p-ISSN 2012-3612 | e-ISSN 2782-8824
www.edjournal.cfnr-uplb.org

Ecosystems and Development Journal
Volume 14 | Number 1 | pp. 9–23 | 2024

Analysis of youth workers' characteristics and knowledge level in harvesting natural rubber in Liberia

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ABSTRACT. This study analyzed the characteristics and knowledge level of the youth workers in natural rubber harvesting in Liberia to sustain the rubber industry as a source of income for the youth sector. A semi-structured questionnaire was administered to 139 youth workers of a private rubber company. A two-choice category scale determined whether they performed steps and activities using the Technical Education and Skills Development Authority (TESDA) training manual competencies. Descriptive statistics (percentage distribution, frequency, and mean) and Chi-square test were analyzed the data. Results revealed that majority of the respondents belonged to age bracket 15–35 years (68.4%), males (84.9%), married (54.9%), children of three to four (27.3%), from Nimba County (51.7%), completed junior high school (29.5%) but had no formal education (25.9%), residents in plantation (57.5%), tappers (95.7%), and employed for four to six years (64.8%). The frequency of performed steps was revealed highest in five out of the nine procedural steps as described in TESDA's training module such as: 1) measuring tappable trees, 2) tapping criteria, 3) collecting and storing of latex and cup lumps, 4) installing tapping paraphernalia, and 5) coagulating latex and preparing formic acid. This suggests that the youth's inadequacy of procedural science-based knowledge in harvesting latex, and those five steps were shared by the parents and adults on the plantation. Also, a medium level of knowledge and Chi-square analysis revealed a highly significant association between experience and skill. This may imply that they are practicing some form of science-based latex harvesting but inadequately done. Tools used in the plantation may be similar to some in the training manual but should be a subject for further study to determine the satisfaction in performance while using the tools. Using the SECI Model, knowledge in latex harvesting was sourced informally (tacit to tacit) from parents and adults and not through other knowledge conversion phases/activities like training.

Keywords: *Hevea brasiliensis,* latex harvesting, Liberia youth tappers, SECI Model

Article Information
Received 27 September 2023
Accepted 15 July 2024
Published online
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INTRODUCTION

Liberian youth workers (13–35 years old) are the most marginalized sector. Either they are denied employment in the mainstream economy or hired, yet underemployed, in various sectors like the rubber industry (Verité, n.d.; ILO, 2013). Approximately 33% of the 65% of the country's Liberian youth population had been employed by the rubber industry (Chiarelli *et al*., 2018; Boateng, 2020; Fortune, 2021). Youth's present education and employment status in Liberia may have been brought by the disruption of the educational system due to a civil war and virus occurrence and the consequential turnout of events in government affairs (Moore, 2017).

In large natural rubber (*Hevea brasiliensis* Muell. Arg.) plantations, harvesting or tapping of latex, a sticky, milky, and white substance, has been a youth's preoccupation (Verité, n.d.; ILO, 2013). Latex is a key ingredient used in manufacturing rubber products like tires. Collecting latex on the plantation is physically demanding and risky, for example, due to carrying heavy loads after tapping and snakebite (Verité, n.d.). Poor resident households in the plantations had to engage their children to assist in completing a daily job (Verité, n.d.; ILO, 2013; Pailey, 2024), which later will succeed the work of the present youth workers and become part of the major workforce.

However, natural rubber production and tapping of latex require some form of learning activities like a series of training to acquire specialized knowledge and skills for better work performance (Verité, n.d.; Darmawan *et al*., 2014; Kawano, 2019; Ballesteros & Ancheta, 2021; Singh *et al*., 2021; TESDA, 2021). However, the author, a former worker in a large rubber plantation in Liberia, affirmed that no training had been instituted by the company he worked with on natural rubber production for the youth. Sustaining the life of rubber trees for the rubber industry depends on the performance of jobs based on the workers' knowledge and skills.

The continuous recruitment of young people for the job over many years has made them develop the necessary experience and skills through the tutorship of parents and other adults. Later, the youth workers become sources of technical know-how in latex harvesting to their peers in the company. Such knowledge acquisition may have undergone the SECI (Socialization, Externalization, Combination, Internalization) Model, a knowledge conversion that originated in organizations and firms (Nonaka, 1994), which the study aims to contribute to the literature.

This study analyzed the characteristics and knowledge level of the youth workers in natural rubber harvesting in Liberia. To achieve this, the study answered the following questions: What are the characteristics of youth workers in the plantation that have capacitated them to become technical information sources in latex harvesting to their co-workers in the plantation? What is their knowledge level in natural rubber tapping if they base it on some science-based procedural manual? What knowledge-sharing processes were found helpful for the youth to become knowledge sharers to other youth?

The disruption of educational systems in Liberia

Liberian education is significantly lagging as compared to other countries due to the disruption of the educational systems brought about by the recent civil war and the Ebola Virus Disease epidemic. The situation of the prolonged and brutal 14 years (1989–2003) civil conflict became compounded by the Ebola Virus Disease epidemic (2014–2015), causing the system to collapse (Santos & Novelli, 2017; Boateng, 2020). Consequently, the extension services through the Ministry of Agriculture, research institutions, and universities were also disrupted (Moore, 2017).

