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Exploring the Factors Driving Coffee Farmers' Innovative Behavior in GAP Implementation: A TPB Approach

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ABSTRACT

This study aims to identify the factors underlying the innovative behavior of coffee farmers in implementing Good Agriculture Practice (GAP) using the Theory of Planned Behavior (TPB). The main variables studied are attitudes, subjective norms, and Perceived Behavioral Control, followed by local characteristics and innovation of variables as additional variables of the TPB concept. Data were analyzed quantitatively with primary data through distributing questionnaires to 120 Arabica coffee farmers in Solok Regency. The PLS-SEM method was used to analyze statistical data. The study found that innovation characteristics directly affect attitudes and knowledge, while local characteristics only affect attitudes. Perceived Behavioral Control affects farmers' innovative intentions and behavior. Innovation characteristics indirectly affect innovative behavior in implementing GAP through knowledge and intentions, while farmer knowledge indirectly affects innovative behavior through farmers' intentions in implementing GAP. This study offers further insight into how innovation characteristics, local context, and perceived behavioral control significantly shape coffee farmers' attitudes, intentions, and innovative behavior in adopting Good

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Agriculture Practices (GAP). By accommodating more factors that affect intentions and behavior, adding new variables can improve the accuracy of the predictive model. This allows us to predict better how farmers will respond and adopt good agricultural practices. The results of this study can provide valuable information for policymakers and businesses to develop more effective strategies to encourage farmers to implement GAP.

Keywords: Characteristics Local; Characteristics Innovation; Behavior

1. Introduction

The potential of coffee is very promising and will continue to be developed. Indonesia became the second-largest coffee-producing country in Asia and Oceania after Vietnam in 2022/2023 [1]. According to ICO data, in the 2022/23 coffee year, Indonesia's coffee production grew by 6.0% to 9.9 million tons. This increase can be attributed to the expansion of coffee planting areas, which indicates a promising future for the Indonesian coffee industry.

This encouraging fact continues to demand an increase in the coffee-drinking experience as coffee is widely accepted and popular among young people. Drinking coffee increases the demand for coffee production and encourages coffee farmers from all over the country to produce more and more sustainable coffee [2]. This condition is an opportunity for farmers to profit from this segment. Market demand for coffee that can be processed with high quality and has access to the proper marketing channels [3].

Several provinces contribute to coffee production in Indonesia, including South Sumatra, Lampung, Aceh, North Sumatra, Bengkulu, West Java, Central Java, East Java, East Nusa Tenggara, South Sulawesi, and West Sumatra [4]. Almost 98% of coffee plantations in Indonesia are managed and operated by small farmers. The management of these people's plantations is less intensive due to several obstacles that must be faced by farmers, starting from the availability of production facilities such as fertilizers, availability of capital, and technical knowledge of cultivation efforts from maintenance to post-harvest [5–8]. Solok Regency is one of the main coffee-producing areas in West Sumatra. In addition to Robusta coffee, this district also produces Arabica coffee, with production centers in Lembah Gumanti District, with a production of 429 tons, and Pantai Cermin, producing 745 tons in 2023. This production figure had increased compared to 2022, when coffee production in Lembah Gumanti District was only 332.8 tons, and Pantai Cermin District was 363.58 tons [9]. However, when viewed from the level of productivity, coffee production in this area is not optimal. Based on the Good Agricultural Practices Guidelines/GAP on Coffee issued by the Indonesian Ministry of Agriculture in 2014, Arabica coffee productivity can reach 0.7–1.4 tons/hectare. However, the productivity of coffee farmers in this area is still around 0.6 tons/ha. The low productivity also impacts the availability of raw materials for the coffee processing industry in the region [10]. As a result, the coffee powder processing industry in West Sumatra still has to rely on supplies from other provinces. On the other hand, the market potential of the coffee processing industry in this province continues to grow rapidly. Still, it is constrained by the availability of raw materials that are not yet sufficient. This condition is a great opportunity and a challenge for local farmers to increase productivity and optimize supply to support the sustainability of the coffee processing industry in this region.

Utilization innovation for activity production needs to encourage farmers to increase production results [11]. Application of Good Agriculture Practice (GAP), with the application of several introductory innovations, starts to use superior seeds, maintenance with pruning non-productive branches, land conservation, and pest control in an integrated manner. Utilization and introduction of innovation through implementing GAP activities have positively influenced the level of expediency innovation advantage relative to the resulting production [5]. The decision to use innovation by farmers is only seen from the economic aspect produced but also requires an approach from the psychological side of the farmer [12].

Farmers face several challenges in utilizing GAP innovation. The main challenges faced start from the lack of understanding of GAP and farmers' hesitation in accepting innovation due to the complexity of the technology introduced. Lack of knowledge and experience sometimes causes conventional farming efforts carried out by farmers to clash with the GAP [13]. Farmers have difficulty in implementing GAP stages, such as not pruning and not intensive fertilization [7, 14]. Jailani's research [15] results also show that in terms of harvesting, farmers still pick whole fruit and do not choose red fruit to harvest, resulting in coffee that does not have uniform quality when marketed.

