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Sustainable Development: Development of Wisdom for Dyeing Natural Fibers Used to Create Community Textile Products

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The objectives of this research were: (1) to examine the factors influencing the natural dyeing process using teak leaves, and (2) to evaluate consumer satisfaction with textiles dyed using this technique. A structured questionnaire was employed as the research instrument, focusing on the characteristics of environmentally friendly textile products. Utilizing Exploratory Factor Analysis (EFA), the study identified 28 variables affecting the natural dyeing process from teak leaves, and Confirmatory Factor Analysis (CFA) established separate discriminant validity data. Four key factors were identified: (1) Policy and Natural Materials, (2) Knowledge of Local Materials, (3) Wisdom/Skills, and (4) Textile Products. All factors met the standard criteria for fit indices, with values of $\chi 2$ = 11.164, df = 15, relative $\chi 2$ = .744, p = .741, GFI = .991, AGFI = .956, NFI = .994, TLI = 1.009, CFI = 1.000, RMSEA = .000, and RMR = .020, allowing for the evaluation of new textile product prototypes through Multiple Regression Analysis. The study found that these four independent variables collectively explained 86.0% of consumer satisfaction, as indicated by the standardized regression equation = .434(X1) + .325(X2) + .292(X3). The findings highlight the potential of using local materials to enhance environmental sustainability, generate community income, and preserve traditional wisdom in Thailand.

Keywords: Sustainability, Natural materials, Dyeing, Creativity, Products.

Introduction

Global fluctuations in environmental and economic conditions have led to widespread negative impacts on populations worldwide (Harper, 2021). These fluctuations are primarily driven by rapid human development, which has resulted in the overexploitation of natural resources and significant environmental degradation. Additionally, the release of substantial amounts of pollutants has contributed to increased environmental toxicity, leading to unprecedented variability in global temperatures. Thailand, in particular, is experiencing severe effects from climate variability, including frequent natural disasters and environmental issues such as droughts, pest infestations, floods, soil degradation, and increased dust particles (PM2.5). These challenges have adversely affected the livelihoods of the Thai population and have also disrupted the economy, leading to increased product prices.

The current environmental challenges necessitate a strategic response from the Thai government to comprehensively address these issues. This strategy should include initiatives to raise environmental awareness among provincial populations and to promote changes in the production methods of small-scale industries within local communities. Emphasizing sustainable development is crucial, particularly through the integration of traditional local knowledge to foster environmentally friendly practices. This approach should be aligned with community needs, focusing on enhancing production processes and meeting market and consumer demands. In response, the Thai government has introduced a plan to advance national development through the Bio-Circular-Green (BCG) economic model, which aims to achieve sustainable development in three key areas: (1) social security, (2) environmental stability, and (3) economic stability. This initiative is part of the broader Thailand 4.0 policy, which seeks to ensure comprehensive sustainability across all sectors of the country.

The Thai government has supported local communities nationwide by promoting development through three primary economic models: (1) Bioeconomy, (2) Circular Economy, and (3) Green Economy. These models serve as critical mechanisms for driving rapid economic growth and facilitating the equitable distribution of income to remote communities across Thailand. The overarching goal of this initiative is to enhance the country's competitive potential, transitioning Thailand from a middle-income nation to a high-income country with increased opportunities for its citizens.

The teak tree is regarded as an endemic species widely cultivated across Thailand, with numerous trees planted in agricultural areas within local communities. This research aims to develop a method for utilising discarded teak leaves and branch fragments for the dyeing of natural fibres. It is essential to encourage local communities to recognise the value of teak trees by using fallen leaves to dye fibres before weaving them into fabrics. This approach not only fosters community learning and highlights local potential but also generates income for communities involved in processing teak leaves into vibrant woven fabrics. The colours derived from teak leaves contribute to a unique identity for these textiles, enhancing their appeal through distinctive hues and patterns. Such practices present an opportunity to promote sustainability within provincial communities across Thailand. Consequently, this research seeks to enhance the use of teak leaves in dyeing community textiles by advancing the principles of the Circular Economy through natural dyeing processes. This approach is crucial in the creation of environmentally friendly and socially responsible textile products.

The utilisation of local natural materials in community textile production necessitates active community participation (Pradhan & Khandual, 2020). This approach highlights the potential of leveraging local resources to foster economic development and reduce poverty within communities (Muzekenyi, Nyika, & Hoque, 2023). Additionally, it encourages communities to engage in ongoing sustainable development practices, including the promotion of sustainable supply chains and the creation of employment opportunities that support local livelihoods. In this context, the small-scale textile industry present in communities across Thailand embodies the concept of economic resilience, contributing to positive structural changes in society and promoting sustainable stability for the future environment and way of life in Thailand (Levickaitė, 2011).

