Global J. Environ. Sci. Manage. 9(4): 983-994, Autumn 2023, Serial #36

Global Journal of Environmental Science and Management
(GJESM)

Homepage: https://www.gjesm.net/

Podcasts

CASE STUDY

The effect of income and smallholder characteristics on cultivation, harvesting, and post-harvest management of natural rubber

Nurliza

Department of Agribusiness, University of Tanjungpura, Pontianak, Indonesia

ARTICLE INFO

Article History:
Received 20 December 2022
Revised 10 March 2023
Accepted 20 April 2023

Keywords:
Farm factors
Farm management
Harvest
Natural rubber
Post-harvest
Smallholder factors
Sustainable agricultural practices

DOI: 10.22035/gjesm.2023.04.21

ABSTRACT

BACKGROUND AND OBJECTIVES: Indonesia is the second largest natural rubber producer, which it gets primarily from smallholders. However, smallholders are less and less competitive because of unsustainable agricultural practices, while there is huge potential for sustainable natural rubber. This study aimed to measure the effect of income and smallholder characteristics on cultivation, harvesting, and post-harvest management.
METHODS: Mixed methods with non-probability sampling were used for 100 natural rubber smallholders in Kapuas Hulu Regency, West Kalimantan, Indonesia, one of the regional centers of Indonesian natural rubber. Partial least square path modeling was used with SmartPLS software to estimate the complex cause-effect relationships of smallholder and farm factors for adopting sustainable agricultural practices.
FINDINGS: The effect of the relationship between income and smallholder characteristics on cultivation and income on post-harvest management was not significant. Age and education affected some harvesting parameters, such as tapping knives, bamboo and clean latex collection, and latex stimulus risk, and some post-harvest parameters, such as a risk of acid coagulation and storage. The worker's income source, based on off-farm, on-farm, or non-farm activities, affected harvesting parameters, including tapping knives, bamboo and clean latex collection, and latex stimulus risk.
CONCLUSION: This study offers empirical evidence for sustainable agriculture management. The acceptance of sustainable cultivation and management of rubber practices uses smallholder and farm factors as constraints since they do not form a homogenous group, and the theory of planned behavior failed to provide an effective way to explain the behaviors. Good agricultural practices must be used at all steps, including cultivation, harvesting, and post-harvest management, to prevent problems.

NUMBER OF REFERENCES
69

NUMBER OF FIGURES
2

NUMBER OF TABLES
6

*Corresponding Author:
Email: *nurliza.spmm@gmail.com*
Phone: +6281345249199
ORCID: 0000-0002-8819-1264

Note: Discussion period for this manuscript open until January 1, 2024 on GJESM website at the "Show Article".