Theory of Planned Behavior (TPB) TPB argues that the intention to adopt a new behavior depends on attitudes, social norms, perceived behavioral control, and the intentions that lead to adopting the behavior [16]. Ajzen continued to conduct further studies on applying the theory in various contexts and integrations. Ajzen highlighted the role of perceived behavioral control and examined the relationship between self-efficacy and locus of control in influencing individual intentions and behaviors and how attitudes toward objects and subjective norms interact to shape intentions [17, 18]. Further research was also conducted by reflecting on the development of the TPB, evaluating its application in various fields such as health, consumer behavior, and the environment, and highlighting the extension of this theory to include emotional and automatic factors, cross-cultural applications, and examining the challenges faced in the era of new technologies and social changes that affect human behavior [19–21]. J. Sok, J. R. Borges, et al. [22] in a critical review of farmer behavior, argue that the TPB, in its most basic form, may be less responsive to external variables or contextual factors that play a significant role in farmer decision-making. The need to modify the TPB to include these factors can improve the accuracy of predicting farmer behavior with a more flexible approach that can integrate emotional factors, intrinsic motivation, and cultural aspects in understanding farmer decisions, especially in sustainable and innovative practices.

Many studies have used TPB in the field with the use of the TPB variable [12, 23–27]. Several researchers have already expanded the TPB because TPB variables are considered too simple [28]. Extending the Theory of Planned Behavior (TPB) is done by adding new like add variables such as personal norms, moral norms [23, 29–33], knowledge, and social-economic characteristics [34]. The expansion was also carried out by integrating another theory, in particular in utilization adoption innovation as done by Daxini, et al. [35] with the integration of the Nutrient Management Plan (NMP), Protection Motivation Theory (PMT) [36–39], the diffusion of innovation (DOI) [40, 41].

This study adds evidence of the use of other variables besides the variables in the TPB. We chose to test and adapt the TPB and combine it with the design of the diffusion of innovation (DOI) theory in the case of coffee production in Solok Regency, West Sumatra, Indonesia, because the area has local community characteristics between openness, collectivism, and long-term orientation. The findings of Putri et al.'s study [42–44] highlight the importance of innovation in improving coffee farming practices. This relationship shows that an approach that strengthens openness increases long-term orientation and facilitates the implementation of GAP, which can be an effective strategy to support the coffee sector in this region. Openness to innovation and long-term orientation are not only social characteristics but also act as key drivers of the sustainability of the coffee sector. Indicators of innovation characteristics, relative advantage, compatibility, and trialability, according to research results S. Thamrin [45], also influence the implementation of GAP. Research of Putri [43] also confirms that relative advantage and compatibility are two main factors that must be considered in designing policies or training programs to encourage GAP adoption, and the complexity and observability variables show that although GAP can bring clear benefits, challenges such as perceived complexity and lack of visibility to other farmers must be overcome to accelerate wider adoption.

The variables of local and innovation characteristics are new variables added to the TPB concept in this study. The addition of local community characteristic variables is based on the conditions of the West Sumatran community using Hofstede's theory of cultural dimensions [46]. This dimension can be applied to describe the characteristics of a community group, including the community in West Sumatra. D. R. Sovia Firdaus et al.'s research results [47] show that the West Sumatran community (Minangkabau) has a collectivist culture with a long-term orientation, egalitarian values, and gender balance in its social structure, all of which are rooted in customs and religion, with this combination allows cultural identity to be maintained while remaining adaptive to change.

The study's results A. Bukowski and S. Rudnicki [48] show a positive relationship between long-term orientation and innovation performance in innovation and culture. Indicators of innovation characteristics, relative advantage, compatibility, and testability, according to research results Putri [43] and S. Thamrin [46], also affect the application of GAP. Farmers' knowledge of GAP will influence their intention to implement GAP. Increasing knowledge in the application of GAP can be done through repeated training. The training is carried out using a participatory approach to improve the knowledge and skills of farmers so that they can change and encourage farmers' attitudes in applying the knowledge gained [49]. Knowledge factors are needed to encourage communities to manage farming activities effectively by utilizing collective innovation [50, 51].

This research contributes. Adding new variables to the Theory of Planned Behavior (TPB) concept can contribute to understanding and predicting a person's behavior. Adding local characteristic variables and innovation brings broader environmental factors into the analysis. This allows us to understand how unique local environmental factors and implemented innovations influence farmers' attitudes and behavior. More profound policy implications can be generated by understanding how local characteristics and innovation influence farmer behavior. This helps interested parties, especially local government (policy markers), design more effective support strategies. Based on the description above, this study aims to determine the factors influencing farmer behavior in implementing Good Agricultural Practices (GAP) to increase coffee productivity.

2. Materials and Methods

This research method uses a quantitative descriptive and associative approach to emit the influence and relationship between variables related to the implementation of GAP by Arabica coffee farmers. Descriptive analysis provides an overview of the variables studied and the response pattern for each indicator. Meanwhile, the associative approach focuses on identifying and measuring the relationship or influence between variables such as innovative behavior, innovation characteristics, knowledge, and intentions to understand the dynamics of factors that influence the implementation of GAP. This research is an expo facto study conducted to find possible causes of changes in behavior or phenomena caused by events or behaviors that cause changes in the independent variables. This approach is considered relevant for research like this because it aims to understand the influence of independent variables on dependent variables based on existing data. Analysis of the available data allows for an in-depth understanding of the pattern of relationships between variables and allows researchers to test indirect relationships between variables.