Literature Review

Conceptual Framework

Conceptual Framework for Process Development: Dyeing fibres before weaving them into long lengths is a crucial step in the production of woven products, imparting a distinctive appearance that reflects the community's cultural identity. Community members have traditionally sourced natural materials from their local environment as raw materials for textile production, guided by principles of sustainability (Saxena & Raja, 2014; Zakariya, Mandy, & Peeters, 2023). Consequently, research on natural dyes has focused on developing dyeing techniques that minimise environmental impact (Arora, Agarwal, & Gupta, 2017; Tavera, 2023; Zhang et al., 2022). The use of dyes derived from local natural materials not only enhances the aesthetic appeal of textiles but also supports environmental sustainability. The application of natural dyes found in many communities offers several notable benefits, including: (1) biodegradability, (2) non-toxicity to humans, (3) reduced risk of allergic reactions, (4) environmental friendliness, (5) job creation within the community, (6) promotion of local material use, and (7) the potential for recycling natural dyes.

Application of Conceptual Framework: The dyes used for colouring textile fibres are derived from various plant components, such as leaves, roots, bark, and stems. These plant-based dyes are environmentally friendly and have minimal negative impact on the environment. Substituting natural dyes for synthetic petroleum-based dyes represents a viable strategy for reducing environmental harm (Ahsan et al., 2020; Muthuswamy, 2023). This approach supports the development of community textile products by focusing on three key factors: (1) reducing the release of harmful chemicals into the environment, (2) encouraging and supporting closed-loop production systems, and (3) promoting a circular economy that benefits the community (Bishal et al., 2023; Zhu & Chandran, 2023).

*Creative Concept Framework***:** This approach involves producing textiles by dyeing fibres with natural teak leaves, which creates a distinctive identity in terms of colour, setting these products apart from others in the market. This uniqueness enhances consumer interest in textile products and influences changes in consumer behaviour and attitudes towards purchasing decisions. Consumers increasingly prioritise products made using environmentally friendly and sustainable processes, making this a key factor in their purchase decisions (Niinimäki et al., 2020; Subandowo & Winardi, 2022). Textiles made from natural materials hold a competitive advantage over conventional products that lack environmental conservation attributes. Consumers are now more inclined to make quicker purchasing decisions by assessing the environmental and social impacts of products (Khalid Sandhu & Makki, 2023; Luchs et al., 2010). Therefore, the design of textile products dyed with teak leaf colours aligns well with current market trends and evolving consumer demands.

Conceptual Framework for Integration: The framework integrates traditional wisdom with technology tailored to community conditions, promoting sustainable development through the use of teak leaves in the natural dyeing process. This approach fosters an environmentally, socially, and economically conscious method of textile production, engaging community members in utilizing local resources to enhance economic potential. It generates income, supports the circular economy (Saha, Dey, & Papagiannaki, 2022; Zhao, Chen, & Li, 2024), and fosters the creative economy (Kopiievska et al., 2023) for sustainable development. This concept is demonstrated in a case study of the Ko Sub-district, Li District, Lamphun Province, as depicted in Figure 1(A-G).

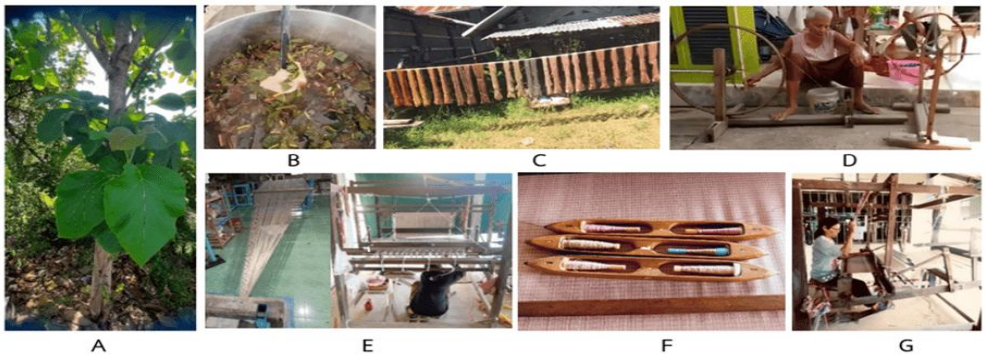

Figure 1: A: Young Teak Leaves; B: Breaking Them into Small Pieces with Boiling Water to Extract Color; C: Putting Silk Threads through a Dyeing Process and Drying Them in the Sun; D: Preparing Silk Threads; E: Process of Winding the Warp to be Formed in a Striped Pattern of Warped Threads; F: A Wooden Weaving Shuttle Containing a Spool of Weft Thread to be Used to Weave Back and Forth While Lifting the Warp Threads Up and Down; G: The Weaving Process.