INTRODUCTION

Indonesia is the second largest natural rubber producer (Statista.com, 2022), and its rubber SIR 20 is the second largest commodity exported after oil palm as an essential raw material for the industry, especially in the manufacturing sector (ETRMA, 2022). It contributes 0.52 % of Indonesia's gross domestic product (GDP) or 88.61 trillion rupiahs for manufacturing (Satista.com, 2022). In 2021, Indonesia produced 3.12 million metric tons of natural rubber, making 4 billion U.S. dollars (USD), or 23.8 % of global sales (Statista.com, 2022). East Asia Pacific is the main importer of Indonesian rubber, followed by North America, the U.S., Europe, Central Asia, China, and Japan (WITS, 2020). The majority of natural rubber is produced by smallholders. Indonesian natural rubber constitutes about 80 % or 65–70 % of global production (Statista.com, 2022). Smallholders managed rubber farming as family-based agriculture with farms smaller than 10 ha (Gouyon, 2003). In 2021, dry rubber production of smallholders reached 92.81% (2.83 million tons), followed by state estates with 4.32% (0.13 million tons) and private estates with 2.87% (0.09 million tons). The majority of rubber originated from South Sumatera (29%), North Sumatra (11%), Riau (10%), Jambi (10%), and West Kalimantan (8%) (BPS, 2021). However, smallholders have faced challenges for decades, making them less competitive (Zuhdi and Anggraini, 2020). Indonesia produces 0.96 tons per hectare, way behind Thailand, Vietnam, and Malaysia, with 1.80, 1.72, and 1.51 tons per hectare, respectively (WWF, 2020). Smallholders are often forced to combine their holdings with other crops or increase land area (WWF, 2020), leading to decreased rubber exports (Fatahillah *et al.*, 2022), degraded soil (Nguyen *et al*., 2020), and loss of forest ecosystems, biodiversity, and carbon storage (Panda and Sarkar, 2020; He and Martin, 2016). Limited downstream industries can only absorb 15% of the semi-finished goods (GBGI, 2016). Natural rubber markets also remain volatile due to distinct supply-side drivers of synthetic rubber (Wagner, 2020), fluctuations in oil prices, and political changes (Raju, 2016), leading to changes in farm prices and affecting smallholders' profits in the short run (Srisuksai, 2020). Unsustainable agricultural practices are a challenge for smallholders (Inkonkoy, 2022). Most smallholders still use large amounts of chemical fertilizers (Kullawong *et al*., 2020), seedlings and unproven cultivars, outdated planting methods, few legumes cover crops, and high-frequency and low-quality tapping (Zaw and Myint, 2016). Their harvest and post-harvest methods are unsuitable (Yardha *et al*., 2022), and they lack systematic management. However, there is potential for sustainable practices in natural rubber production. Regarding environmental aspects, cultivating rubber emits little greenhouse gas (GHG), requires less fertilizer (Nguyen *et al*., 2020), and increases carbon sinks and sequestration (Pinizzotto *et al*., 2021), thus promoting soil health (Nguyen *et al*., 2020; Chotiphan *et al*., 2019), and biodiversity conservation (Wang *et al*., 2020; Lan *et al*., 2017). Mixtures of rubber trees with Eucalyptus and Acacia can enhance water use efficiency (Chotiphan *et al*., 2019), and changing the land use from the cultivation of edible crops does not threaten food availability (Kullawong *et al*., 2020). Regarding socioeconomic aspects, household incomes are increasing, with the possibility of moving households and communities out of poverty (Hauser *et al*., 2015). Sustainable agricultural practices for rubber cultivation can provide smallholders with quality assurance (Gouyon, 2003), increased productivity (Esekhade *et al*., 2021), improved livelihoods (Inkonkoy, 2022), compliance with relevant legislation (Leimona *et al*., 2015), and proper use of natural resources (Piñeiro *et al*., 2020). Adopting sustainable practices along the value chains will strengthen strong long-term resilience to climate change (Nkeuwa *et al*., 2022; Kangogo *et al*., 2020) and markets shocks (Davis *et al*., 2021) and meet current and future societal needs (Makate *et al*., 2017). The Indonesian government tried to support smallholders in improving their rubber cultivation and post-harvest management practices through The Sustainable Natural Rubber Platform of Indonesia (SNARPI) and cooperatives or other collective organizations in processing and marketing activities for higher prices and profits (Suttipong and Koichi, 2019). However, the results depend on how and whether smallholders can get measurable outcomes, such as a higher level of technical efficiency for enhancing productivity (Kuswanto *et al*., 2019), welfare (Danso-Abbeam and Baiyegunhi, 2020), and planning its implementation (WEF, 2016). Sustainable agricultural practices for rubber cultivation are not only a goal but a learning process (Garzón-Delvaux, 2020). Stimulating the adoption of intentions of self-identity can be a driving force to overcome the barriers of high costs and behavioral changes (Yanakittkul and Aungvaravong, 2020; Silva *et al.*, 2020). This will be encouraged by providing assistance and transferring knowledge (Barbosa Junior *et al.*, 2022), social awareness (Punzano *et al.*, 2021), perceived ease of use, and attitudes based on experience and environmental sensibilities (Saengavut and Jirasatthumb, 2021). The decision to adopt sustainable practices among smallholders has been a subject of scientific inquiry with different theoretical frameworks and is based on the interdependence of multiple factors (Kassie *et al.*, 2015). The study tried to focus on the simultaneous relationship of smallholder characteristics, such as age, education level (Coulibaly *et al.*, 2021), and income (Khanal *et al.*, 2021), and farm factors, such as experience and farming methods (Coulibaly *et al.*, 2021), as constraints for adopting rubber cultivation and management practices. Identifying the smallholder characteristics is necessary as they do not form a homogenous group (Fan and Rue, 2020) but dynamic and sensitive targets (Etana *et al.*, 2020). Education, income, and experience are key characteristics of the success potential of smallholders to cultivate and manage rubber practices (Dissanayake *et al.*, 2013), while age is linked to their ability to allocate production inputs (Kuswanto *et al.*, 2019). Smallholders' income initiates a process of using and combining inputs to acquire and assimilate information and technology (Rapsomanikis, 2015). Yet, smallholder's history, culture, traditional knowledge, economic disparity, and geographic distribution reflect their different approaches to cultivating and managing rubber (Min *et al.*, 2017). While the theory of planned behavior is commonly used to encourage the adoption of sustainable agricultural practices, it failed to provide an effective way for the intentions to explain the behaviors themselves (Norman and Conner, 2005). There are intention-behavior gaps (Nguyen *et al.*, 2019) and significant variability within the strength connection (Fan and Rue, 2020). A sustainable agricultural practice uses good agricultural practices (GAP), defined as preventing problems before they occur (Shareen, 2016). Among the three steps of GAP, cultivation addresses the risks of farm work (APO, 2016), harvesting contributes to income and employment (Abdullah *et al.*, 2021), and post-harvest ensures product quality (Coffelt *et al.*, 2009) using natural coagulation, acid coagulation, air drying and ripening, storage, and sales (Henderson, 1977), and handling the losses (UNCAPSA, 2015). Little literature has proposed mediator factors for the behavior connection in the context of GAP adoption. The current study aims to determine the effect of income and smallholder characteristics on cultivation, harvesting, and post-harvest management. It was conducted in West Kalimantan, one of the regional centers of Indonesian natural rubber production, in 2022.

MATERIALS AND METHODS

Mixed methods were used to answer research questions that could not be addressed by a singular approach (Doyle *et al.*, 2009). The study was conducted in five districts Kapuas Hulu, West Kalimantan, Indonesia: Emabaloh Hulu, Batang Lupar, Boyan Tanjung, Kalis, and Hulu Gerung (Fig. 1). The area has a very wet climate, and most of the land is covered by forest (Lusiana *et al.*, 2008).

Non-probability sampling was used as a valid and efficient non-random method (Tongco, 2007) for 100 smallholders (Purwanto and Sudargini, 2021) through a semi-structured questionnaire and an in-depth interview (Brounéus, 2011). The study was composed of three phases. First, the smallholder characteristics, including age, formal education (Coulibaly *et al.*, 2021), household income (i.e., on-farm, off-farm, non-farm activities) (Khanal *et al.*, 2021), and farm experience (Coulibaly *et al.*, 2021) were identified using quantitative descriptive with percentage (%) tabulation. Second, the characteristics of cultivation, harvesting, and post-harvest management of natural rubber (Shareen, 2016; APO, 2016) were identified based on good rubber (*Hevea brasiliensis*) cultivation guidelines from the Indonesian Ministry of Agriculture, Directorate General of Plantations (Kementan, 2014) and sustainable natural rubber production and post-harvest management (Henderson, 1977) were determined using quantitative description with percentage tabulation. The cultivation/Skillfar parameter includes pests and diseases/Y11 (i.e., pesticide usage, integrated pest management and diseases, and usage of chemical pesticides); land/Y12 (i.e., organic material, soil organisms, fertilizer, the role of forests, soil erosion control, and terracing); processed products/Y13 (i.e., costs and benefits of farming, cider cone, trees layers, products and services, use of local trees, and waste management); cultivation/Y14 (i.e., sustainable farming, optimal

