice (GAP)→Economic Well-being (Econ Well)	H2	0.184 **	2.676	0.008	Supported
Indirect effect (mediation)					
Good Agriculture Practice (GAP)→Farm Performance (Farm Perf)→Economic Well-being (Econ Well)	H4	0.062 **	2.229	0.026	Supported
Total effect		0.246 **	Complementary mediation		

Note: Sample (n) = 157; Summary of the hypothesis test (*** $p < 0.001$; ** $p < 0.05$).

5. Conclusions

We analyzed the GAP among farmers of peat land oil palm, and it effects on farm performance and economic well-being. We conducted a path analysis of direct and indirect effects on farmers' economic well-being, which is key to understanding the effectiveness of GAP in peat land oil palm cultivation. The empirical results showed that GAP have direct positive effects on farm performance and positive total effects on economic well-being. The GAP of small-scale peat land farmers needs to be further intensified. Irrespective of the planting and maintenance process; harvesting and pruning techniques, drainage and transport, and parasite control and planting systems, although functional, need to be enhanced. The optimum yield of oil palm in peat land needs to be sustained in the medium and long term due to progressive soil subsidence. With little adoption of the integration of crops and livestock, we propose that peat land oil palm farmers in this area intensify crop or livestock integration, which is guided and supported by agriculture agencies, to diversify their income. Intensified digital dissemination of environmentally sustainable farming techniques may increase among farmers the perceived effectiveness of GAP and enhance their inclination to adopt such practices. Continuous learning may also facilitate a higher level of understanding and adoption of socio-ecologically friendly practices in peat land oil palm cultivation. In the future, organic farming technology, which is more environmentally friendly, should be gradually introduced to peat land oil palm farmers. One of the major limitations of this study is the small sample size and that the limited selected peat land area does not reflect the national level. Therefore, it may be necessary to replicate the variables in this study at a national or regional level in other peat land areas. Longitudinal assessment and review are important to ensure that sustainable agriculture programs are responsive to farmers' needs and goals.

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Appendix A

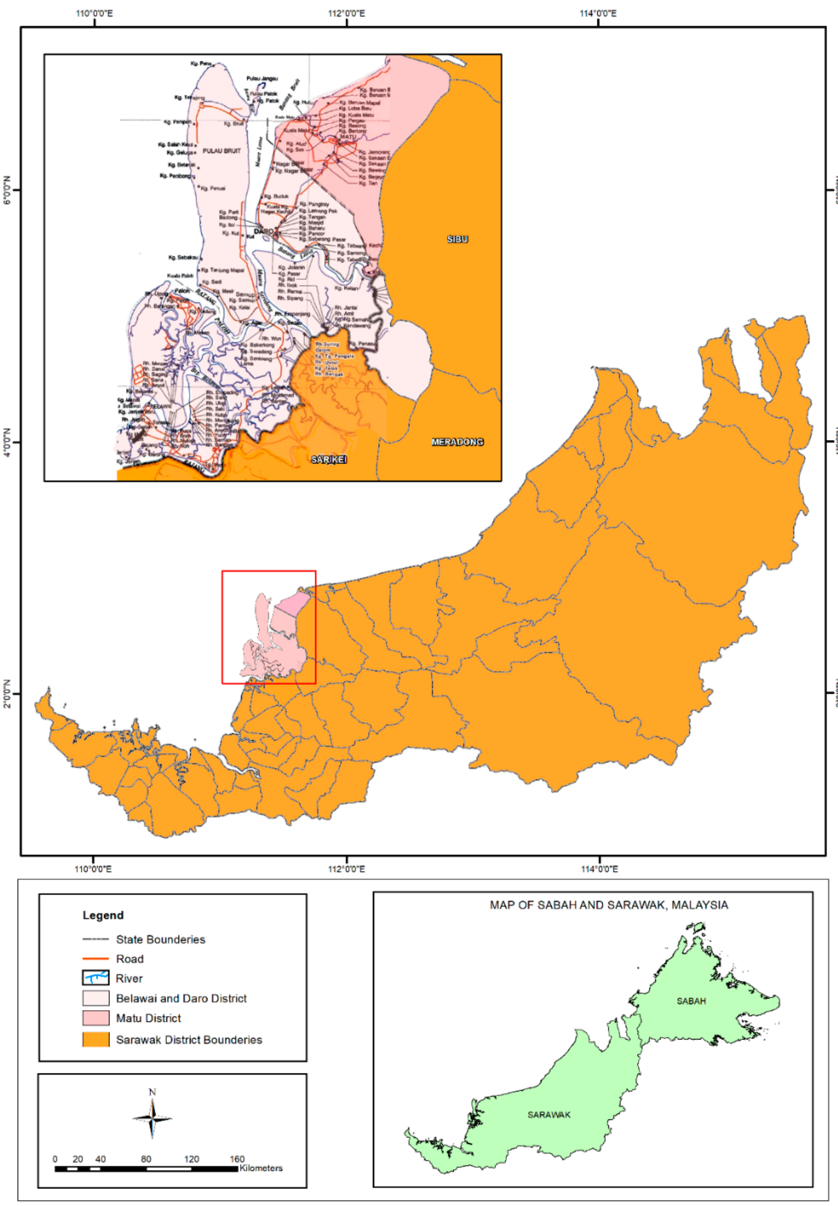

Figure A1. Study Area. Dalat, Sarawak.