The selection of research samples was taken from two main sub-districts in Solok Regency, namely Lembah Gumanti Sub-district and Pantai Cermin Sub-district. Both areas are the main coffee-producing areas in this Regency. This area is considered capable of reflecting efforts to integrate geographical diversity and local characteristics in the analysis of GAP implementation by Arabica coffee farmers. In the Lembah Gumanti Sub-district, sample farmers were taken from Nagari Surian and Nagari Lolo, while in the Pantai Cermin Sub-district, sample farmers were taken from Nagari Aie Dingin.

The farmer samples were determined using a non-probability sampling technique, namely 120 farmers taken from members of farmer groups in the area. This technique aims to obtain a representation of farmers who are relevant and active in implementing agricultural practices. The selection of farmers is based on their involvement in farmer groups that play an important role as agents of change and distributors of information related to GAP.

The variables used in this study are Attitude (ATT), Subjective Norms (SN), Perceived Behavioral Control (PBC), Knowledge (KL), Local Characteristics (CL), and Innovation Characteristics (CINV) as independent variables. Intention (INT) is a mediator variable, and Innovative Behavior (INBH) is a dependent variable. Each variable has a different number of indicators. The attitude variable has four indicators: attitudes toward using superior seeds, maintenance, harvesting, and post-harvest activities (sorting). The knowledge variable has four indicators: knowledge of using superior seeds, fertilizers, harvesting, and post-harvest. The Local Characteristics variable has three indicators: openness related to the desire to know about GAP, collectivism related to cultivation activities in applying GAP through group cooperation, and long-term orientation related to increasing crop yields, land area, and market reach. The Innovation Characteristics variable has five indicators: relative advantage, compatibility, Complexity, Trialability, and Observability. The perceived behavioral control variable has three indicators, namely self-confidence, availability of resources, and ability to overcome obstacles in implementing innovation. The Subjective Norm variable has three indicators: confidence in facing obstacles, availability of resources, and ability to overcome obstacles. The intention variable has four indicators: the desire to know and learn GAP innovation, the desire to use GAP innovation, a strong desire to use innovation, plans to implement innovation, and the desire to recommend innovation. The innovation behavior variable has five indicators, namely confidence in implementing innovation starting from the use of superior seeds to post-harvest, the implementation of GAP innovation is carried out starting from the use of superior seeds to post-harvest, willing to accept new ideas, always looking for new information and failure in using innovation is a risk. Each indicator is assessed using a Likert-type scale (1 = strongly disagree to 5 = strongly agree).

Data was analyzed in a quantitative use tool Structural Equation Model (SEM) analysis with Partial Least Square (PLS-SEM) approach. SEM are a method of multivariate data analysis used to test hypotheses about the connection between observed variables and latent [52, 53]. SEM uses constructs, abstract concepts that, when operationally defined, are latent variables. Latent variables are measured through observed variables, often indicators or manifest variables. Exogenous variables are latent variables influenced by variables outside the model and act only as independent variables. In contrast, endogenous variables are latent variables that are influenced by other variables in the model and, therefore, can act as dependent variables or both, depending on the context. If all exogenous and endogenous variables in the model are observed variables, the cause and effect between them can be analyzed using regression or path analysis methods. Stages in the SEM-PLS model:

a. Creating a structural model (inner model).
This model measures the relationship between endogenous and exogenous variables. The structural model is designed with arrows to show the influence of one variable on another.
b. Creating a measurement model (outer model)
The measurement or outer model explains how the observed variables measure the latent variables. This model determines how the variable indicators present the latent variables.
c. Determining the measurement indicator scale.
The measurement scale determines whether each indicator connected to the latent variable is a formative or reflective indicator
d. Construction (Path Diagram). The model path is a model that represents the existing structural model (inner model) and measurement model (outer model). Built along the direction of the specified arrow (**Figure 1**). The path diagram visualizes the relationship between all elements in the model by looking at the relationship between latent variables (inner model) and the relationship between latent variables and indicators (outer model). The path diagram provides a systematic overview of the SEM-PLS model structure.
e. Model Evaluation.
f. PLS output evaluation (results) can occur in the outer Model and inner evaluation stages. Outer Model Evaluation (Measurement): conducted by convergent and discriminant validity tests. Validity tests are carried out in research with confirmatory factor analysis (CFA). Confirmatory test analysis shows that the forming constructs are valid indicators as measurements of latent constructs. Convergent Validity is measured by Average Variance Extracted (AVE), which must be >0.50, and

Discriminant Validity is tested by cross-loading indicators and AVE values that distinguish one latent variable from another. Reliability is tested using Outer Loading. If the loading value is >0.7, the indicator is considered reliable. However, for exploratory studies, values between 0.5–0.7 are acceptable. And if 0.5 is not enough, the variable indicator must be removed [45, 47]. Furthermore, the Inner Model Evaluation (Structural) is carried out. This evaluation is done by looking at the R Square (R^2) value, which shows the magnitude of the influence of exogenous latent variables on endogenous ones. A higher R^2 indicates a better mode