Methodology

This study utilised an applied research methodology, comprising the following stages: 1) data collection, 2) design, 3) experimentation, 4) analysis, and 5) identification of factors for a new design. The research involved investigating the factors associated with the application of the natural dyeing process using teak leaves and evaluating the satisfaction levels with textiles dyed using this technique.

Objectives

1. To investigate the factors involved in the application of the natural dyeing process using teak leaves.
2. To evaluate the level of satisfaction with textile products created from yarn dyed with teak leaves.

Scope of Research in the Study of Factors for the Application of the Natural Dyeing Process From Teak Leaves

A) The study population included individuals involved in weaving local textiles in Li District, Lamphun Province, as well as attendees of the "Silk Road Identity of Thai Lanna Fabrics" exhibition. This exhibition was held from 23 to 25 June 2023 at the Hariphunchai Handwoven Textile Institute, Lamphun Province, and attracted a total of 480 participants.
B) The sample group consisted of a community engaged in weaving local textiles and 214 consumers who attended the trade show. Sampling was conducted using Krejcie and Morgan's random sample table with a tolerance level of 0.05 and Simple Random Sampling (Krejcie & Morgan, 1970).
C) The research employed a structured questionnaire designed to gather information on the use of teak leaf dyes in creating community textile products. The questionnaire utilized a 5-point Likert scale and demonstrated reliability with a high alpha coefficient (Cronbach's Alpha = 0.962) (Peterson, 1994).
D) Data analysis was performed using EFA and CFA to assess the research findings.

Scope of Research on Satisfaction Assessment of Consumers Who Purchase Textile Products Made of Yarn From the Natural Dyeing of Teak Leaves

A) The population for the study consisted of consumers who attended the Winter Fair in Nakhon Lampang in 2024, amounting to a total of 1,000 individuals (National News Bureau of Thailand, 2023).
B) The sample group comprised attendees of the Lampang Winter and Good Products Fair for local community products in 2024. A sample of 316 individuals was selected using Taro Yamane's random sampling table with a tolerance level of 0.05 and Simple Random Sampling (Yamane, 1973).
C) The research employed a structured questionnaire designed to assess satisfaction with textile products. The questionnaire included observable variables measured on a 5-point Likert scale. The reliability of the instrument was confirmed with a high alpha coefficient (Cronbach's Alpha = 0.902), indicating strong reliability for data collection (Peterson, 1994).
D) Data analysis involved descriptive statistics, including mean and standard deviation, to examine the relationships between variables, complemented by Multiple Regression Analysis (MRA).
The research was conducted in accordance with ethical standards and received certification from the Institutional Review Board (IRB) at King Mongkut's Institute of Technology Ladkrabang, as documented in approval number EC-KMITL 67 029.

Results

Results of the Study Concerning Factors in the Application of the Natural Dyeing Process From Teak Leaves

The assessment of natural dyes derived from teak leaves involves understanding the factors applied in the creation of new textile products, which can be divided into two stages:
Step 1: Exploratory Factor Analysis (EFA)
This stage involves grouping collected data into variables using EFA. The data analyzed includes consumer preferences and variables influencing consumer selection and satisfaction with woven fabrics dyed using natural dyes. The objective is to explore variables and identify common factors that elucidate the relationships among all observable variables (Hair et al., 2019). The specific steps undertaken are as follows:

1. Identification of 28 variables for study.
2. Establishment of a sample size of 214 individuals, which is deemed sufficient for reliable analysis.
3. Assessment of the commonality values of variables to explain commonalities based on specified criteria (> 0.71), with commonality values ranging from 0.842 to 0.713. The Kaiser-Meyer-Olkin (KMO) measure and Bartlett's Test results exceed 0.71, as detailed in Table 1.

Table 1: KMO and Bartlett's Test of the Sample Group with the Desire to Use Textile Products Utilizing Techniques for Natural Dye Made From Teak Leaves.

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy		.800
Bartlett's Test of Sphericity	Approx. Chi-Square	7141.761
	Df	378
	Sig.	.000

The KMO measure and Bartlett's Test yielded a KMO value of 0.800, which is greater than the recommended threshold of 0.50, indicating that the data are suitable for exploratory factor analysis. The Bartlett's Test of Sphericity yielded a Chi-Square value of 7141.761 with a significance level of 0.000, further supporting the appropriateness of the data for this analysis. The factor analysis extracted four key factors from the 28 variables, accounting for the total variance as follows: Factor 1 explained 50.528% of the variance, Factor 2 accounted for 8.652%, Factor 3 contributed 7.387%, and Factor 4 represented 4.887%. The Scree Plot analysis, which

revealed a cumulative variance of 71.455%, illustrated that the Eigenvalues of the 28 variables aligned perfectly with the graphical representation, showing a clear slope from Factor 1 to Factor 4, as presented in Table 2.

Table 2: Axis Rotation Weight Value of Factors with the Verimax Method.