Knowledge and knowledge types

Knowledge is a "set of truths and beliefs, perspectives and concepts, judgments and expectations, methodologies and know-how" (Wiig, 1999). Two general types of knowledge can be identified in organizations – the tacit and explicit. Tacit knowledge can be attributed to Michael Polanyi's (1891–1976) thesis, "The Tacit Dimension," which states that it resides within an individual's mind and is not easily expressed. Explicit knowledge is the encoded data and information (thus formal) that can be transferred and shared with communities, industries, and organizations in systematic knowledge (Nonaka, 1994; Mohajan, 2017). Explicit knowledge or externalized knowledge makes the knowledge-sharing processes easy. Therefore, for tacit knowledge to be fully utilized, it should be converted to explicit knowledge using the process of externalization or internalization. The SECI Model provides the possibilities of sharing knowledge through the transformation and conversion phases, namely, Socialization/Tacit to Tacit, Externalization/Tacit to Explicit, Combination (Explicit to Explicit), and Internalization (Explicit to Tacit) (Nonaka, 1994; Nonaka *et al*., 1995). The authors emphasized that tacit knowledge, acquired through socialization, is based on hands-on experience rather than written manuals.

Informal and non-formal types of learning

Informal learning may be viewed as work-based learning, where learning can happen anytime and anywhere (Cross, 2007). It is a lifelong educational process through which learners acquire skills, attitudes, insights, and knowledge from the environment. In Liberia, in Nimba, Grand Bassa, Margibi, Maryland, and Montserrado Counties, examples of apprenticeship/mentorship or informal training are carpentry, auto mechanics, and artisanal skills (Latchem, 2014; Ralston *et al*., 2016). For the youth workers in the natural rubber industry, the most prevailing form of education is informal education (Ralston *et al*., 2016). Extension education, a non-formal education, facilitates peoples' access to new knowledge, information, and technologies and promotes interaction with research, education, agri-business, and other relevant institutions to assist them in developing their own technical, organizational, and management skills and practices (Suvedi & Kaplowitz, 2016; Cook *et al*., 2021).

Experience and skills acquisition and studies in the harvesting of natural rubber

Experience is acquired when knowledge (know-how) of and skill (ability to follow steps) on something is applied. Skill is acquired through several events; it is done and can be related to practice (Carnevale, 1990; Guile, 2002; Asonitou, 2022). In both, acquiring scientifically correct or adequate knowledge, experience, and skills about something is important. Specifically, on using tools in harvesting latex in Liberia, the emphasis was on the wrong placement of tapping utensils, panel markers, spouts, wire hangers, cups, and buckets and the lack of effective communication skills – reading and writing, as inadequacy in tool handling may impede the tapping process and growth of the industry (Adam Smith International-Growliberia, 2019). The lack of skills among tappers in Liberia is common; however, parents engaged their children (below 18 years) in harvesting natural rubber to help them finish their quota on time (Pailey, 2024). Through this, the children develop skills through the tutorship of parents and later become youth expert workers. Research shows that most African rubber tree tappers were young, particularly those in the top natural rubber-producing regions (Onoji *et al*., 2021; Ejenavi & Adade, 2022). Youth tappers were hired to fill the labor gaps in these plantations. The authors highlighted the need to train and encourage unemployed youths into rubber tapping to accelerate the transformation of natural rubber production (Onoji *et al*., 2021; Ejenavi & Adade, 2022). Similarly, Pierre-André *et al*. (2010) emphasized that "young rubber farmers are often better disposed to trying innovations and have lower risk aversion and longer planning horizons.

METHODOLOGY

The study was conducted at the Cocopa Rubber Plantation in Nimba County, Liberia (**Figure 1**). Nimba is in the northeastern region of Liberia, with a population of about 462,026 and a land size of approximately 13,500 ha. It has an average annual temperature of 25.9^{o}C and an average annual rainfall of 2,000 mm. The plantation has a concession area of approximately 10,117.14 ha, of which 3,439.823 ha (33.99%) have been cultivated (IMF, 2008; Milbrandt, 2009; Outram, 2016; Verité, n.d.).