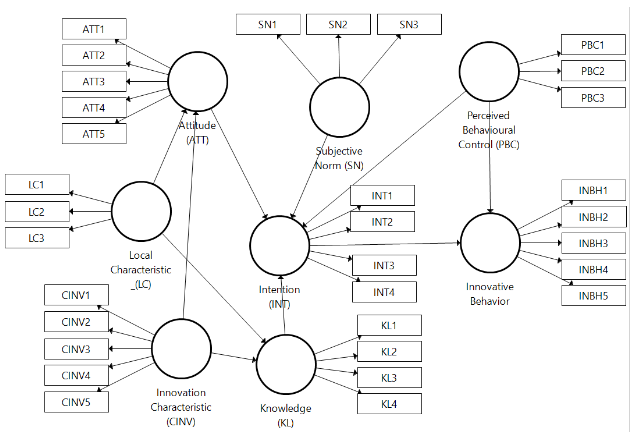

Figure 1. Path diagram.

3. Results

3.1. Description of the Sample

The results of the data description in **Table 1** provide an overview of the characteristics of coffee farmers. Most sample farmers are male (86%), indicating a male-dominated role in agricultural activities. In comparison, only 14% of respondents are female, which may reflect the traditional division of labor or land ownership in the farming community. Regarding age, most respondents are in the 31-39 year age group (30%) and 41–49 year age group (29%), indicating that farming activities are mainly carried out by the productive to middle-aged age group. Younger respondents (20–29 years, 10%) and older respondents (over 60 years, 8%) contributed in smaller proportions, perhaps due to other job preferences for young people or physical limitations for the older age group. Respondents' education level is relatively low, most only reaching elementary school (38%) and junior high school (37%). A few others have completed education up to high school (35%), while only 1% have a bachelor's degree. This indicates limited access to higher education in the farming community, which may affect the application of new technologies or innovations in the agricultural sector. Regarding agricultural status, most respondents (51%) consider agricultural activities a side job, while 49% consider it their primary job. This shows a balance between farmers who are wholly dependent on the agricultural sector and those who use agriculture as an additional source of income. Regarding farming experience, most respondents have quite a long experience, with 11–15 years (52%) as the largest group, followed by 6–10 years (43%). Only 6% have less than 5 years of experience, while those with 16–20 years and 21 years and above account for 15% and 3%, respectively. This reflects that most respondents are experienced farmers who potentially have a deep understanding of local agricultural conditions. Overall, these data provide a picture that men of product who have dominated the farming community, that is, the respondents of this study, have quite a long farming experience and tend to have a low level of education, and most still rely on agriculture as a side job.

3.2. Measurement of Variable Indicators

Measurement of each construct on the variables Attitudes (ATT), Knowledge (KL), Local Characteristics (LC), Characteristic Innovation (CINV), Perceived Behavioral Control (PBC), Subjective Norm (SN), Intentions (INT), and Innovative Behavior (INBH) that influence farmers' innovative behavior in implementing GAP can be seen in **Table 2**. Attitude (ATT) has an average value ranging from 3.44 to 3.63, indicating farmers' positive attitude towards using superior seeds and intensive maintenance through GAP with a Cronbach Alpha value of 0.807, which means good internal consistency in this construct. Knowledge (KL) scored high on purchasing seeds from certified producers and applying organic fertilizers, with an average score of 3.10 to 4.50 and a Cronbach Alpha reliability of 0.624. This indicates that farmers' knowledge of GAP is quite good, although there are

Table 1. Descriptive of the sample.

Item	Classification	Frequency	Percentage (%)
Gender	Male	103	86
	Female	17	14
Age (year)	20–29	12	10
	31–29	36	30
	41–49	35	29
	51–59	28	23
	over 60	9	8
Education Level	Primary school	45	38
	Junior high school	32	37
	Senior high school	42	35
	Bachelor's degree	1	1
Farming Stat	Primary Job	59	49
	Side Job	61	51
Farming experience (year)	Under 5	7	6
	6–10	38	43
	11–15	51	52
	16–20	18	15
	21 and above	6	3

differences in perception between items. Local Characteristics (LC) show farmers' enthusiasm to learn and try innovations through group collaboration. The average score ranges from 3.15 to 3.5, with a Cronbach Alpha of 0.713, indicating reasonably good reliability. Characteristic Innovation (CINV) recorded an average value between 3.06 and 3.56, indicating that the application of GAP is considered valuable and easy to implement, with the consistency of this construct indicated by a Cronbach Alpha of 0.757. Perceived Behavioral Control (PBC) has an average value of 3.24 to 3.64 and a Cronbach Alpha of 0.669, indicating farmers' positive perceptions of their ability to overcome obstacles in implementing GAP innovations. Subjective Norms (SN) indicate farmers' confidence in their ability to overcome the barriers with an average score between 3.19 to 3.28 and a Cronbach Alpha of 0.798, indicating positive perceptions of social support in using innovation. Intention (INT) had a consistent mean score between 3.52 to 3.63 with a Cronbach Alpha of 0.807, indicating a strong intention of farmers to implement GAP and encourage others to follow suit and innovative behavior (INBH), indicating farmers' tendency to try innovations despite the risk of failure, with a mean score ranging between 2.89 to 3.15 and a Cronbach Alpha of 0.615, indicating areas that could be further strengthened.