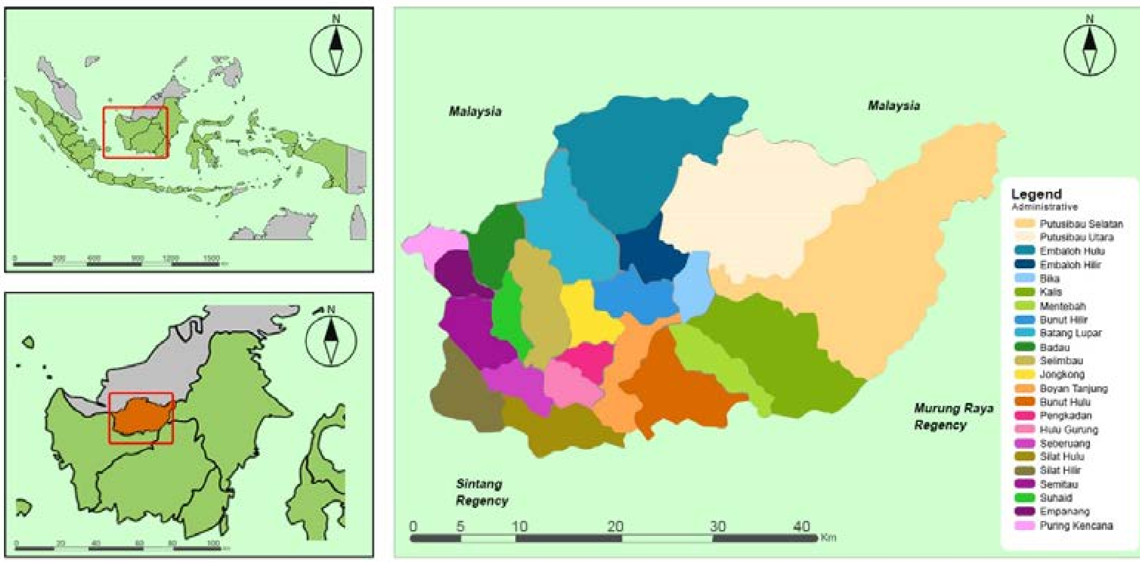

Fig. 1: Geographic location of the study area in Kapuas Hulu, West Kalimantan, Indonesia

growing conditions, optimal density, thinning for density control, pruning, and weeding); and labor/ Y15 (i.e., child labor and safety, workers' rights, and community relations). The harvesting /Skillharv parameter includes time/Y21 (i.e., tapping time and frequency); step/Y22 (i.e., tapping technique); tools and materials/Y23 (i.e., tapping knife, bamboo latex collector, clean latex collection, and latex stimulus risk). Finally, the post-harvest/ Skillphar parameter includes results and sales/Y31 (i.e., quality processing, air drying, maturation, and sales) and risk/Y32 (i.e., acid coagulation and storage). Third, simultaneous effects of cultivation/Skillfar/Y1, harvesting/Skilharv/ Y2, and post-harvest/Skilphar/Y3 management on household income (i.e., on-farm/X11, off-farm/X12, and non-farm/X13), and smallholder characteristics (i.e., formal education/X21, age/X22, and farm experience/X23) were studied using a partial least square (PLS) path modeling with a PLS structural equation modeling (PLS-SEM or Smart-PLS) software due to its efficiency for small sample sizes and complex models (Willaby *et al.*, 2015). PLS-SEM includes two elements: the structural/inner model and the measurement/outer model (Hair *et al.*, 2021). They include the following steps: i) reflective measurement model; ii) evaluation of formative measurement models; and iii) evaluation of the inner/ structural model (Purwanto and Sudargini, 2021). In the reflective measurement model, a model is tested for the interrelationship between the variables using composite reliability (CR) > 0.70, which tends to give an estimate higher than Cronbach's alpha (α), for the internal consistency/reliability of the constructs due to the different weights of each indicator. The average variance extracted (AVE) > 0.50 is used to assess the construct validity of a measurement procedure (Chan and Lay, 2018). In formative measurement models, the content specification must relate to the scope of the latent construct using a variance inflated factor (VIF) < 10 to ensure no multicollinearity data. The accuracy of the prediction is indicated by the R-squared (R^2) and Q-squared (Q^2) values. $R^2 <$ 0.19 is considered unacceptable or interpreted as the exogenous variables that cannot explain the endogenous dependent variable. $Q^2 > 0$ is relevant for a specific dependent construct (Hair *et al*., 2021). In the inner/structural model, the significance of the relationship between the constructs/variables is assessed using a critical ratio (CR) > 1.96 or a probability *(p)* > 0.05. The f-square (f^2) indicates the effect of the size criterion on the structural level: $0.02 \leq f^2 \leq 0.15$ is small, $0.15 \leq f^2 \leq 0.35$ is moderate, and $f^2 \geq 0.35$ is a large effect. The outer loading factor indicates the estimated relationships or determines an item's absolute contribution to its assigned construct (Hair *et al.*, 2021).

RESULTS AND DISCUSSION

Smallholder characteristics

Smallholder characteristics include on-farm, off-farm, and non-farm income, education, age, and farm experience (Table 1).

As indicated in Table 1, most smallholders' income is over 25.96–45.42 USD/month from on-farm and non-farm activities and over 97.34 USD/month from off-farm activities. Most have a senior high school level or 12 years of formal education, over 45–55 years of age, and over 20 years of farm experience. Moreover, the rubber price impacts smallholders. The fluctuating rubber prices affect the product type produced, working hours, type of input (Erlina *et al.,* 2019), safety standards, use of toxic chemicals, discrimination, and child labor (Aidenvironment, 2016). The combination of biological and economic aspects of rubber production (Purnamasari *et al.*, 2002) and institutional assistance (Wang *et al.,* 2023) have been conceived to mitigate price fluctuations.

Cultivation, harvesting, and post-harvest management characteristics of natural rubber

The cultivation, harvesting, and post-harvest management characteristics of natural rubber are presented in Table 2.

Most used cultivation methods include sustainable farming, optimal growing conditions, optimal density, thinning for density control, pruning, and weeding. Most harvesting methods include tapping, and

Table 1: Natural rubber smallholder characteristics (%)

Income (USD/month):	
On-farm:	
≤5.84	1.11
>5.84-25.96	16.67
>25.96-45.42	36.67
>45.42-97.34	33.33
>97.34	12.22
Off-farm:	
≤5.84	17.78
>5.84-25.96	17.78
>25.96-45.42	7.78
>45.42-97.34	20.00
>97.34	36.67
Non-farm:	
≤5.84	3.33
>5.84-25.96	8.89
>25.96-45.42	40.00
>45.42-97.34	33.33
>97.34	14.44
Education (year):	
≤6	1.11
>6-<9	24.44
9	26.67
12	42.22
>12	5.56
Age (year):	
<25	2.22
25-35	4.44
>35-45	30.00
>45-55	52.22
>55	11.11
Farm experience (year):	
<5	2.22
5-10	3.33
>10-15	28.89
>15-20	31.11
>20	34.44