	Policy and Natural Materials - Factor 1	F/1	F/2	F/3	F/4
A17	The development of textile products can increase economic value.	.797			
A19	It can promote the budget and increase the competitiveness of the community.	.785			
A18	The process creates environmentally friendly textile products.	.755			
A20	It can promote and support the creation of community stores that sell textile products.	.744			
	Local Materials Knowledge - Factor 2	**F/1**	**F/2**	**F/3**	**F/4**
A14	It can increase knowledge and skills in using teak leaves to produce natural dyes.		.809		
A11	The dye produced from teak leaves is unique for meeting market demand.		.794		
A16	The dye production and weaving processes are suitable for the community's potential.		.784		
	Wisdom / Skills - Factor 3	**F/1**	**F/2**	**F/3**	**F/4**
A12	The process of natural dyeing from teak leaves is appropriate for the community's potential.			.842	
A13	Products using dyes from teak leaves are appropriate for existing community wisdom.			.741	
A8	The prices of textile products must be at a level appropriate for consumer groups.			.731	
	Textile Products - Factor 4	**F/1**	**F/2**	**F/3**	**F/4**
A3	The distinctive colors are appropriate for the patterns of woven fabric.				.746
A6	The color of teak leaves used for dyes can bind the fibers.				.740

* Set element weight values at a level of 0.71 and above

The analysis identified four distinct factors from the 28 variables studied. Factor 1 (Policy and Natural Materials) comprises variables A17, A19, A18, and A20. Factor 2 (Local Materials Knowledge) includes variables A14, A11, and A16. Factor 3 (Wisdom/Skills) is represented by variables A12, A13, and A8. Factor 4 (Textile Products) consists of variables A3, A6, and additional variables. Out of the original 28 variables, the analysis prioritized the 12 with the highest correlations, consolidating them into these four factors. These factors are pivotal for evaluating the potential success in addressing consumer needs for textile products dyed with natural teak leaf dyes, as demonstrated in Figure 2.

	A17_A11	A19_A12	A18_A13	A20_A14	A14_B11	A11_B12	A16_B13	A12_C11	A13_C12	A8_C13	A3_D11	A6_D12
A17_A11	.874[a]											
A18_A13	-.376	.887[a]										
A19_A12	-.469	-.283	.872[a]									
A20_A14	-.147	-.317	-.064	.928[a]								
A14_B11	-.209	-.095	.229	.094	.802[a]							
A11_B12	.107	.142	-.211	-.082	-.479	.832[a]						
A16_B13	.049	.028	-.138	-.014	-.502	-.186	.854[a]					
A12_C11	-.087	.087	.077	.005	.037	.128	-.087	.701[a]				
A13_C12	-.086	-.079	.061	-.160	-.046	-.193	.125	-.498	.848[a]			
A8_C13	.145	-.226	.091	-.070	-.047	-.284	.134	-.648	.118	.777[a]		
A3_D11	-.181	.130	-.040	.182	.078	-.115	-.035	.190	-.007	-.310	.808[a]	
A6_D12	-.126	-.028	-.035	-.140	.066	.135	-.287	.001	.031	-.114	-.471	.882[a]

Figure 2: Analysis of Anti-Image Matrices (Measures of Sampling Adequacy: MSA).

Step 2: Confirmatory Factor Analysis (CFA)

a) First-Order Confirmatory Factor Analysis: Prior to conducting the CFA, data inspection revealed a KMO measure of 0.829, and Bartlett's Test of Sphericity yielded a value of 2769.750 with a significance level of 0.000 (Hair et al., 2019). These results indicate that the data are sufficiently related for analysis. Additionally, the reliability of the data collection instrument was high, with a Cronbach's Alpha coefficient of 0.899.

b) Second-Order Confirmatory Factor Analysis: The fit indices for the second-order CFA were as follows: Chi-Square = 11.164; degrees of freedom (df) = 15; Relative Chi-Square = 0.744; p-value = 0.741; RMSEA = 0.000; RMR = 0.020; GFI = 0.991; AGFI = 0.956; NFI = 0.994; TLI = 1.009; CFI = 1.000. These indices meet the specified criteria: Relative Chi-Square is less than 2, RMSEA and RMR are below 0.05, and GFI, NFI, AGFI, TLI, and CFI exceed 0.95 (Schumacker & Lomax, 2015; Suksawang, 2020). Consequently, it can be concluded that the factors influencing consumer satisfaction with textile products dyed with teak leaves are effectively represented by four factors, ranked in order of their impact: 1) Policy and Natural Materials, 2) Local Materials Knowledge, 3) Wisdom/Skills, and 4) Textile Products. These factors collectively influence the success of introducing and fabricating textile products from natural teak leaf dyes to meet consumer needs, as detailed in Table 3.