Table 2. Assessment and Measurement of Variable Indicators.

Statement	Mean	Cronbach Alpha
1. Contruct: Attitudes (ATT)		0.807
a. superior seeds and GAP provisions are required for better results. (ATT_1)	3.52	
b. Intensive maintenance, according to GAP, is carried out by fertilizing, pruning, and managing shade plants. (ATT_2)	3.63	
c. Coffee harvesting is done manually by picking ripe fruit (ATT_3)	3.57	
d. Sorting and drying coffee is done by drying for 2-3 weeks on a clean base (ATT_4)	3.44	
2. Construct: Knowledge (KL)		0.624
a. Superior seeds must be purchased from certified producers (KL_1)	4.50	
b. Organic fertilizer is applied twice a year, and primary branch pruning is done before the plant bears fruit. (KL_2)	3.77	
c. Red fruits are harvested, with total harvest at the end of the season. (KL_3)	3.64	
d. Firm and uniform fruits are separated to facilitate sorting and maintain quality (KL_4)	3.10	

Table 2. *Cont.*

Statement	Mean	Cronbach Alpha
3. Construct: Local Characteristic (LC)		0.713
a. High curiosity towards GAP innovation and enthusiasm to learn from the environment and dare to try innovation (openness) (LC_1)	3.5	
b. Farming is done through group cooperation, regular meetings, and discussions to implement GAP (collectivism). (LC_2)	3.15	
c. Farm management can be adjusted to GAP innovation to increase production results, land area, and marketing reach (long-term orientation) (LC_3)	3.36	
4. Construct: Characteristic Innovation (CINV)		0.757
a. Implementing GAP increases production, land optimization, and input efficiency, thus providing relatively higher profits (Relative advantage). ($CINV_1$)	3.46	
b. Implementing GAP creates a better business environment without deviating from old habits and forming new, beneficial habits (Compatibility) ($CINV_2$)	3.56	
c. The technical implementation of GAP from superior seeds to post-harvest is easy to practice, and supporting facilities are easy to obtain (Complexity). ($CINV_3$)	3.06	
d. GAP can be applied to small businesses and bring about change with clear implementation guidelines (Trialability). ($CINV_4$)	3.35	
e. The results of implementing GAP innovation can be measured through increased quantity and quality of production and income (Observability). ($CINV_5$)	3.39	
5. Construct: Perceived Behavioral Control (PBC)		0.669
a. Self-confidence is very important to overcome obstacles in implementing GAP innovation independently (PBC_1)	3.64	
b. The availability of adequate resources and knowledge supports the use of GAP innovation (PBC_2)	3.24	
c. Able to overcome obstacles that arise in implementing innovation (PBC_3)	3.43	
6. Construct: Subjective Nomr (SN)		0.798
a. Having the confidence to face obstacles in implementing GAP innovation and using innovation under one's control. (SN_1)	3.25	
b. Using innovation because of the availability of infrastructure resources and having sufficient knowledge and information in implementing GAP. (SN_2)	3.28	
c. Being able to overcome obstacles that arise in implementing innovation. Subjective Norms (SN_3)	3.19	
7. Contuct: Intention (INT)		0.807
a. Having a desire to know, learn, and seek all information, starting from the use of superior seeds to post-harvest by GAP (INT_1)	3.52	
b. Having a strong desire to use GAP innovation shortly, starting from the use of superior seeds to post-harvest (INT_2)	3.63	
c. Having a plan to implement innovation in farming activities starting from planting to post-harvest shortly (INT_3)	3.57	
d. Recommending to family or closest people, member groups, and farmers outside the group (INT_4)	3.44	
8. Innovative behavior (INBH)		0.615
a. Confidence in implementing innovations, starting from the use of superior seeds to post-harvest ($INBH_1$)	3.11	
b. GAP innovation is implemented starting from the use of superior seeds to post-harvest ($INBH_2$)	3.11	
c. Willing to accept new ideas to be implemented and master the skills in using innovations by utilizing all information media ($INBH_3$)	2.89	
d. Always looking for new information that has never been done and recommending others to use innovations that have been implemented previously ($INBH_4$)	3.15	
e. Failure to use innovation is a risk in farming and cooperation activities ($INBH_5$)	2.89	

3.3. Factors Influencing Coffee Farmers' Innovative Behavior in GAP Implementation

3.3.1. Confirmatory Factor Analysis (CFA)

Based on the results of the confirmatory factor analysis of the predisposing variables in **Figure 2**, several indicators have met the convergent validity criteria (Loading Factor value > 0.5). **Figure 2** shows four indicators of attitude variables, three indicators of subjective norms, two dimensions of local characteristics, three dimensions of knowledge, three dimensions of innovation characteristics, and three indicators of innovation characteristics. The four indicators describe innovative intentions and behavior explained by the three indicators.