Table 2: Cultivation, harvesting, and post-harvest management characteristics of natural rubber (%)

Cultivation	
Pesticide usage, integrated pest management and diseases, and usage of chemical pesticides	71.11
Organic material, soil organisms, fertilizer, the roles of forests, healthy soil, soil erosion control, and terracing	47.78
Costs and benefits of farming, cider cone, trees layers, products and services, the use the local tree, and waste management	43.33
Sustainable farming, optimal growing conditions, optimal density, thinning for density control, pruning, and weeding	70.00
Child labor and their safety, workers' rights, and community relations	65.56
Harvesting	
Tapping time and frequency	88.89
Tapping technique	90.00
Tapping knife, bamboo latex collector, clean latex collection, and latex stimulus risk	84.44
Post-Harvest	
Quality processing, air drying, maturation, and sales	93.33
Risks of acid for coagulation, and storage	84.44

Table 3: Reflective measurement model

The variables/structural model	CR	AVE
Income (Income/X1)	0.844	0.570
Smallholder characteristics (Charac/X2)	0.799	0.643
Cultivation (Skillfarm/Y1)	0.917	0.691
Harvesting (Skillharv/Y2)	0.877	0.704
Post-harvest (Skillphar/Y3)	0.902	0.822

most post-harvest methodologies include quality processing, air drying, maturation, and sales.

Effect of income and smallholder characteristics on cultivation, harvesting, and post-harvest management

In the reflective measurement model, the interrelationship model between the income/X1, smallholder characteristics/X2, cultivation/Y1, harvesting/Y2, and post-harvest/Y3 management displayed valid and consistent results (Table 3).

In formative measurement models, the content specification has proven related to the scope of the latent construct, and no multicollinearity data were observed (Table 4).

The accuracy of the prediction of the exogenous variables (i.e. income and smallholder characteristics) to explain the endogenous dependent variable (i.e. cultivation, harvesting, and post-harvest management) is indicated by the value of R^2 and Q^2 (Table 5).

As indicated in Table 5, income and smallholder characteristics are relevant in explaining cultivation, harvesting, and post-harvest management. In the structural/inner model, the significance of the relationship between the constructs/variables is assessed using CR value (Fig. 2).

Fig. 2 presents the non-significant effect of the relationship between income and smallholder characteristics on cultivation and income on post-harvest management.

The effect of the others relationships is significant based on f^2 values for the effect of size on the structural level (Table 6).

The size effect of the significant relationship between income and smallholder characteristics on harvesting and of smallholder characteristics on post-harvest management is small. Income is a key characteristic of the success potential of smallholders to cultivate and manage rubber plantations in the selected study area and other areas (Dissanayake *et al.*, 2013). Mentoring and introducing site-specific technology help smallholders overcome the limitations of their income and resources in rubber cultivation and management (Yardha *et al.,* 2022). The outer loading factor that indicates the estimated relationships or determines an item's absolute contribution to its assigned construct is presented in Fig. 3.

Table 4: Formative measurement model

The content specification	VIF
Income/X1:	
On-farm/X11	1.545
Off-farm/X12	1.471
Non-farm/X13	1.321
Smallholder characteristics/X2:	
Education/X21	1.160
Age/X22	1.305
Farm experience/X23	1.421
Cultivation/Y1:	
Pesticide usage, integrated pest management and diseases, and usage of chemical pesticides (Pets and Diseases/Y11)	2.721
Organic material, soil organisms, fertilizer, the roles of forests, healthy soil, soil erosion control, and terracing (Land/Y12)	3.211
Costs and benefits of farming, cider cone, trees layers, products and services, the use of local tree, and waste management (Processed products/Y13)	2.116
Sustainable farming, optimal growing conditions, optimal density, thinning for density control, pruning, and weeding (Cultivation/Y14)	2.836
Child labor and their safety, workers' rights, and community relations (Labor/Y15)	1.687
Harvesting/Y2:	
Tapping time, and frequency (Time/Y21)	1.566
Tapping technique (Step/Y22)	1.754
Tapping knife, bamboo latex collector, clean latex collection, and latex stimulus risk (Tools and Materials/Y23)	1.779
Post-Harvest/Y3:	
Quality processing, air drying, maturation, and sales (Results and Sales/Y31)	1.747
Risks of acid for coagulation, and storage (Risk/Y32)	1.747

Table 5: R^2 and Q^2 values

Endogenous dependent variable	R^2	Adj. R^{2*}	Q^2
Cultivation (Skillfarm/Y1)	0.188	0.167	0.149
Harvesting (Skillharv/Y2)	0.283	0.264	0.194
Post-harvest (Skillphar/Y3)	0.237	0.217	0.124
Mean	0.236	0.216	0.155

*Adjusted r-squared

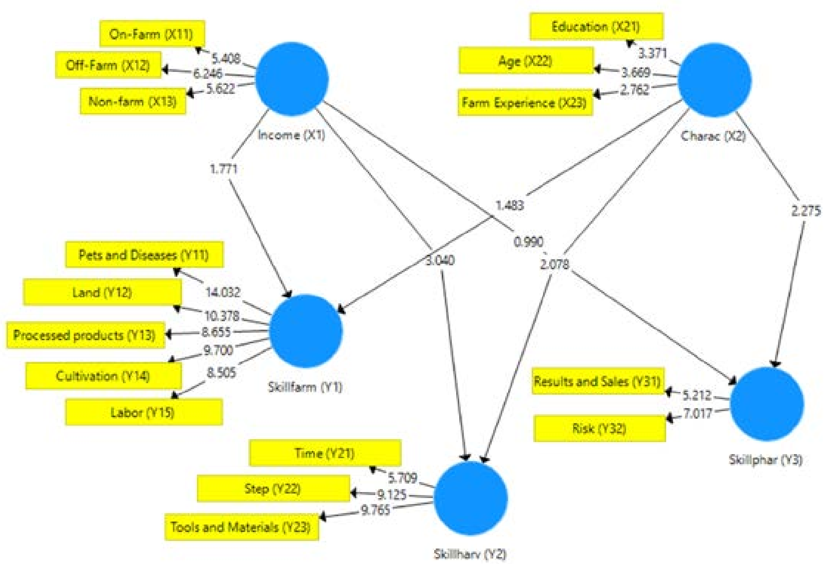

Fig. 2: *CR* value

Table 6: f^2 value

Effect of size on the structural level	Cultivation (Skillfarm/Y1)	Harvesting (Skillharv/Y2)	Post-harvest (Skillphar/Y3)
Income (Income/X1)	**0.053**	0.053	**0.054**
Smallholders characteristics (Charac/X2)	**0.047**	0.057	0.016