Appendix B

Table A1. Farmer's Socio-Economic Profile.

	Frequency	Percent
Land ownership [a]		
Own land	76	49.7
Mortgage land	37	24.2
Heritage land	28	18.3
Others	12	7.8
Age		
Less than 39 years	22	14.0
40–59 years	87	55.4
More than 60 years	48	30.6

Table A1. *Cont.*

	Frequency	Percent
Academic qualification		
No formal education	87	55.4
Primary School	31	19.7
Lower secondary school	24	15.3
Upper and high school	11	7.0
Certificate and diploma	2	1.3
Bachelor degree	2	1.3
Monthly cash income [b]		
Less than MYR500	21	15.2
MYR501-MYR1500	92	66.7
MYR1501-MYR2500	18	13.0
MYR2501-MYR3500	4	2.9
MYR3501- MYR4500	1	0.7
More than MYR4501	2	1.4

Note: Sample (n) =157, [a] 4 missing cases; [b] 19 missing cases. Money converter (9:40 a.m., 8 June 2021) MYR = 0.242725 USD 1 USD = 4.11989 MYR.

Table A2. Good Agriculture Practice Dimension, Farm Performance and Economic Wellbeing Variables.

Laten Variable and Item	N	S	A	Mean	SD
Good Agriculture Practice (GAP) Dimension					
(a) Fertilisation					
Oil palm is fertilised sufficiently (F01).	5.1	63.7	31.2	2.2611	0.54475
Oil palm is fertilised more than two times a year (F02).	5.1	65.0	29.9	2.2484	0.53895
Fertilisers are scattered in the circular area around the base of the oil palm (F03).	1.9	62.4	35.7	2.3376	0.51334
Fertilisers are scattered within a month of purchase or receipt (F04).	2.5	63.1	34.4	2.3185	0.51935
(b) Harvest and pruning					
After pruning, the leaves are arranged tidily (HP01).	1.9	49.7	48.4	2.4650	0.53743
Only mature, fresh fruit bunches (FFB) are harvested (HP03).	2.5	47.1	50.3	2.4777	0.54989
FFB stalks are cut short (HP04).	3.2	55.4	41.4	2.3822	0.54930
All loose fruits are collected (HP05).	1.3	61.1	37.6	2.3631	0.50830
(c) Drainage System					
Paths are well maintained (DS01).	1.9	48.4	49.7	2.4777	0.53811
A drainage ditch is built where it is needed (DS02).	1.3	47.1	51.6	2.5032	0.52653
Drainages are well maintained to control water level and flood (DS03).	2.5	60.5	36.9	2.3439	0.52761
The water level is always controlled at a reasonable level (DS04).	1.9	71.3	26.8	2.2484	0.47577
(d) Parasite and Cultivation					
Oil palm is planted according to the standard system (PC01).	1.3	28.0	70.7	2.6943	0.48914
Palm trees comply with the standard density system (PC02).	1.3	44.6	54.1	2.5287	0.52575
Palm trees are free of shrubs (PC03).	1.9	67.5	30.6	2.0637	0.53925
Oil palm plantation areas are grown with soft weeds (PC04).	11.5	70.7	17.8	2.2930	0.52209
(e) Management and Finances					
FFB are delivered on time to fruit dealers or millers (FM01).	1.3	53.5	45.2	2.4395	0.52303
Crop integration is adopted (FM02).	28.7	59.2	12.1	1.8344	0.61859
(f) Soil and Water					
Lands are levelled or drained if they fall (SW01).	6.4	29.3	64.3	2.5796	0.61109
Silt pits are constructed for sloping farm (SW02).	30.6	52.2	17.2	1.8662	0.68027
Farm Performance (Farm-Perf)	N	S	A	Mean	SD
Optimum oil palm fresh bunches are yielded (ton/ha) according to age (FPO1).	2.5	53.5	43.9	2.4140	0.54355
Oil palms have no symptoms of nutrient deficiency (FPO2).	1.9	72.6	25.5	2.2357	0.46877
Oil palms are free from pests and parasites (FPO3).	3.2	68.8	28.0	2.2484	0.50200
Oil palms are free from Ganoderma and other fungal infection (FPO4).	4.5	61.1	34.4	2.2994	0.54848

Table A2. *Cont.*

Laten Variable and Item	N	S	A	Mean	SD
Economic Wellbeing (Econ-Well)	DS	MA	AA	Mean	SD
Income generated from oil palm cultivation is sufficient for a family's daily meals (EW01).	12.7	79.6	7.6	1.9490	0.45002
Income generated from oil palm cultivation is sufficient for children's daily schooling expenses (EW02).	15.9	76.4	7.6	1.9172	0.47987
Income generated from oil palm cultivation is adequate for basic utilities (EW03).	10.2	82.2	7.6	1.9745	0.42289
Income generated from oil palm cultivation is sufficient for daily transportation costs (EW04).	13.4	77.7	8.9	1.9554	0.47155
Income generated from oil palm cultivation is adequate for detergent and toiletry expenses (EW05).	10.2	80.3	9.6	1.9936	0.44573

Note: Sample (n) =157; N = never, S= sometimes, and A = always; DS = disagree, MA= moderate agree, AA = agree.

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