The study respondents were youth workers (Onoji *et al*., 2021; Ejenavi & Adade, 2022), ages 15–35, who came from seven camps or estates and listed as plantation workers in 2022 as per telephone communication with the human resources manager on 15 March 2022. Accordingly, 274 of the workforces were youth, comprising the survey study's total population. A sample size was calculated as 145 and subjected to stratified random sampling (Panacek, 2008; Creswell, 2014). During the survey, 139 participated and as semi-structured questionnaire was used. A two-choice category scale determined whether they performed steps and activities using TESDA (2021) (**Appendix Table 1**). The TESDA's training module was the source of the science-based procedural manual for this study. It details the competencies required of a trainee for various activities from rubber plantation nursery production to tapping, like the proper handling of tools, among others. Gathered data were tabulated (McCaffrey *et al*., 2022), encoded,

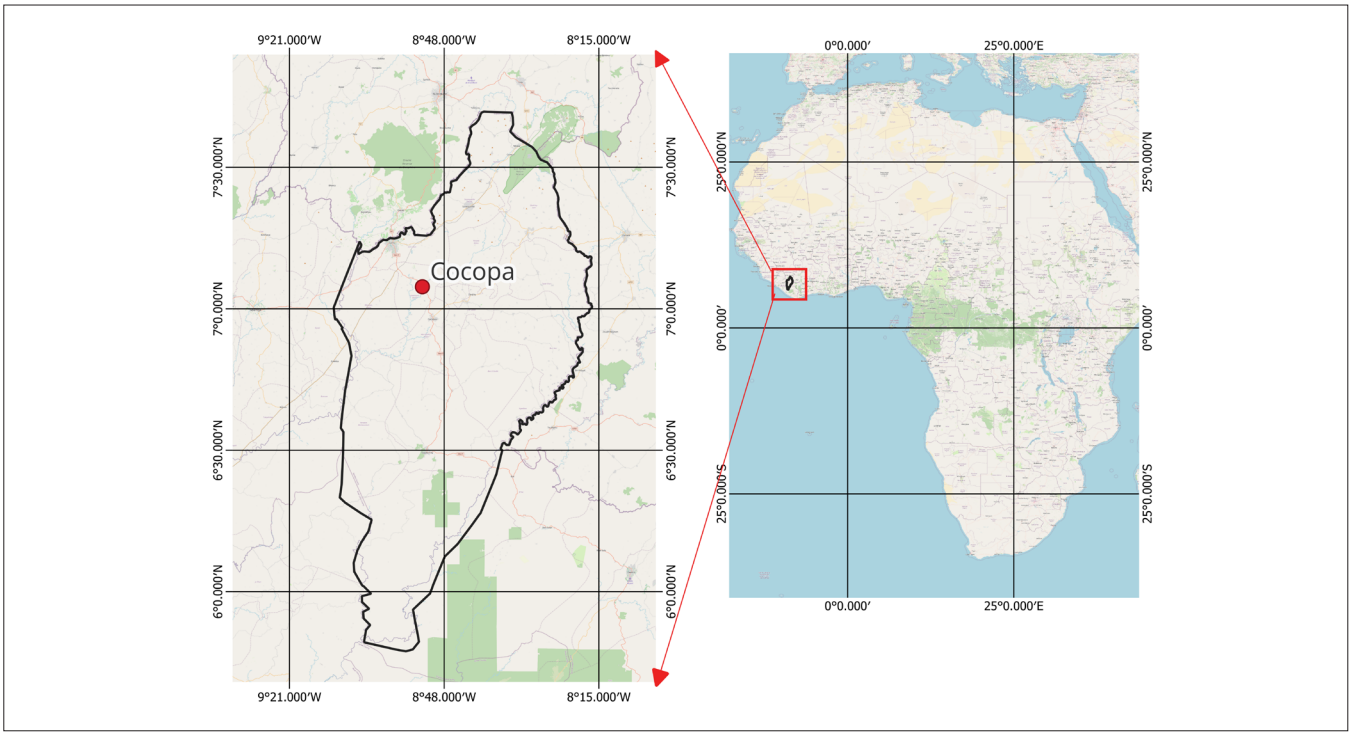

Figure 1. Study site and its location in the map of Africa (Map courtesy of A. Salvacion and Map data, 2024).

and analyzed (frequency, percentage distribution, mean, standard deviation, and Chi-square) using the Statistical Package for Social Sciences (SPSS 12.0). Additionally, the company's human resources manager and a supervisor were interviewed to validate the youth's responses. A focus group of seven adult plantation residents verified the gathered responses. Permission to conduct the study was also obtained from the plantation owners.

RESULTS AND DISCUSSION

Characteristics of the youth workers

Table 1 presents the social and economic status of the plantation's youth workers in Nimba County, Liberia.

Age. Most respondents (68.4%) were aged 31 to 35, followed by the age bracket 26 to 30 (30.2 %). The mean age of the respondents was 30 years old. In a study in South-south Nigeria by Betty *et al*. (2018), the mean value age of natural rubber tappers was 43.6. This suggests that the rubber tappers in north-east Liberia were relatively younger than the South-south Nigerians.

Educational level. Nearly one-third (29.5%) completed junior high school, typically the minimum education that rubber plantation companies expect from their employees in Liberia. Furthermore, 25.9% have no formal education, which, according to the interviews with the company staff, was generally acceptable on a natural rubber plantation in Liberia since latex harvesting is primarily labor intensive and requires a high skill level. However, respondents who reached primary education at 25.2% were very close to the percentage of those with no formal education. The lowest percentages were those who finished senior high school (18.7%) and had a school certificate in general agriculture (0.7%). Similarly, a study conducted by Ejenavi & Adade (2022) on smallholder rubber production under different tapping arrangements in Delta State, Nigeria, found that 87% of the tappers were up to junior high education. This implies that rubber plantation owners may not be interested in the formal education of tappers but instead in their skills acquired through time working with their older mentors (informal education).