[Pol]=Policy and Natural Materials [Loc]=Local Materials Knowledge [Wis]=Wisdom / Skills [Tex]=Textile Products

The AVE and CR values for the four identified factors are summarised as follows: 1) Policy and Natural Materials (AVE = 0.753, CR = 0.924), 2) Local Materials Knowledge (AVE = 0.725, CR = 0.887), 3) Wisdom and Skills (AVE = 0.761, CR = 0.905), and 4) Textile Products (AVE = 0.718, CR = 0.799). These values satisfy the established criteria for validity (Hair et al., 2019), where

CR exceeds 0.7, AVE is greater than 0.5, and both the MSV and ASV are lower than the AVE. Consequently, the data demonstrate discriminant validity, indicating that the four factors, derived from twelve indicator variables, are distinct and separable. These findings are presented in Table 3 and illustrated in Figure 3.

Table 3: Second Order Confirmatory Factor Analysis.

Latent Variable, Observable Variable	Policy and Natural Materials			Local Materials Knowledge			Wisdom / Skills			Textile Products			r^2
	b	*β*	*S.E.*	*b*	*β*	*S.E.*	*b*	*β*	*S.E.*	*b*	*β*	*S.E.*	
PolA17	1.000	.951	-										.905
PolA19	.886	.887	.041**										.787
PolA18	.777	.881	.036**										.777
PolA20	.748	.753	.050**										.567
LocA14				1.000	.922	-							.850
LocA11				.783	.815	.052**							.664
LocA16				.765	.818	.050**							.669
WisoA12							.875	.756	.121**				.571
WisA13							1.000	.906	-				.822
WisA8							.986	.973	.086**				.946
TexA3										.747	.728	.075**	.530
TexA6										1.000	.956	-	.915

Latent Variable	New Design			R^2	AVE	CR
	b	*β*	*S.E.*			
Pol	1.000	.847	-	.717	.753	.924
Loc	.783	.669	.097**	.447	.725	.887
Wis	.560	.548	.081**	.301	.716	.905
Tex	.737	.789	.083**	.623	.718	.833

Chi-Square = 11.164 ; df = 15, Relative Chi-Square = .744, p-value = 0.741, GFI = 0.991, AGFI =0.956, NFI = 0.994, TIL = 1.009, CFI = 1.000, RMSEA = 0.000, RMR = 0.020 [P < .05; ** P < .01]*

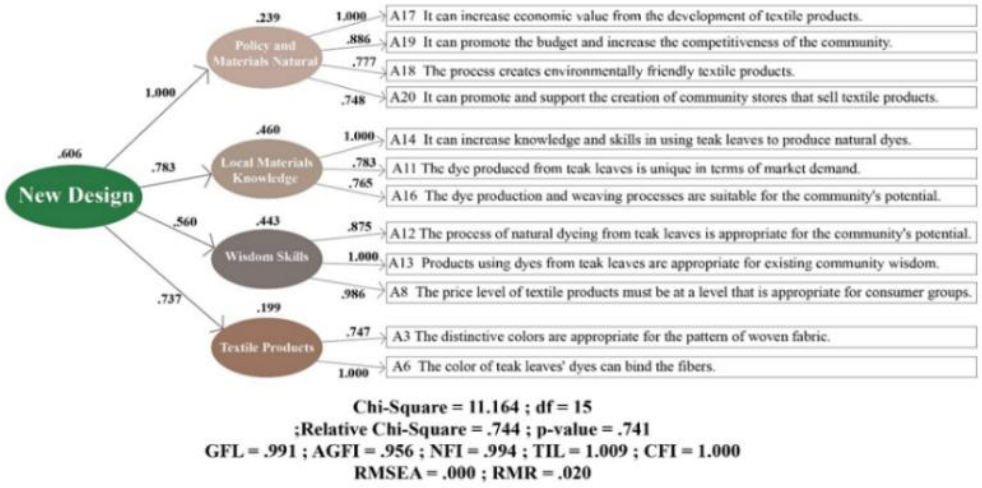

Figure 3: Second Order Standardized Estimates and Final Structural Equation Model.

In conclusion, consumer satisfaction with textile products dyed using teak leaves is influenced by four key factors, ranked from highest to lowest impact as follows:

1. Policy and Natural Materials: This factor includes variables PolA17, PolA19, PolA18, and PolA20.
2. Textile Products: This factor comprises variables TexA6 and TexA3.
3. Local Materials Knowledge: This factor consists of variables LocA14, LocA16, and LocA15.
4. Wisdom and Skills: This factor includes variables WisA8, WisA13, and WisA12.

These factors collectively determine the level of consumer satisfaction with textiles utilizing natural dyes from teak leaves.