Note: Bold mark is insignificant

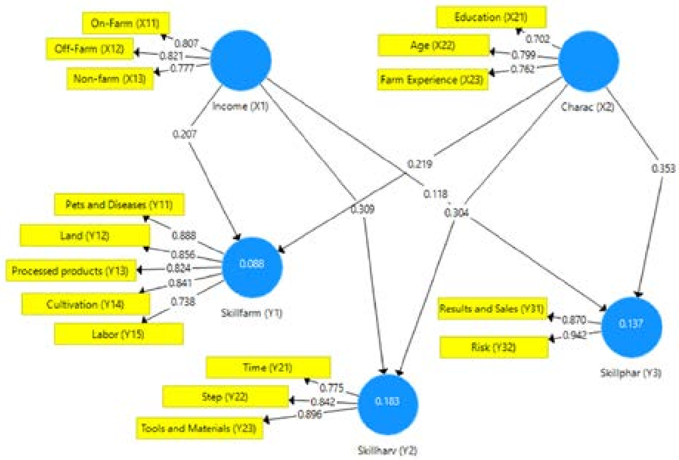

Fig. 3: Estimated coefficient

As indicated in Fig. 3, increased harvesting is more likely to depend on increasing income than smallholder characteristics, and increased income is more likely to depend on off-farm activities, followed by on-farm and non-farm activities. Increased post-harvest management depends on increased smallholder characteristics, while increased smallholder characteristics depend more on increased age than education. Increased harvesting depends more likely on increasing tapping knife, bamboo latex collector, clean latex collection, and latex stimulus risk. Finally, increased post-harvest management is likely due to increasing risks of acid coagulation and storage. Organic material, soil organisms, fertilizer, the role of forests, soil erosion control, and terracing can enhance biodiversity and soil ecology (Ogunsola *et al*., 2020). The tapping technique, a costly activity, can be improved by tapping from high left to low right (Rodrigo, 2007). Natural coagulation, formic acid coagulation, and air-drying methods are the key drivers of structuration (Noinart *et al*., 2022) for resin quality, limiting post-harvest latex losses, and increasing the time interval between harvesting and processing (Coffelt *et al*., 2009). A smallholder identity factor that is contrary to their productivity attitude can lead to non-pros-farm management behavior (Shen *et al*., 2022), the perception of which (Dixon *et al*., 2022) might mean more regulation (McGuire *et al*., 2015), fear of losing non-pecuniary benefits (Howley *et al*., 2015), place attachment (Maricchiolo *et al*., 2021), and underestimating the importance of environmental benefits (Shen *et al*., 2022; Gosling and Williams, 2010). The support of supply chain dialogue and emotional valuing of nature to target particular groups of smallholders (Barnes *et al*., 2022; Gosling and Williams, 2010) and engage in long-term supply chain relationships and co-investment with the rubber industry can create awareness and commitment while solving sustainability issues (Aidenvironment, 2016). Income changes do not necessarily reflect changes confronted by farm households (Mishra *et al*., 2002) since economic incentives alone are unlikely to encourage specific cohorts of smallholders (Howley *et al*., 2015).

CONCLUSION

Most smallholders' income is over 25.96–45.43 USD/month from on-farm and non-farm activities and over 97.36 USD/month from off-farm activities. Most have a senior high school level or 12 years of formal education, over 45–55 years of age, and over 20 years of farm experience. Most cultivation methods include sustainable farming, optimal growing conditions, optimal density, thinning for density control, pruning, and weeding. The most used harvesting technique is tapping, and the most used post-harvest management method includes quality processing, air drying, maturation, and sales. The results indicate that the effect of the relationship between income and smallholder characteristics on cultivation and income on post-harvest management is not significant. However, the effect of the relationship between income and smallholder characteristics on harvesting and of smallholder characteristics on post-harvest management is significant. Most harvesting increases are due to increased income rather than smallholder characteristics, and most income increases are due to increased off-farm activities, followed by on-farm and non-farm. Most post-harvest increases are due to increased smallholder characteristics, and most smallholder characteristics increases are due to increased age rather than education. Increasing tapping knives, bamboo latex collectors, clean latex collection, and latex stimulus risk present challenges in managing the harvesting step, while increasing risks of acid coagulation and storage present challenges in managing the post-harvest processing and marketing of natural rubber. Using organic materials, soil organisms, and fertilizers by considering healthy soil, tapping techniques, coagulation and drying methods with the support of supply chain dialogue and emotional value of nature to target particular groups of smallholders, and engaging in long-term supply chain relationships and co-investment with the rubber industry can promote pro-sustainable farm management behavior. Thus, the adoption of rubber cultivation and management methods depends on whether smallholders can provide measurable outcomes, such as a higher level of technical efficiency to enhance productivity and welfare, building partnerships in the planning and implementation of cultivation, and management with key stakeholders.

ACKNOWLEDGEMENT

Thank the study Grant of Doktor Lektor Kepala of the Faculty of Agriculture from the University of Tanjungpura Budget Execution List with the Decree of the Chancellor No. [2822/UN22.3/PT.01.03/2022], April 6th 2022 for providing Research Program Funding.

CONFLICT OF INTEREST

The author declares that there is no conflict of interests regarding the publication of this manuscript. In addition, the ethical issues, including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancy have been completely observed by the authors.