Gender. Majority of the respondents (84.9%) were male. Ejenavi &Adade (2022) had almost the same result, showing that the majority (84.45%) of the tappers were male. These results suggest that the harvesting of natural rubber is male dominated because of the extensive labor involved.

Income. Almost half of the respondents (46.8%) received a monthly income of USD 100.1 to 133.3. The combined ranges of USD 66.7 to 100 (22.3%) and USD 133.4 to 166 (21.6%) are close to the earlier income range received. The highest received salary ranged from USD 166.8 to 200. Those with a substantial income range (7.9%) were usually in an

Table 1. Descriptive characteristics of youth workers.

Parameter			Frequency	Percentage (%)
Age	31–35		95	68.4
	20–30		42	30.2
	20–25		2	1.4
		Total	139	100
		Mean	30	
Educational level	Junior high school		41	29.5
	Primary education		35	25.2
	Senior high school		26	18.7
	Vocational school		1	0.7
		Total	139	100
Sex	Male		118	84.9
	Female		21	15.1
		Total	139	100
Monthly income (USD)	100.1–133.3		65	46.8
	66.7–100		31	22.3
	133.4–166.7		30	21.6
	166.8–200.1		11	7.9
	>200.1		2	1.4
		Total	139	100
		Mean	124.87	
Job title	Tapper		133	95.7
	Headmen		4	2.9
	Overseer		2	1.4
	Supervisor		0	0.0
		Total	139	100
Number of years employed	4–6		90	64.8
	7–10		23	16.6
	1–3		18	12.9
	>10		8	5.8
		Total	139	100
Marital status	Married		75	53.9
	Single		51	36.7
	Divorced		7	5
	Widow		5	3.6
	No response		1	0.7
		Total	139	100
Place of origin	Nimba County		72	51.7
	Bong County		47	33.9
	Lofa County		7	5.1
	No Response		6	4.3
	Grand Bassa County		5	3.4
	Gbarpulu		1	0.8
	Margibi County		1	0.8
		Total	139	100

advantageous position in terms of other sources of income or improved livelihood. The study result agrees with the findings of Mulbah *et al*. (2021) that there are low incomes and high poverty rates among the smallholder natural rubber farmers who are approximately below (58%) USD 1.90 day^{-1}.

Job title. The majority of the respondents (95.7%) were tappers, followed by 2.9% who were headmen. According to the company's human resources manager, the tappers were required to harvest latex from at least 500 trees day^{-1} and work for 26 days mo^{-1}. Further, the headman was a junior supervisor who directed field activities and monitored a group of at least 25 tappers. The overseers (1.4%) were responsible for supervising the headmen. They ranked higher than the headmen and supervised five headmen or five groups comprising 125 tappers. The supervisors administered the work of the overseers, controlling two to three camps, and reported directly to the Estates' Manager. The study result agreed with the findings of Betty *et al*. (2018) and Ejenavi &Adade (2022) that most of the respondents surveyed at various sites were tappers. This implies that on most rubber plantations, the highest employed jobs were tappers.

Number of years of employment. Most (64.8%) respondents worked on the plantation for four to six years. This is followed by those employed for 7 to 10 years (16.6%). Only 12.9% of the youth workers worked on the plantation for one to three years. This suggests that respondents' long work engagement may have helped them acquire and share knowledge and technical skills about tapping practices. Also, the result is consistent with the work of Betty *et al*. (2018), which concludes that the long years of experience of rubber farmers in Nigeria indicate that most of the farmers started farming at a young age.

Marital status. Youth workers have four marital status categories: single, married, widow, and divorced. According to the study's findings, most respondents (53.9%) were married, implying the importance of family labor in the natural rubber industry. It also highlights the importance of marriage in the Liberian culture, as emphasized in Betty *et al*. (2018), such that Nigerian natural rubber farmers value marriage and its attached significance. Additionally, the rest of the percentage comprised either single (36.7%), divorced (5.0%), or widow (3.6%) status.

Number of children of the youth workers. More than a quarter (27.3%) of the respondents revealed to have 3 to 4 children. About 25.9% and 20.9% had 5 to 6 children and 7 to 8 children, respectively. Those with the least number of children, two children, accounted for 12.9%. Another 12.9% revealed to have no children. The motivation of the children to work in the rubber plantation is to assist their parents meet the daily needs and to support their education (Heriberta *et al*., 2022). Based on the same study, those with more children, particularly four to six kids, were in an advantageous position in meeting a household's daily quotas for higher earnings for the family

Place of origin. Most respondents (51.7%) hailed from Nimba County, but a significant percentage came from Bong County (33.9%). In comparison 5.1% came from Lofa County, which only showed that the youth workers came from various counties of Liberia. This contrasts with a study conducted in Thailand (Tongkaemkaew & Chambon, 2018), noting that labor movements in rubber plantations fluctuated over time. The Thai research showed conditions of hired labor in-migration to rubber plantations, while family laborers pursued livelihood opportunities through out-migration.