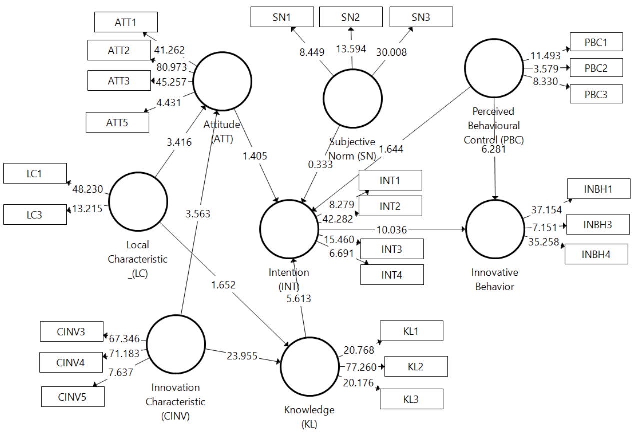

Figure 2. CFA variable value.

3.3.2. Outer Model Analysis

Convergence validity was also evaluated by looking at the square root of the average variance extracted (AVE). The AVE test is excellent and acceptable if the AVE value is more significant than 0.5. By fulfilling the AVE value > 0.5, the convergent validity test is said to be very good and feasible to proceed to further testing. **Table 2** shows the AVE values ranging from 0.587 to 0.856. This means the AVE test is feasible and acceptable. By fulfilling the AVE value > 0.5, the convergent validity test is considered excellent and feasible for further testing. The next test is the composite reliability test to measure latent variables. The reliability of latent variables is measured through internal consistency reliability. **Table 3** confirms that the composite reliability value ranged from 0.797 to 0.922, which means that the overall composite reliability value was greater than 0.7. These results indicate that all latent variables have good composite reliability.

3.3.3. Evaluation of the Structural Model (Inner Model)

The inner model is measured using the dependent latent variable R-square with the same interpretation as the regression. The predictive relevance of Q-Square for structural models measures how much the model and parameter estimates produce good value observations. Q-square value > 0 indicates the model has predictive relevance; conversely, if the Q-square sign ≤ 0 indicates poor predictive relevance of the model. The R-square value is the result (percentage form) above the representation of the independent variable to the dependent variable. Changes in the value of R-squares can be used to explain the effect of certain exogenous latent variables on endogenous latent variables having a substantive effect. A good R^2 value is above 0.2 (equivalent to 20%). The R-squares values are 0.75, 0.50, and 0.25. It can be concluded that the model is strong, medium, and weak. The PLS R-squares results represent the magnitude of the variance of the variables described by the model. The R^2 value for innovative behavior in applying the GAP of 0.796 or 79% can be explained by the variable farmer's intention (INT) and perceived behavioral control, and the rest is explained by other variables not examined in this model, including the strong model.

In the Path Coefficient Model, Hypothesis Testing is conducted to analyze the relationship between variables. Causality analysis can be used to determine the influence between exogenous and endogenous variables. Exogenous variables significantly influence endogenous variables if the p-value (probability) <0.05. Hypothesis testing is intended to test the influence of exogenous variables on endogenous variables or the influence of endogenous variables on other variables. In other words, we want to test the significance of the influence of variables both directly and indirectly.

The results of the research hypothesis indicate a direct effect between several variables that provide significant results (**Table 4**). Innovation characteristics (CINV) have a significant effect on attitude (ATT) with a p-value of 0.001 (<0.05) and on knowledge (KL) with a p-value of 0.000 (<0.05), indicating a strong direct influence. Knowledge (KL) also has a significant direct relationship to intention (INT) with a p-value of 0.000 (<0.05), and in-

Table 3. AVE and Composite Reliability.

Variable Latent	Composite Reliability	AVE	Status
Attitude (ATT)	0.915	0.731	Good
Innovation Characteristic (IC)	0.893	0,738	Good
Innovative Behavior (INBH)	0.829	0.624	Good
Intention (INT)	0.872	0.631	Good
Knowledge (KL)	0.864	0.682	Good
Local Characteristic (LC)	0.922	0.856	Good
Perceived Behavioural Control (PBC)	0.797	0.571	Good
Subjective Norm (SN)	0.877	0.704	Good

tention (INT) directly has a significant effect on innovative behavior (INBH) with a p-value of 0.000 (<0.05). In addition, local characteristics (LC) have a significant direct influence on attitude (ATT) with a p-value of 0.003 (<0.05), while perceived behavioral control (PBC) has a significant direct effect influence on innovative behavior (INBH) with a p-value of 0.000 (<0.05). However, several other variables did not have a considerable effect, namely attitude (ATT) towards intention (INT) (p = 0.239), local characteristics (LC) towards knowledge (KL) (p = 0.107), perceived behavioral control (PBC) towards intention (INT) (p = 0.082), and subjective norms (SN) towards intention (INT) (p = 0.732). These results confirm that the direct relationship between the main variables, such as innovation characteristics, local characteristics, knowledge, and behavioral control, plays an essential role in shaping attitudes, intentions, and innovative behavior. In contrast, other insignificant relationships require further exploration to understand the overall role of the variables.

Table 4. Hypothesis Test Results From Direct Effect.