ABBREVIATIONS

%	Percent
AVE	Average variance extracted
Adj. R^2	Adjusted r-squared
α	Cronbach's alpha
CR-value	Critical ratio
CR	Composite reliability
f^2	F-square
GAP	Good agricultural practices
GDP	Gross domestic product
GHG	Greenhouse gas
p	Probability
PLS	Partial least squares
Q^2	Q-squared

R^2	R-squared
SEM-PLS	Structural equation modeling-partial least squares
USD	U.S. dollars
VIF	Variance inflated factor

REFERENCES

Abdullah, N.I.; Syahlan, S.; Khalid, F.; Aliuddin, M., (2021). Farmers' perception of good agricultural practices (GAP) on rubber's (Hevea Brasiliensis) production in Malaysia: Case study of Kuala Ketil Kedah. Int. J. Acad. Res. Bus. Soc. Sci., 11(10): 329–336 **(8 pages).**

Aidenvironment, (2016). Low prices drive natural rubber. Cologny: World Economic Forum **(39 pages).**

APO, (2016). Manual on good agricultural practices (GAP). Tokyo: Asian Productivity Organization **(253 pages).**

Barbosa Junior, M.; Pinheiro, E.; Sokulski, C.C.; Ramos Huarachi, D.A.; de Francisco, A.C., (2022). How to identify barriers to the adoption of sustainable agriculture? A study based on a multi-criteria model. Sustainability, 14(20): 13277 **(18 pages).**

Barnes, A.P.; Thompson, B.; Toma, L., (2022). Finding the ecological farmer: A farmer typology to understand ecological practice adoption within Europe. Curr. Res. Environ. Sustainability. 4: 100125 **(10 pages).**

BPS, (2021). Indonesian rubber statistics 2021. Jakarta: Badan Pusat Statistik **(127 pages).**

Brounéus, K., (2011). In-depth Interviewing: The process, skill and ethics of interviews in peace research. In Understanding peace research: Methods and challenges. Oxford: Routledge **(16 pages).**

Chan, S.H.; Lay, Y., (2018). Examining the reliability and validity of research instruments using partial least squares structural equation modeling (PLS-SEM). J. Balt. Sci. Educ., 17(2): 239–251 **(13 pages).**

Chotiphan, R.; Vaysse, L.; Lacote, R.; Gohet, E.; Thaler, P.; Sajjaphan, K.; … Gay, F., (2019). Can fertilization be a driver of rubber plantation intensification? Ind. Crops Prod., 141: 111813 **(35 pages).**

Coffelt, T.A.; Nakayama, F.S.; Ray, D.T.; Cornish, K.; McMahan, C.M., (2009). Post-harvest storage effects on guayule latex, rubber, and resin contents and yields. Ind. Crops Prod., 29(2–3): 326–335 **(10 pages).**

Coulibaly, T.P.; Du, J.; Diakité, D., (2021). Sustainable agricultural practices adoption. Agriculture (Pol'nohospodarstvo), 67(4): 166–176 **(11 pages).**

Danso-Abbeam, G.; Baiyegunhi, L.J.S., (2020). Do farm-level technical efficiency and welfare complement each other? Insight from Ghana's cocoa industry. J. Econ. Struct., 9(1): 23-38 **(15 pages).**

Davis, K.F.; Downs, S.; Gephart, J.A., (2021). Towards food supply chain resilience to environmental shocks. Nat. Food, 2(1): 54–65 **(12 pages).**

Dissanayake, D.; Wijesuriya, W.; Herath, H.; Gunaratne, P., (2013). Socio-economic status of smallholder rubber farmers in the Moneragala district. Emir. J. Food Agric., 3(1–2): 41-49 **(9 pages).**

Dixon, A.P.; Arbuckle, J.G.; Ellis, E.C., (2022). Farmer identities influence wildlife habitat management in the US Corn Belt. People Nat., 4(1): 103–114 **(12 pages).**

Doyle, L.; Brady, A.M.; Byrne, G., (2009). An overview of mixed method research. J. Res. Nurs., 14(2): 175–185 **(11 pages).**

Erlina, Y.; Koestiono, D.; Hanani, N.; Syafrial, (2019). The influence of rubber price fluctuation on the performance of smallholder rubber plantation in Central Kalimantan, Indonesia. WSEAS Trans. Bus. Econ., 16(1): 130-137 **(8 pages).**

Esekhade, T.U.; Idoko, S.O.; Abolo, C.U.; Igberase, S., (2021). Sustainability of rubber agroforestry strategies in boosting smallholders' resilience to cope with the realities of new global challenges. E3S Web Conf., 305: 02004 **(13 pages).**

Etana, D.; Snelder, D.J.R.M.; van Wesenbeeck, C.F.A.; de Cock Buning, T., (2020). Dynamics of smallholder farmers' livelihood adaptation decision-making in Central Ethiopia. Sustainability, 12(11): 4526 **(12 pages).**

ETRMA, (2022). Natural rubber supply chain its supply chain. Brussel: European Type and Rubber Manufacturers' Association **(2 pages).**

Fan, S.; Rue, C., (2020). The role of smallholder farms in a changing world. In The role of smallholder farms in food and nutrition security. New York: Springer International Publishing **(16 pages).**

Fatahillah; Andriyani, D.; Rahmah, M.; Syafira, S., (2022). Effect of rubber production, dollar exchange rate and inflation on rubber exports in Indonesia. J. Malikussaleh Public Econ., 5(1): 1–8 **(8 pages).**

Garzón-Delvaux, P.A.; Riesgo, P.A.; Gomez, L., (2020). Sustainable agricultural practices and their adoption in Sub-Saharan Africa: A selected review. Luxembourg: European Union **(47 pages).**

GBGI, (2016). Indonesia's rubber industry: Increased competition and falling prices. Global Business Guide Indonesia.

Gohet, E.; Lacote, R.; Leconte, A.; Chapuset, T.; Rivano, F.; Chambon, B., (2016). Improving rubber smallholdings productivity and resilience through adoption of good agricultural practices. Singapore: Focus Forum on Natural Rubber Sustainability **(15 pages).**

Gosling, E.; Williams, K., (2010). Connectedness to nature, place attachment and conservation behaviour: Testing connectedness theory among farmers. J. Environ. Psychol., 30(3): 298–304 **(7 pages).**

Gouyon, A., (2003). Eco-certification as an incentive to conserve biodiversity in rubber smallholder agroforestry systems: A preliminary study. Nairobi: World Agroforestry Centre **(51 pages).**

Hair, J.F.; Hult, G.T.M.; Ringle, C.M.; Sarstedt, M.; Danks, N.P.; Ray, S., (2021). Partial least squares structural equation modeling (PLS-SEM) using R: A workbook. Cham: Springer **(197 pages).**

Hauser, I.; Martin, K.; Germer, J.; He, P.; Blagodatskiy, S.; Liu, H.; … Cadisch, G., (2015). Environmental and socio-economic impacts of rubber cultivation in the Mekong region: Challenges for sustainable land use. CAB Rev., 10(027): 1–12 **(12 pages).**