Residence. More than half of the respondents (57.5%) were residents of Cocopa Rubber Plantation, while the rest (42.5%) were non-residents. A high percentage of the respondents residing in the plantation may suggest their fondness for natural rubber production. Similarly, Gitz *et al*. (2020) highlighted those temporary migrations for tapping played a role in expanding rubber plantations such as in Liberia. Aside from the income from tapping, developed skills may have influenced the present and future households to carry on such work.

Knowledge level in latex production

Knowledge level refers to the measure of the information an individual has acquired on natural rubber production in terms of experience, skills, and tool handling.

Experience and skills in natural rubber production and comparisons. Experience refers to acquired knowledge in producing natural rubber over a long period through mentorship from parents, peers, and supervisors. A person can be experienced and knowledgeable in something through a long period of mentorship with experts (knowledge acquired from experts). **Table 2** reveals that most of the youth workers were knowledgeable in such as measuring tappable trees (76.3%) and tapping criteria (72.7%), collecting and storing latex and cup lumps (69.8%), installing tapping paraphernalia (66.9%), and coagulating latex and preparing formic acid (66.9%), which are tapping-related activities. This implies that the respondents were knowledgeable in tapping but only in some steps. Skills refer to the ability to organize and perform specific tasks (Baartman & De Bruijn, 2011), from pre-tapping to skills in marketing (self-nurtured knowledge). As revealed, youth workers were skilled in opening tappable trees (94.2%), measuring tappable trees (93.5%), installing tapping paraphernalia before tapping (78.4%), collecting and storing latex and cup lumps (76.3%), and coagulating-latex-and-preparing formic acid (66.9%).

Comparatively, the respondents were knowledgeable and skilled in the same steps as in harvesting latex. It suggests that these were the only aspects the respondents learned from their parents and adult mentors. Yet, there was an inadequacy of knowledge learned, given that not all of the steps were shared with them, which may imply that their mentors may have inadequate knowledge and skills. The majority of respondents were found

Table 2. Experience and skills/practice of the youth workers in latex production.

Parameter	Response	Experience		Skill	
		Frequency (n=139)	%	Frequency (n=139)	%
Pre-tapping girth size inventory	Yes	52	37.4	45	32.4
	No	87	62.6	93	66.9
Installation of tapping paraphernalia	Yes	93	66.9	109	78.4
	No	46	33.1	27	20.9
Tapping criteria	Yes	101	72.7	130	93.5
	No	38	27.3	9	6.5
Tappable measurement	Yes	106	76.3	131	94.2
	No	33	23.6	6	4.3
Coagulation of latex and preparation of formic acid	Yes	93	66.9	93	66.9
	No	46	33.1	46	33.1
Coagulation of latex and application of formic acid	Yes	26	18.7	10	7.2
	No	112	80.6	129	92.8
	None	1	0.7		
Collection and storage of latex and cup lumps	Yes	97	69.8	106	76.3
	No	42	30.2	31	22.7
	None	0		2	1.4
Weighing, collection of latex, and cup lumps	Yes	61	43.9	56	40.3
	No	77	55.4	83	59.7
Marketing, classification of latex, and cup lumps	Yes	17	12.1	13	9.4
	No	121	87.1	126	90.7
	None	1	0.7	2	0.0
Marketing computation for costing of latex and cup lumps	Yes	3	2.2	2	1.4
	No	136	97.8	137	98.6

insufficient in knowledge (87.1%; 97.8) and skill (90.7%; 98.6%) in marketing and computation for the cost of latex and cup lumps, respectively. Betty *et al*. (2018) has a different result, which revealed that rubber farmers have the required knowledge and skills to improve their marketing performance, such as effective communication, record keeping, and devising strategies to enhance efficient marketing activities. This confirms that harvesting latex requires specialized knowledge and skills.

Regarding respondents' distribution of scores (**Table 3)**, it was found that the majority (72%) obtained scores ranging from 4 to 7, which is classified as medium level. The medium score (4.96) implies that the respondents have inadequate experience and skills in natural rubber production. At the same time, the low score of 18% means that the respondents have limited capacity in terms of experience and skills in the harvesting of natural rubber. Therefore, as it may suggest, there is a need to train the youth workers in Cocopa Rubber Plantation in natural rubber production also to acquire the required knowledge and skills and contribute to the sustainability of rubber trees and rubber industry similar to the natural rubber tappers in South-south, Nigeria (Betty *et al*., 2018).

Table 3. Distribution of respondents by experience and skills score.