Results of the Satisfaction Assessment of Textile Products Produced with Yarn From Natural Dyeing with Teak Leaves

a) New Textile Product Design Process: The design process for new textile products incorporates all four factors derived from the 12 indicator variables. This approach is used in the creation of woven fabrics naturally dyed with teak leaves, specifically by female weavers in Ko Sub-district, Li District, Lamphun Province, as detailed in Table 4.

b) Brainstorming for Designing Textile Products: Ideas drawn from the arts and culture of Lamphun Province have been integrated into the design of new textile products, focusing on utilising locally abundant materials (Tresnawati, Saleh, & Wardani, 2020). The colours achieved through natural dyeing with teak leaves offer a distinctive aesthetic compared to dyes derived from other sources (Rather et al., 2023). Additionally, these textile products positively impact the health and environmental well-being of individuals in community groups, employing a sustainable development approach that efficiently minimises environmental impact, as outlined in Table 4.

c) Evaluation of Satisfaction in New Textile Products:

Consumer satisfaction with participation can be evaluated through the exhibition titled "Silk Road Identity of Thai Lanna Fabrics," held at the Hariphunchai Handwoven Textile Institute in Lamphun Province from June 23 to 25, 2023, as illustrated in Figure 4.

Table 4: Textile Production by Using Natural Dyes From Teak Leaves.

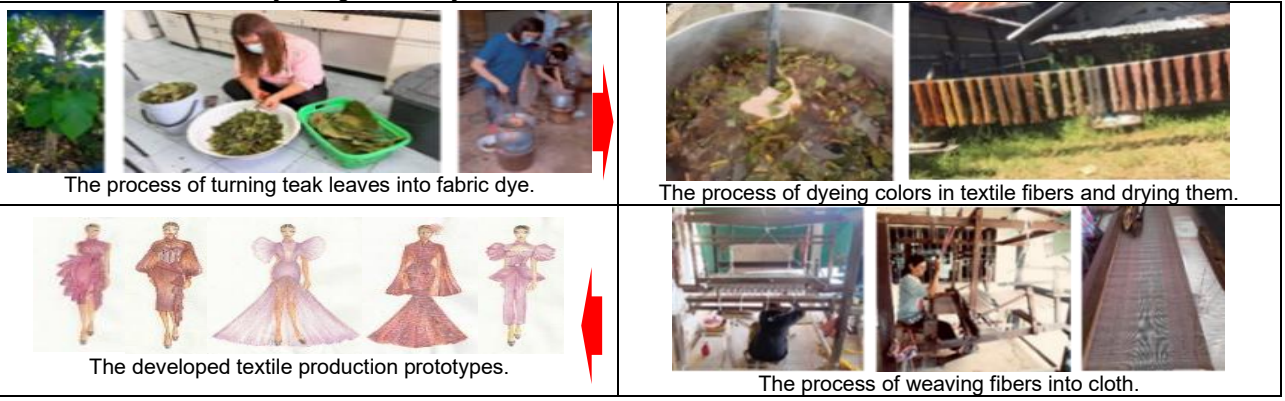

Figure 4: Prototype of Developed Textile Product.

Table 5: Consumer Satisfaction with Textile Products from Natural Dyeing with Teak Leaves (n=316).

	Factor	Mean	S.D.	Cronbach's Alpha	Satisfaction Level
1	**Policy and Natural Materials**	4.02	0.93	.926	Very Satisfied
A17	It can increase economic value from the development of textile products.	4.16	0.86	.928	Very Satisfied
A19	It can promote the budget and increase the competitiveness of the community.	4.06	0.81	.926	Very Satisfied
A18	It enables a process for creating environmentally friendly textile products.	4.06	0.90	.928	Very Satisfied
A20	It can promote and support the creation of community stores that sell textile products.				
2	**Totals Local Materials Knowledge**	4.07	0.79	.927	Very Satisfied
A14	It can increase knowledge and skills in using teak leaves to produce natural dyes.	3.32	0.94	.929	Moderately Satisfied
A11	The dye produced from teak leaves is unique and meets market demand.	3.60	0.88	.928	Very Satisfied
A16	The dye production and weaving processes are suitable for the community's potential.	3.66	0.83	.929	Very Satisfied
3	**Totals Wisdom / Skills**	3.53	0.79	.929	Very Satisfied
A12	The process of natural dyeing from teak leaves is appropriate for the community's potential.	3.59	0.88	.931	Very Satisfied
A13	Products using dyes made from teak leaves are appropriate for existing community wisdom.	3.78	0.84	.933	Very Satisfied
A8	The price level of textile products is appropriate for all consumer groups.	3.59	0.80	.928	Very Satisfied
4	**Totals Textile Products**	3.66	0.73	.931	Very Satisfied
A3	The distinctive colors are appropriate for the patterns of the woven fabric.	4.15	0.74	.930	Very Satisfied
A6	The color of the dyes made from teak leaves can bind to the fibers well.	4.23	0.75	.928	Very Satisfied
	Totals Sum Total	4.19	0.68	.929	Very Satisfied
		3.85	0.82	.929	Very Satisfied