Henderson, A.J., (1977). The rubber tree. Rome: Food and Agriculture Organization of the United Nations **(40 pages).**

He, P.; Martin, K., (2016). Effects of rubber cultivation on biodiversity in the Mekong Region. CAB Rev., 10: 1–7 **(7 pages).**

Howley, P.; Buckley, C.; ODonoghue, C.; Ryan, M., (2015). Explaining the economic 'irrationality' of farmers' land use behaviour: The role of productivist attitudes and non-pecuniary benefits. Ecol. Econ., 109: 186–193 **(13 pages).**

Inkonkoy, F., (2022). Sustainability in the natural rubber supply chain: Getting the basics right (Vol. 3th). Cham: Springer **(19 pages).**

Kangogo, D.; Dentoni, D.; Bijman, J., (2020). Determinants of farm resilience to climate change: The role of farmer entrepreneurship and value chain collaborations. Sustainability, 12: 3 **(15 pages).**

Kassie, M.; Teklewold, H.; Jaleta, M.; Marenya, P.; Erenstein, O., (2015). Understanding the adoption of a portfolio of sustainable intensification practices in Eastern and Southern Africa. Land Use Policy, 42: 400–411 **(12 pages).**

Kementan, (2014). Pedoman budidaya karet (Hevea Brasiliensis) yang baik. Jakarta: Indonesian Ministry of Agriculture, Directorate General of Plantations **(120 pages)**.

Khanal, B.; Dutta, J.P.; Puri, P., (2021). Factors affecting adoption of good agricultural practice of rubber (Hevea Brasiliensis) Orchard in Jhapa, Nepal. Acta Sci. Agric., 5(2): 87–92 **(6 pages).**

Kullawong, S.; Aditto, S.; Chambon, B.; Promkhambut, A., (2020). Farmer fertilization practices of mature rubber plantations in Northeast Thailand during a period of low rubber prices. For. Soc., 4(1): 162–180 **(19 pages).**

Kuswanto, K.; Zulkifli, A.; Armandelis, A.; Zulfanetty, Z., (2019). The impact of the efficiency of rubber production on the welfare of rubber farmers in Jambi Province. Int. J. Econ. Financ. Issues, 9(2): 80-86 **(7 pages).**

Lan, G.; Wu, Z.; Chen, B.; Xie, G., (2017). Species diversity in a naturally managed rubber plantation in Hainan Island, South China. Trop. Conserv. Sci., 10: 1940082917712427 **(7 pages).**

Leimona, B.; Amaruzaman, S.; Arifin, B.; Yasmin, F.; Hasan, F.; Agusta, H.; … Frias, J., (2015). Indonesia's 'green agriculture' strategies and policies: Closing the gap between aspirations and application. Nairobi: World Agroforestry Centre **(67 pages).**

Lusiana, B.; Widodo, R.; Mulyoutami, E.; Nugroho, D.A.; Noordwijk, M.Van., (2008). Assessing hydrological situation of Kapuas Hulu Basin, Kapuas Hulu Regency, West Kalimantan. Bogor: World Agroforestry Centre **(78 pages).**

Makate, C.; Makate, M.; Mango, N., (2017). Sustainable agriculture practices and livelihoods in pro-poor smallholder farming systems in southern Africa. Afr. J. Sci. Innovation Dev., 9(9): 269–279 **(11 pages).**

Maricchiolo, F.; Mosca, O.; Paolini, D.; Fornara, F., (2021). The mediating role of place attachment dimensions in the relationship between local social identity and well-being. Front. Psychol., 12: 1–9 **(9 pages).**

McGuire, J.M.; Morton, L.W.; Arbuckle, J.G.; Cast, A.D., (2015). Farmer identities and responses to the social–biophysical environment. J. Rural Stud., 39: 145–155 **(11 pages).**

Min, S.; Waibel, H.; Cadisch, G.; Langenberger, G.; Bai, J.; Huang, J., (2017). The economics of smallholder rubber farming in a mountainous region of Southwest China: Elevation, ethnicity, and risk. Mt. Res. Dev., 37(3): 281-293 **(13 pages).**

Mishra, A.K.; El-Osta, H.S.; Morehart, M.J.; Johnson, J.D.; Hopkins, J.W., (2002). Income, wealth, and the economic well-being of farm households. Washington, D.C.: U.S. Department of Agriculture, Economic Research Service **(73 pages).**

Nguyen, H.V.; Nguyen, C.H.; Hoang, T.T.B., (2019). Green consumption: Closing the intention-behavior gap. Sustainable Dev., 27(1): 118–129 **(12 pages).**

Nguyen, T.T.; Do, T.T.; Harper, R.; Pham, T.T.; Linh, T.V.K.; Le, T.S.; … Giap, N.X., (2020). Soil health impacts of rubber farming: the implication of conversion of degraded natural forests into monoculture plantations. Agriculture, 10(8): 357 **(13 pages).**

Nkeuwa, W.N.; Zhang, J.; Semple, K.E.; Chen, M.; Xia, Y.; Dai, C., (2022). Bamboo-based composites: A review on fundamentals and processes of bamboo bonding. Composites, Part B, 235: 109776 **(20 pages).**

Noinart, J.; Vaysse, L.; Musigamart, N.; Sainte-Beuve, J.; Flori, A.; Liengprayoon, S.; … Bonfils, F., (2022). Coagulation methods and drying step are the key drivers of the dynamics of structuration of natural rubber during the maturation of coagula. eXPRESS Polym. Lett., 16(11): 1161–1176 **(16 pages).**

Norman, P.; Conner, M., (2005). The theory of planned behavior and exercise: Evidence for the mediating and moderating roles of planning on intention-behavior relationships. J. Sport Exercise Psychol., 27(4): 488–504 **(17 pages).**

Ogunsola, O.A.; Adeniyi, O.D.; Adedokun, V.A., (2020). Soil management and conservation: An approach to mitigate and ameliorate soil contamination. In Soil contamination. London: IntechOpen **(15 pages).**

Panda, B.K.; Sarkar, S., (2020). Environmental impact of rubber plantation: Ecological vs. economical perspectives. Asian Jr. of Microbiol. Biotech. Environ. Sc., 22(4): 657–661 **(5 pages).**

Piñeiro, V.; Arias, J.; Dürr, J.; Elverdin, P.; Ibáñez, A.M.; Kinengyere, A.; … Torero, M., (2020). A scoping review on incentives for adoption of sustainable agricultural practices and their outcomes. Nat. Sustainability, 3(10): 809–820 **(12 pages).**