Score	Frequency (n=139)	Percentage (%)
Low 0-3	25	18
Medium 4-7	100	72
High 8-10	14	10
Total	139	100
Average		4.96

Sources of experience and means of sharing of natural rubber harvesting

Sources of experience. Respondents' sources of experience through mentorship is shown in **Figure 2.** A mentor is an individual who helps another person make significant transitions in their knowledge, work, or thinking through informal mentoring (Zin, 2014). Younger peers mentored the majority (30.2%), while the rest of the sources were respondents' fathers (27.3%), siblings (15.1%), and older peers (12.2%). However, 0.7% of the respondents did not respond to the question regarding their mentorship source, which may mean the need for peer mentorship.

Manner of knowledge sharing. During the knowledge sharing on natural rubber harvesting, the respondents were mentored through the following SECI model of knowledge-sharing processes (Nonaka, 1994).

- **Socialization (Tacit to Tacit).** Knowledge is shared through observation, guidance, imitation, and practice (Nonaka *et al*., 1995). As revealed in **Table 4**, most respondents (79.1%) were mentored informally through field demonstrations, which is exemplary of tacit-to-tacit mentoring, confirming Ralston *et al*. (2016). Such knowledge-sharing activity was done on the rubber plantation, which Cocopa Plantation Company did not organize. The highest rating of field demonstrations among activities may suggest that it is an effective way of mentoring the youth on natural rubber production. The FGD adult participants revealed that in the past, they were mentored by younger peers through demonstration in the field. Accordingly, these informal mentorships were conducted for two to three days to prepare them for the job.

- **Externalization (Tacit to Explicit).** This phase is focused on converting tacit knowledge to explicit knowledge (Nonaka *et al*., 1995), where knowledge is shared informally and formally using encoded data (Nonaka, 1994; Mojan, 2017), such as documented notes. The result showed that only 0.7% of respondents used tacit to explicit knowledge-sharing (**Table 4**).

- **Combination (Explicit to Explicit)**. A combination of knowledge sources, *i.e*, encoded data and information, *e.g*., a training manual. Some respondents (4.3%) did not use a training manual because the company has yet to develop a document for sharing knowledge on natural rubber production.

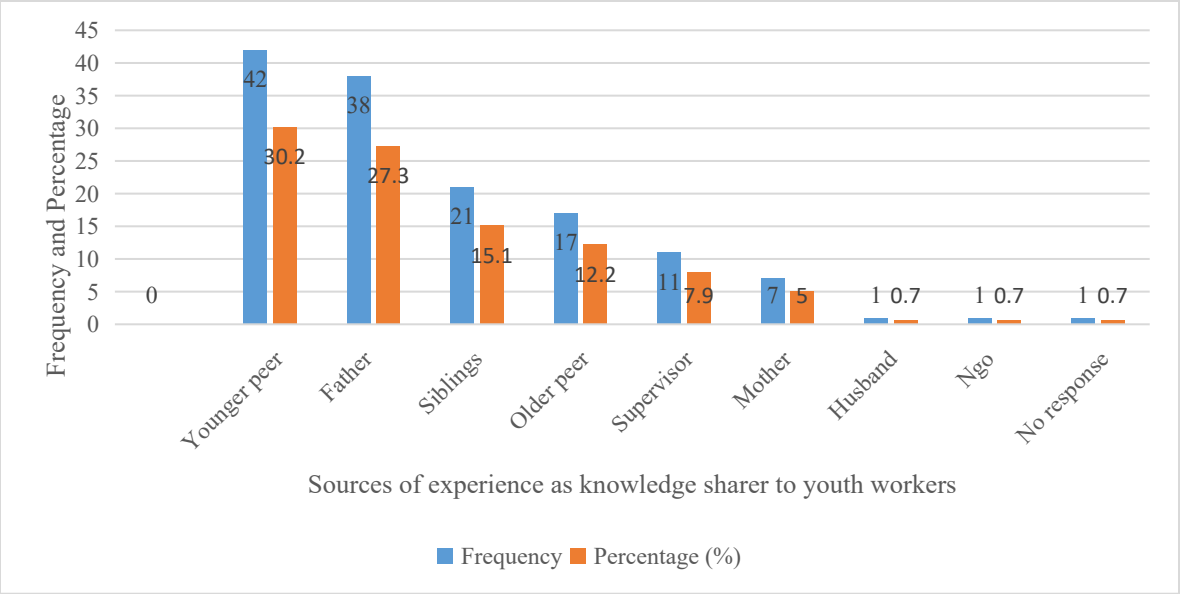

Figure 2. Sources of experience as knowledge sharer to youth workers.

- **Internalization (Explicit to Tacit).** This process involves experientially transforming an individual's existing knowledge. About 15.8% of the respondents said they were mentored through the internalization process.

Similarly, in **Table 4**, when the SECI Model was applied in sharing knowledge in latex tapping activities, the results showed that 66.2% of the respondents performed tapping practices based on explicit to tacit knowledge sharing (internalization). On the other hand, 33.1% of the respondents said they harvested latex according to the company's standard, typical of explicit-to-explicit knowledge sharing (combination). This may suggest that the shared knowledge in harvesting latex by the old, previous mentors may have been acquired from the Cocopa Rubber Plantation. In other words, today's youth workers may not have attended training organized and conducted by the company, but previously, it may be assumed that there was. Furthermore, only 0.7% of the respondents answered the question positively or negatively regarding the standard at which they performed tapping. FGD adult participants, however, mentioned that their knowledge gained in natural rubber production was provided by their younger peers (tacit-to-tacit knowledge sharing, *i.e*, demonstration in the field), which contradicts the earlier assumption. This may need a future investigation as younger peers may refer to children who were found to be a part of the tapper workforce, too (Pailey, 2004; Verité, n.d.).