The evaluation of consumer satisfaction with textile products dyed with natural teak leaf dye yielded the following results: 1) Textile products received a high level of satisfaction, with a mean score of 4.19 and a standard deviation of 0.68; 2) Policy and Natural Materials were also rated highly, with a mean of 4.07 and a standard deviation of 0.79; 3) Wisdom/Skills achieved a high satisfaction level, with a mean of 3.66 and a standard deviation of 0.73; 4) Local Materials Knowledge received a high satisfaction rating, with a mean of 3.53 and a standard deviation of 0.79. Overall, the consumer group rated all four factors with a high level of satisfaction, averaging a mean score of 3.85 and a standard deviation of 0.82. The analysis, based on 316 sets of data, included normality testing for the four factors: 1) Policy and Natural Materials, 2) Local Materials Knowledge, 3)

Wisdom/Skills, and 4) Textile Products. All four factors met the criteria for normality (Hair et al., 2019), as normality was not considered significant when the sample size is 200 or more, as shown in Table 5.

Figure 5: Relationship Between Independent Variables (X) and Dependent Bariables (Y).

In summary, 1) the graph shows a normal distribution with no outliers and data conforming to the normal distribution line; 2) a linear relationship exists between independent and dependent variables; 3) scatterplots indicate equal variance; and 4) data is consistently arranged, confirming suitability for analysis. Four independent variables—creative thinking, skill development, knowledge creation, and consumer satisfaction with natural dye textiles—are identified. The model predicts 86.0% of consumer satisfaction ($R^2 = 0.860$; $R = 0.927$; Adjusted $R^2 = 0.860$), exceeding the minimum 60% criterion, as illustrated in Figure 5 and Table 7. Subsequent analysis revealed statistical significance ($p = 0.000$), with the multiple regression equation effectively capturing the phenomena under investigation, as detailed in Table 6.

Table 6: ANOVA.

Model	Sum of Squares	df	Mean Square	F	P-Value
1 Regression	94.328	4	23.582	477.067	.000
Residual	15.373	311	.049		
Total	109.702	315			

Table 7: Stepwise Multiple Regression Analysis.

Model	Unstandardized Coefficients		Standardized Coefficients	t	P-Value	Zero-Order	Collinearity Statistics	
	B	Std. Error	Beta				Tolerance	VIF
1 (Constant)	.257	.089	-	2.899	.004	-	-	-
Policy and Natural Materials	.324	.020	.434	16.271	.000	.799	.632	1.582
Local Materials Knowledge	.242	.019	.325	12.442	.000	.718	.662	1.512
Wisdom / Skills	.237	.020	.292	11.891	.000	.665	.746	1.341
Textile Products	.127	.023	.146	5.452	.000	.642	.629	1.589
R=0.927, R^2=0.860, Adj R^2=0.858, SEE=0.22233, Durbin-Watson=2.155								

*p < .05

The analysis presented in Table 7 identifies key factors influencing consumer satisfaction with textile products dyed using natural dyes from teak leaves. Four variables significantly impact consumer satisfaction: 1) Policy and Natural Materials ($\beta = 0.324$, $t = 16.271$, $p = 0.000$), 2) Local Materials Knowledge ($\beta = 0.242$, $t = 12.442$, $p = 0.000$), 3) Wisdom/Skills ($\beta = 0.237$, $t = 11.891$, $p = 0.000$), and 4) Textile Products ($\beta = 0.127$, $t = 5.452$, $p = 0.000$). Collectively, these factors account for 86.0% of the variance in consumer satisfaction. All variables exhibit a statistically significant impact at the 0.05 level. The regression equation reflecting these relationships is as follows:

Regression Equation in Raw Score Form

$$\hat{y} = 257 + .324(X_1) + .242(X_2) + .237(X_3) + .127(X_4)$$

Regression Equation in Standard Score Form

$$Z = .434(X_1) + .325(X_2) + .292(X_3) + .146(X_4)$$

Discussion

The investigation into factors influencing the design of textile products using natural dyes from teak leaves employed EFA to identify 28 variables, from which 12 with the highest correlations were distilled into four factors: 1) Policy and Natural Materials, 2) Local Materials Knowledge, 3) Wisdom/Skills, and 4) Textile Products. Subsequently, CFA was conducted, demonstrating discriminant validity and high predictive value across these factors. Community groups can leverage these four factors to design textile products, enhancing the likelihood of future success. These factors reflect consumer preferences and the demand for new textile products dyed with teak leaves (Aktan & Anjam, 2022). Consequently, this approach supports community sustainability in three key areas: environmental, economic, and lifestyle sustainability (Jourabchi Amirkhizi, Pourtalebi, & Anzabi, 2023).