Pinizzotto, S.; Kadir, A.A.S.A.; Gitz, V.; Beuve, J.S.; Nair, L.; Gohet, E.; … Meybeck, A., (2021). Natural rubber systems and climate change. Bogor: The CGIAR Research Program on Forests, Trees and Agroforestry **(110 pages).**

Punzano, A.P.; Rahmani, D.; Delgado, M.D.M.C., (2021). Adoption and diffusion of agroecological practices in the horticulture of catalonia. Agronomy, 11(10): 1959 **(22 pages).**

Purnamasari, R.; Cacho, O.; Simmons, P., (2002). Management strategies for Indonesian rubber production under yield and price uncertainty: A bioeconomic analysis. Agrofor. Syst., 54(2): 121-135 **(15 pages).**

Purwanto, A.; Sudargini, Y., (2021). Partial least squares structural squation modeling (PLS-SEM) analysis for social and management research: A literature review. J. Ind. Eng. Manage. Res., 2(4): 114–123 **(10 pages).**

Raju, K.V., (2016). Instability in natural rubber prices in India: An empirical analysis. IOSR J. Econ. Finance, 7(3): 2321–5933 **(13 pages).**

Rapsomanikis, G., (2015). The economic lives of smallholder farmers. Rome: Food and Agriculture Organization **(39 pages).**

Rodrigo, V.H.L., (2007). Adoption of different tapping systems in the rubber industry of Sri Lanka with special reference to low frequency tapping. J. Rubber Res. Inst. Sri Lanka, 88: 1–21 **(21 pages).**

Saengavut, V.; Jirasatthumb, N., (2021). Smallholder decision-making process in technology adoption intention: implications for Dipterocarpus alatus in Northeastern Thailand. Heliyon, 7(4): e06633 **(10 pages).**

Shareen, S., (2016). A scheme and training manual on good agricultural practices (GAP) for fruits and vegetables: Bangkok: Food and Agriculture Organization 1 **(122 pages).**

Shen, C.C.; Wang, D.; Loverio, J.P.; Liu, H.L.; Wang, H.Y., (2022).

Influence of Attachment theory on pro-environmental behavior and well-being: A case of organic agricultural tourism in Taiwan Hualien and Taitung. Agriculture, 12(12): 1-16 **(16 pages).**

Silva, J.R.; Mauad, J.R.C.; Domingues, C.H.; Marques, S.C.C.; Borges, J.A.R., (2020). Understanding the intention of smallholder farmers to adopt fish production. Aquacult. Rep., 17: 100308 **(8 pages).**

Srisuksai, P., (2020). The rubber pricing model: Theory and evidence. J. Asian Finance Econ. Bus., 7(11): 13–22 **(10 pages).**

Statista.com., (2022). Rubber industry in Indonesia-statistics and facts. Statista Research Department.

Suttipong, A.; Koichi, F., (2019). Can cooperatives improve the incomes of rubber smallholders in Thailand? A case study in Chumphon province. Asian Afr. Area Stud., 18(2): 135-156 **(22 pages).**

Tongco, M.D.C., (2007). Purposive sampling as a tool for informant selection. Ethnobotany Res. Appli., 5: 147–158 **(12 pages).**

UNCAPSA, (2015). Post-harvest management for sustainable agriculture. Bogor: The Centre for Alleviation of Poverty through Sustainable Agriculture **(4 pages).**

Wagner, N., (2020). Why the prices of natural and synthetic rubber do not always bounce together. Beyond the Numbers: Prices and Spending, 9(2).

Wang, J.; Jiang, H.; He, Y., (2023). Determinants of smallholder farmers' income-generating activities in rubber monoculture dominated region based on sustainable livelihood framework. Land, 12(2): 1-17 **(17 pages).**

Wang, M.M.H.; Carrasco, L.R.; Edwards, D.P., (2020). Reconciling rubber expansion with biodiversity conservation. Curr. Biol., 30(19): 3825-3832 **(8 pages).**

WEF, (2016). Building partnerships for sustainable agriculture and food security: A guide to country-led action contents preface. Cologny: World Economic Forum **(39 pages).**

Willaby, H.; Costa, D.; Burns, B.; Maccann, C.; Roberts, R., (2015). Testing complex models with small sample sizes: a historical overview and empirical demonstration of what partial least squares (PLS) can offer differential psychology. Personality and Individual Differ., 84: 73–78 **(6 pages).**

WITS, (2020). Indonesia plastic or rubber exports. World Integrated Trade Solution.

WWF, (2020). Exploring smallholder solutions in the rubber sector. Washington, D.C.: World Wildlife Fund **(30 pages).**

Yanakittkul, P.; Aungvaravong, C., (2020). A model of farmers intentions towards organic farming: A case study on rice farming in Thailand. Heliyon, 6(1): e03039 **(9 pages).**

Yardha; Izhar, L.; Salwati, (2022). Farming support systems for smallholders rubber production in Jambi, Indonesia. IOP Conf. Ser.: Earth Environ. Sci., 978(1): 12005 **(11 pages).**

Zaw, Z.; Myint, H., (2016). Common agricultural practices and constraints of natural rubber industry in Myanmar. Songklanakarin J. Plant Sci., 3(3): 1–8 **(8 pages).**

Zuhdi, F.; Anggraini, R.S., (2020). The Indonesian natural rubber export competitiveness in global market. Int. J. Agric. Syst., 8(2): 130–139 **(10 pages).**

AUTHOR (S) BIOSKETCHES

Nurliza, Ph.D., Associate Professor, Department of Agribusiness, University of Tanjungpura, Pontianak, Indonesia.

- Email: *nurliza.spmm@gmail.com* or *nurliza@faperta.untan.ac.id*
- ORCID: 0000-0002-8819-1264
- Web of Science ResearcherID: AAM-9614-2021
- Scopus Author ID: 57211030793
- Homepage: https://pertanian.untan.ac.id

HOW TO CITE THIS ARTICLE

Nurliza, (2023). The effect of income and smallholders' characteristics on cultivation, harvesting, and post-harvest management. Global J. Environ. Sci. Manage., 9(4): 983-994.

DOI: 10.22035/gjesm.2023.04.21

URL: https://www.gjesm.net/article_704435.html