	Original Sample (O)	Sample Means (M)	Standard Deviation	T Statistics	P Values
ATT -> INT	0.123	0.115	0.1045	1,181	0.239
CINV -> ATT	−0.505	−0.494	0.162	3,119	**0.002**
CINV -> KL	0.981	0.989	0.042	23.327	**0.000**
INT -> INBH	0.657	0.650	0.068	9,612	**0.000**
KL -> INT	0.543	0.492	0.106	5,147	**0.000**
LC-> ATT	0.600	0.583	0.210	2,85	**0.005**
LC -> KL	−0.097	−0.095	0.060	1,615	0.107
PBC) -> INBH	0.346	0.346	0.059	5,880	**0.000**
PBC -> INT	0.253	0.296	0.145	1.742	0.082
SN -> INT	0.052	0.082	0.151	0.343	0.732

The results of the indirect effect analysis in **Table 5** show that the CINV -> KL -> INT -> IB and KL -> INT -> IB paths have a very significant effect on innovative behavior, with p values of 0.000 and T-statistics of 4.192, respectively. Likewise, the CINV -> KL -> INT path is also significant with a p-value of 0.000 and T-statistics of 4,206; this indicates that knowledge (KL) mediates the relationship between innovation characteristics (CINV) with intention (INT) and innovative behavior (IB). In contrast, other paths such as CINV -> ATT -> INT -> IB (p = 0.235), ATT -> INT -> IB (p = 0.092), and LC -> ATT -> INT -> IB (p = 0.230) do not show a significant effect. The paths PBC -> INT -> IB (p = 0.062) and LC -> KL -> INT -> IB (p = 0.088) approached significance but remained above the 0.05 threshold. Overall, knowledge (KL) played a significant role in mediating the indirect effect, while the effects through attitude (ATT) or subjective norm (SN) tended to be insignificant.

These results support the hypothesis that innovation characteristics significantly affect innovative behavior through knowledge and intention. Knowledge significantly affects innovative behavior through intention.

Table 5. Hypothesis Results Effect Indirect.

	Original Sample (O)	Sample Means (M)	Standard Deviation	T Statistics (O)	P Values
CINV -> ATT -> (INT) -> IB	−0.041	−0.030	0.034	1.190	0.235
ATT -> INT -> IB	0.081	0.073	0.067	1.203	0.230
LC -> ATT -> INT-> IB	0.049	0.034	0.041	1.187	0.236
CINV -> KL -> INT -> IB	0.350	0.318	0.083	4.206	**0.000**
KL -> INT -> IB	0.357	0.322	0.085	4.192	**0.000**
LC -> KL -> INT -> IB	−0.035	-0.030	0.021	1.689	0.092
PBC -> INT -> IB	0.166	0.188	0.089	1.875	0.062
SN -> INT -> IB	0.034	0.055	0.101	0.336	0.737
CINT -> ATT -> INT	−0.062	-0.048	0.054	1.160	0.247
LC -> ATT -> INT	0.074	0.055	0.063	1.169	0.243
CIN -> KL -> INT	0.533	0.486	0.104	5.105	**0.000**
LC -> KL -> INT	−0.053	−0.047	0.031	1.713	0.088

It also suggests that local characteristics and innovation characteristics influence farmers' adoption of GAP, making knowledge and intention important mediators in driving innovative behavior in the agricultural sector.

4. Discussion

Local characteristics with two indicators of openness and long-term orientation affect attitudes, indicating that coffee farmers in the study area are open to the innovations provided. Farmers accept every change and innovation but can apply new practices to their farming activities. The study's results [40] showed a positive relationship between long-term orientation and innovation performance in innovation and culture. Long-term orientation also shows that farmers do not only focus on short-term profits but also sustainable investment for the sustainability of their farming businesses. Local characteristics play an important role in implementing technologies such as GAP, which impact the stability of coffee supply in West Sumatra.

The uniqueness of local farmers in West Sumatra is generally related to the social structure of the community, communication patterns in farmer groups, and belief systems that play a role in the implementation of innovation. This region has local wisdom by upholding traditions based on deliberation. These values reflect the openness of the community to discussion and collective decisions. The interview results showed that coffee farmers in this area want to implement innovation if exemplary farmers have successfully implemented the innovation. If there are successful group members, then other farmers will follow. In principle, farmers do not reject the innovation given, but for its implementation, they usually have certain considerations for carrying it out. If farmers are assisted with coffee seeds, the seeds are accepted by farmers and planted. However, for the implementation of cultivation, how good cultivation techniques are by GAP may not be followed by farmers as a whole, moreover, if the activity requires costs such as having to fertilize regularly to produce maximum production. This shows that communication patterns in farmer groups in West Sumatra often function as centers for exchanging information and experiences. In collective action activities that influential figures or successful farmers often lead, this group is a "change agent" in introducing and disseminating new technologies. Horizontal communication patterns based on personal relationships and mutual trust among farmer group members can accelerate the acceptance of innovation [54]. However, this pattern can also be an obstacle if key figures reject new technologies.The belief system of local communities also influences the acceptance of innovation. Traditional beliefs in agricultural methods passed down from generation to generation are often the basis for farmers' cultivation practices. The perception that innovations may not be based on what farmers have done or local ways of working can raise doubts about their implementation. For example, some coffee farmers may be hesitant to make drastic changes, such as implementing new techniques in coffee cultivation, especially if they are considered to be contrary to old habits or if the success of the technology has not been directly observed in their area.

These local characteristics are unique characteristics that influence the success of GAP implementation by coffee farmers in West Sumatra. The intervention strategies must respect and utilize local uniqueness, such as involving traditional figures or farmer groups as the main partners in introducing new technologies. In addition, the development of training and mentoring programs needs to adjust traditional communication patterns that are participatory so that GAP implementation is not only accepted as a technical innovation but also as an integral part of farmers' socio-cultural life.