Table 4. Means of knowledge sharing and standard of harvesting natural rubber.

Means of knowledge sharing	Frequency (n=139)	Percentage (%)
Tacit to tacit	110	79.1
Explicit to tacit	22	15.8
Explicit to explicit	6	4.3
Tacit to explicit	1	0.7
Total	139	100.0
Standard at which harvesting is performed	**Frequency (n=139)**	**Percentage (%)**
Explicit to tacit	92	66.2
Explicit to explicit	46	33.1
No response	1	0.7
Total	139	100.0

Experience and skills compared with science-based procedure

Table 3 shows that most respondents (72%) obtained scores ranging from 4 to 7, classified

as medium level. Those who obtained high scores (8–10) were 10%, while those with low scores accounted for 18%. The Chi-square analysis showed an association between experience and skills at 55.70, which is highly significant at a probability level of 0.00 (**Table 5**). To determine their strength of association, Cramer's V was computed, and it was found that the two variables were moderately associated with Cramer's V value of 0.45. This implies that, in general, the respondents were practicing some form of science-based natural rubber harvesting, according to the training manual of TESDA (2021). The study findings also agree with Giroh & Adebayo (2009), showing a positive relationship between farming experience and technical efficiency in rubber latex production in Edo State of Nigeria. However, Tongkaemkaew & Chambon (2018) noted that the lack of experience and skilled tappers could create a competitive disadvantage; rubber tapping would be maintained by reducing the number of workers but introducing new technologies to make tapping more productive.

Table 5. Result of chi-square test between experience score and skills score.

Experience score	Skills score			Total
	0-3	4-7	8-10	
0-3	18	25	0	43
4-7	6	63	4	73
8-10	1	12	10	23
Total	25	100	14	139
Pearson Chi^2, Df =4		55.70	Pr= 0.00	
Cramer's V		0.45		

Use of tools and materials

Tools (*i.e*, tapping knife, spouts, cups, cup hanker, panel marker, and acid) are necessary to perform natural rubber harvesting satisfactorily. According to the survey, the most common tools and materials used by the respondents were: tapping knives (100%), acid (100%), cups (99%), spouts (96%), cup hankers (91%), and panel marker (45%) (**Figure 3**).

This suggests that the respondents may have utilized the varied tools yet are unsure of their experience and skills and whether they are satisfactorily used. They were accustomed to using conventional tools to harvest natural rubber rather than modern tools such as mechanical tapping knives, templates, spouts, cups, cup hankers, panel markers, and formic acid (TESDA, 2021). Yang *et al*.'s (2022) study on developing rubber-tapping machines in intelligent agriculture argues that manual rubber tapping is a time-consuming and skill-oriented labor; hence, the motorized concept of tapping a knife was recommended. This may imply that using modern tools can make the tapping of the respondents less laborious and more productive.

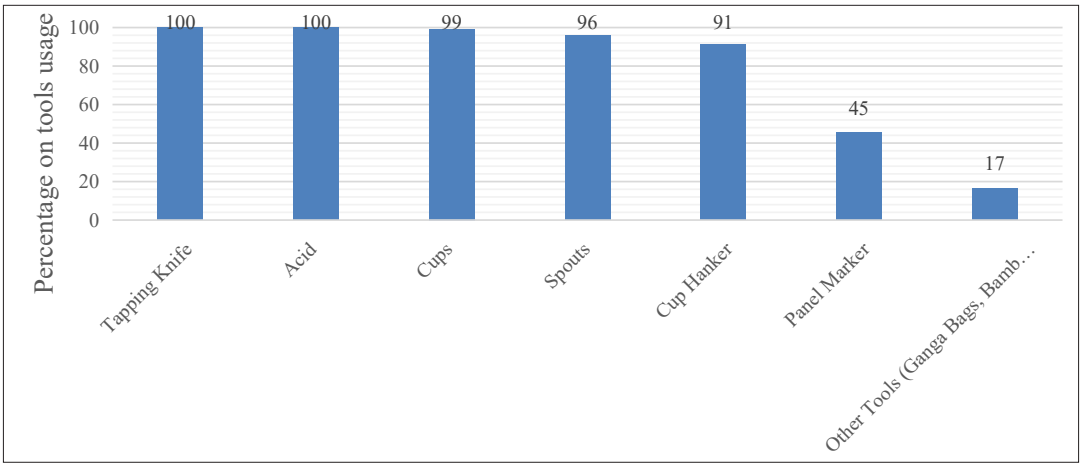

Figure 3. Tools and materials used by the youth workers in the harvesting of natural rubber.