Community development can be enhanced by leveraging local resources to create competitive advantages in the market (Brondízio et al., 2021). The application of natural dyes from teak leaves for fabric dyeing offers a distinctive community identity. This approach provides women's weaving groups in northern Thailand with the opportunity to expand their market reach. Additionally, government support can facilitate the advancement of environmentally sustainable dyeing techniques and promote the refinement of weaving skills to produce high-quality, intricate patterns. Such initiatives contribute to the sustainable development of the community across multiple dimensions and support the preservation of traditional weaving expertise in northern Thailand (Junsongduang et al., 2017).

The satisfaction assessment of the new textile product design reveals three key areas of community potential: 1) the utilization of natural resources, 2) the application of local wisdom, and 3) the enhancement of skills. The evaluation of consumer satisfaction with the prototype product is linked to four factors: 1) policy and natural

materials, 2) local materials knowledge, 3) wisdom/skills, and 4) textile products and related items. The structural equation model analysis of 12 variables meets the established criteria, demonstrating its efficacy in designing textile products using natural dyes from teak leaves. This approach supports community and consumer sustainability in both economic and environmental dimensions (Ebrahim et al., 2022). Additionally, the prototype textile products are characterized by a chemical-free and environmentally friendly production process. The effective application of the four identified factors in creating these prototypes has resulted in high consumer satisfaction, affirming the potential for sustainable development among female weaver groups in Li District, Lamphun Province. This allows them to produce and design textile products that align with consumer preferences across the four factors:

1) Policy and Natural Materials: This factor emphasizes the promotion of locally abundant materials for producing natural dyes. In this instance, the community has chosen teak leaves, which are processed into a distinctive fabric dye that embodies the community's identity. Such products not only generate income and contribute to economic stability but also take into account environmental considerations. This approach raises awareness about the adverse effects on both the community and its surrounding environment. By understanding these environmental impacts and their positive implications, the community's awareness of environmental importance is heightened (Bechtold et al., 2003).

2) Local Materials Knowledge: Community members are learning to identify and utilize local natural materials to develop products that align with the community's resources and potential. In Phrae Province, for example, the abundance of teak trees and the accumulation of fallen teak leaves during the dry season present an opportunity for innovation. These leaves, which often accumulate on the forest floor and contribute to severe forest fires and PM 2.5 dust, can be repurposed. By using these dried leaves, the community can help mitigate the PM 2.5 dust issue, particularly in northern Thailand (Ado et al., 2014). Furthermore, increasing environmental awareness among community members prompts proactive measures to address potential future problems. Implementing a sustainable development strategy will aid in reducing environmental impact and fostering long-term ecological balance in Thailand (Ebrahim et al., 2022).

3) Wisdom/Skills: The tradition of dyeing natural fibers, such as silk and cotton, with teak leaves has been a longstanding practice in Phrae Province, located in northern Thailand. This traditional knowledge not only preserves local cultural values but also emphasizes the utilization of indigenous materials to produce dyes from teak leaves. The resulting colors and patterns on the fabric fibers are distinctive, embodying a unique identity that reflects the cultural heritage and individuality of the community (Junsongduang et al., 2017).

4) Textile Products: The integration of local natural materials in textile product development serves as a model for lifelong learning within the community. The Thai government has endorsed this approach to support continuous education as a means to bolster the grassroots economic system and strengthen community-level economies (Brondízio et al., 2021). This model also facilitates the acquisition of knowledge and skills among local weavers, enabling them to effectively address the needs of contemporary consumers. Utilizing locally abundant natural materials fosters sustainability in three key areas: 1) economic sustainability, 2) livelihood sustainability, and 3) environmental sustainability.

The four factors influencing consumer satisfaction account for 86.0% of the variance, demonstrating their effectiveness in predicting demand and behavior towards textile products dyed with teak leaves. This approach not only supports community income stability by leveraging local wisdom but also promotes traditional Thai handicrafts from Northern Thailand (Tresnawati et al., 2020). Utilizing local natural dyes aligns with environmentally friendly practices, differentiating these products from competitors. By applying local textile dyeing techniques with teak leaves, Lamphun Province can achieve economic and environmental sustainability, reduce chemical use, and improve the health of both weavers and the community. This process meets modern consumer demands for high-quality, eco-friendly products (Ebrahim et al., 2022).

Conclusion

This research explores the use of local materials, specifically teak leaves, to align with Thailand 4.0 and the BCG economic model, aiming for sustainable development in social, environmental, and economic sectors. By integrating traditional wisdom and circular economy principles, the study supports the creation of eco-friendly textile products and fosters community involvement. Utilizing abundant local resources not only promotes sustainable practices but also enhances economic opportunities and reduces poverty. The evaluation of new textile prototypes revealed four key factors influencing consumer satisfaction, highlighting this approach's effectiveness in minimizing environmental impact and preserving traditional dyeing practices while meeting modern demands for sustainable products.

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