GAP innovation bridges the potential of local characteristics of farmers and the needs of an increasingly competitive modern market. Putri's findings [44] show that domestic producer prices and the number of coffee farmers affect coffee supply in West Sumatra. The significance of these two variables suggests that stable and profitable domestic coffee prices and sufficient farmers are key factors in maintaining the stability of the coffee supply in the region. This relationship is further strengthened by the finding that farmers who are open to innovation are more responsive to price changes, while farmer regeneration supported by a long-term orientation contributes to future coffee supply sustainability.

Local characteristics with two indicators of openness and long-term orientation influence attitudes, indicating that coffee farmers in the study area are open to innovations provided. Farmers accept every change and innovation but can apply new practices to their farming activities. Increasing knowledge in the application of GAP can be done through repeated training. The training is carried out using a participatory approach to improve the knowledge and skills of farmers so that they can change and encourage farmers' attitudes in applying the knowledge gained [49]. Knowledge factors are needed to encourage communities to manage farming activities effectively by utilizing collective innovation [50, 51].

Policies that support GAP development should consider these variables by prioritizing increasing farmer knowledge about the practical advantages of GAP and the suitability of technology to local agricultural practices. Successful GAP implementation depends on technical training and increasing farmers' understanding of how GAP can provide direct benefits and relevance to their habits and reduce barriers associated with implementation complexity [55]. Farmers' knowledge of GAP will influence their intention to implement GAP. Increasing knowledge in implementing GAP can be done through repeated training. The training was conducted with a participatory approach to improve farmers' knowledge and skills to change and encourage farmers' attitudes in implementing the knowledge gained [41, 42]. Knowledge is needed to encourage communities to manage farming activities effectively by utilizing collective innovation [42, 44]. Putri's research results [42] also showed a correlation between farmers' knowledge, attitudes, and actions in implementing GAP, which had a significant influence. Increasing education and training and improving infrastructure can result in good practices and increased productivity [56, 57]. In addition, understanding the factors that influence the stages of cultivation and post-harvest is very important to improve GAP implementation. Analytical variables, Hamid's research results [58] showed a significant influence on the productivity of Gayo Arabica coffee in the implementation of GAP, which includes several important aspects in the coffee production cycle, such as land preparation, irrigation systems, seed preparation, planting, and plant care. The implementation of GAP at this stage directly impacts the quality and yield of coffee production. This activity ensures that the land is well managed, water is used efficiently, and the seeds used meet the quality standards required for optimal coffee plant growth.

Implementing GAP through innovative behavior is very much needed at every stage of coffee cultivation. The implementation directly impacts the quality and yield of coffee production. The activity ensures that maintenance is well managed and that the seeds used meet the quality standards for optimal coffee plant growth. Farmers who are willing to invest in the use of good technology and inputs will also produce better-quality coffee. The innovative behavior of coffee farmers is greatly influenced by the characteristics of the innovation, knowledge, and adoption intentions they have. Innovative behavior is formed when farmers can present the benefits and relevance of innovation to their local conditions, which are influenced by openness to change and long-term orientation. These factors create synergies that encourage farmers to implement innovation effectively, increase productivity, and ensure the desires of their agricultural business.

5. Conclusions

This study states that the implementation of Good Agricultural Practices (GAP) by Arabica coffee farmers in West Sumatra is influenced by a combination of innovation characteristics, local characteristics, knowledge, intentions, and farmers' attitudes. The results of statistical tests indicate that innovation characteristics directly affect farmers' attitudes, knowledge, and intentions, while local characteristics directly affect attitudes. Furthermore, farmers' innovative behavior in implementing GAP is indirectly influenced by innovation characteristics, knowledge, and intentions of farmers through the mediation mechanism of attitudes. This finding underlines the significant role of attitude as a mediating variable in the theory of planned behavior (TPB) framework, especially after adding specific variables such as local characteristics, which directly only affect attitudes but still have major implications for behavior. This shows the importance of including local contextual aspects, such as the social and cultural systems of the community, in the design theory and strategies for increasing farm productivity. Local characteristics affect farmers' attitudes and become the basis for understanding complex socio-cultural factors such as communication patterns and farmer group systems. This study paves the way for more adaptive and relevant development and intervention policies by strengthening a more specific and contextual TPB-based behavioral approach. This can help local governments, practitioners, and researchers design programs that support GAP implementation and respect and empower local uniqueness, thereby promoting agricultural poverty and farmer productivity more effectively.

The limitations of this study include the geographical coverage, which only covers two sub-districts in Solok Regency, so it cannot represent the population as a whole. In addition, the number of samples used is still small. For further researchers interested in using the TPB concept with the addition of local characteristic variables and increasing the number of samples used, adding other indicators not limited to openness, collectivism, and long-term orientation is necessary to obtain better predictive values.

Author Contributions

A.P., R.S., H., and A.M. contributed to designing and compiling this study. A.P. conducted data collection and processing in Solok Regency. R.S., H., and A.M. provided input, improvements, and integration of research results. All authors read and approved the final manuscript.

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Conflicts of Interest

The authors disclosed no conflict of interest.

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