CONCLUSION

The study analyzed the characteristics and knowledge (experience and skill) level of youth workers in harvesting latex in the Cocopa Rubber Plantation based on the TESDA training manual. Youths with four to six years of work employment may have capacitated them to share acquired experience and skills from their parents and other adults with co-workers. While more than a quarter (29.5%) have formal education, the least (18.7%) have reached senior high school. A little over a quarter (25.9%) have not attended school. Similar to other study findings, the majority (95.7%) are tappers, which may imply that the rubber companies are not interested in a tapper's formal education but in experience and skills. Therefore, the rubber industry's sustainability is in the hands of the experienced and skilled youth in latex harvesting. With the high relative frequency of performance based on TESDA's training module, they are knowledgeable in five out of the nine procedural steps such as 1) measuring tappable trees, 2) tapping criteria, 3) collecting and storing latex and cup lumps, 4) installing tapping paraphernalia, and 5) coagulating latex and preparing formic acid. While, the computed knowledge level is at medium. This may mean the youth's inadequacy of procedural science-based knowledge, and thus, they will need the institution of training for the youth workers in the plantation to increase the latex harvesting productivity. Also, using the Chi-square analysis, the association between experience and skill was highly significant. This may imply that they are practicing some form of science-based latex harvesting but inadequately done. The tools used on the plantation may be similar to some of the training manuals. However, because the study did not look into the satisfaction of the performance of the tools, a study may be conducted in the future. Using the SECI Model, it has been determined that knowledge in latex harvesting is acquired informally (tacit to tacit) from parents and adults, not through other knowledge conversion phases/activities like training. Through studies such as this, the improvement of the status quo may yet begin, which will likely be helpful to rubber plantation owners and policymakers to improve the knowledge and skills of youth workers and their socio-economic conditions for the sake of the rubber industry.

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Appendix Table 1. Required knowledge and skills in harvesting latex.

No.	Element	Performance criteria	Required knowledge	Required skill
1	Perform pre-tapping operations	Girth inventory is performed based on the standard pre-tapping procedure	Girth size inventory	Performing girth size
		Panel marking is performed using a template according to industry standards	Dotting procedures	Conducting dotting activities
		Tappable trees are pre-opened following industry practices	Preparation of tapping tools, materials, supplies, and equipment	Preparing tapping tools, materials, supplies, and equipment
		Tapping tools, materials, supplies, and equipment were prepared based on work requirements	Installation of tapping paraphernalia and panel markings	Installing tapping paraphernalia
		Area tasking was determined following industry standards	Rubber tasking	Determining rubber tasking
		The farm owner coordinates job assignments	Coordination of job assignments	Coordination of job assignments
		Written agreements are secured following industry standards		
		Safety is applied following OSHS		
2	Perform tapping	Tapping techniques are performed based on industry standards	Criteria of tappable trees	Measuring and determining tappable trees
		Tapping paraphernalia are utilized following industry standards	Measurement and determination of tappable trees	Opening tappable trees
		Tapping paraphernalia were maintained according to established farm practice	Utilizing opening gadgets	Utilizing opening gadgets
		Safety measures were applied based on OSHS	Removal and collection of tree lace and scraps	Removal and collection of tree lace and scraps
			Weed management	Practicing safety
			Maintenance of tapping tools	
				OSHS on rubber tapping activities
				Mathematical skills
3	Coagulate latex	Formic acid solution is prepared following the standard formula	Preparation of formic acid solution	Preparing formic solution
		Formic acid is applied according to industry standards	Application of acid	Applying formic acid
		Safety practices are applied following OSHS	OSHS	Applying safety practices
4	Perform collection activities	Latex and cup lumps are collected according to established farm standards	Collection and storage of latex and lump	Collecting and storing latex and cup lump
		Volume of latex is measured following industry standards	Weighing of collected latex and cup lump	Weighing collected latex and cup lump
		Cup lump is weighed following industry standards	Recording of weight	Recording collections

Appendix Table 1. *Con't.*

No.	Element	Performance criteria	Required knowledge	Required skill
		Safety practices are done according to industry standard	Utilization of a weighing scale	Practising safety
			Safety on handling formic acid	Utilizing weighing scale
5		Market rubber coagulum and cup lumps	Collected latex and cup lumps are classified based on industry criteria	Classification of collected latex and cup lump
		Canvass for a better price of latex and cup lumps is performed with reference to industry practice	Computation for costing of latex and cup lump	Computing cost of latex and cup lump
		Costing of latex and cup lump are computed following industry standards	Sharing arrangement for earnings	Following the sharing arrangement for earnings
		Arrangement for the sharing of earnings is followed based on industry practice	Canvassing for better price of latex and cup lumps	Canvassing better price of latex and cup lump
		Marketing transaction is completed following industry practice	Completion of marketing transaction	Completion of marketing transaction
			Basic mathematical operation	Negotiation skills
			Formalization of agreement	Communication skills

Source: TESDA (2021)