From Practice to Reduced Agrochemical Dependence: Psychosocial Pathways Linking Pro-Environmental Livestock Integration and Coffee Farming

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Abstract. This study explores the psychosocial mechanisms through which Green Livestock Action (GLA) influences farmers' self-tolerance toward synthetic agrochemical use in integrated goat–coffee farming systems. Data were collected from 100 farmers in Kare Subdistrict, Madiun Regency, East Java, Indonesia, and analyzed using Structural Equation Modeling–Partial Least Squares (SEM-PLS). The findings show that GLA has a positive and significant effect on key psychosocial drivers, including Environmental Self-Identity, Eco-Guilt, Injunctive Norms, Descriptive Norms, and Perceived Risks and Constraints. However, GLA does not have a significant direct effect on farmers' self-tolerance toward synthetic inputs, indicating that behavioral change does not occur automatically through technical adoption alone. Instead, the influence of GLA is fully mediated by psychosocial pathways: Environmental Self-Identity, Eco-Guilt, Injunctive Norms, Descriptive Norms, and Perceived Risks and Constraints all significantly shape farmers' tolerance toward synthetic agrochemicals and transmit the indirect impact of GLA. These results highlight that farmers' decisions regarding chemical input use are primarily driven by identity-based motivation, moral emotions, and social normative pressure, while perceived risks and constraints remain an important behavioral determinant within the transition process. This study contributes to the sustainable agriculture literature by confirming that scaling integrated goat–coffee farming requires strengthening psychological and social foundations alongside technical interventions, particularly by enhancing environmental self-identity, fostering ecological awareness, leveraging supportive social norms, and addressing farmers' perceived barriers to green practice implementation.

Keywords: Green Livestock Action, Goat–Coffee Integration, Psychosocial Mechanisms, Social Norms, Synthetic Agrochemical Tolerance

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1 Introduction

Modern agricultural intensification that relies heavily on synthetic fertilizers, pesticides, and herbicides has become the dominant strategy for increasing agricultural productivity in many developing countries. In the short term, the use of synthetic inputs is indeed capable of boosting production yields; however, in the long run, such practices generate significant ecological consequences, including soil fertility degradation, declining soil biological activity, water pollution, and disturbances to agroecological balance [1]. Numerous empirical studies indicate that excessive use of agricultural chemicals reduces soil microbial diversity, inhibits enzymatic functions, and disrupts soil pH stability, ultimately threatening the sustainability of agricultural production systems. These conditions place smallholder farmers in a structural dilemma. On the one hand, they are required to maintain productivity to secure household income and food security. On the other hand, dependence on synthetic inputs increases long-term ecological, economic, and social risks. In Indonesia, this phenomenon is particularly relevant given the high level of chemical fertilizer and pesticide use in smallholder farming systems, coupled with farmers' limited access to environmentally friendly alternatives that are both practical and affordable [2].

One approach that has emerged to address these challenges is integrated farming systems, particularly the integration of plantation crops and livestock. Integrated farming systems are designed to establish reciprocal linkages between the crop and livestock subsectors within a single, mutually reinforcing production cycle. Livestock waste is utilized as a source of organic fertilizer, while crop biomass serves as animal feed, thereby reducing dependence on synthetic inputs while simultaneously improving resource-use efficiency. In this context, the integration of goats and coffee represents a model with considerable potential, especially in rural areas dominated by smallholder plantation agriculture [3].

Green Livestock Action has emerged as an operational form of integrated farming systems that emphasizes resource efficiency, livestock waste management, preventive animal health, and the reduction of environmental impacts. However, the successful implementation of Green Livestock Action is determined not only by technical and economic factors, but also by farmers' psychosocial characteristics as the primary decision-makers. How farmers construct their self-identity, respond to social norms, and perceive risks and constraints strongly influences the extent to which environmentally friendly practices are adopted and consistently maintained [4].

The Theory of Planned Behavior (TPB) provides a robust conceptual framework for understanding farmers' behavior in this context. TPB explains that behavior is influenced by attitudes, subjective norms, and perceived behavioral control. In the development of environmental behavior research, TPB has frequently been extended by incorporating additional psychosocial variables such as Environmental Self-Identity and Eco-Guilt, which have been shown to play an important role in promoting pro-environmental behavior. A self-identity as an environmentally responsible farmer can strengthen commitment to sustainable practices, while ecological guilt arising from chemical use may motivate the search for more environmentally friendly alternatives. In addition to internal factors, social normative pressures also play a crucial role. Injunctive norms derived from group leaders and extension agents, as well as descriptive norms reflected in the practices of surrounding farmers, can shape perceptions of behaviors that are considered appropriate and acceptable. Conversely, perceptions of risk and constraints, such as concerns over costs, availability of alternatives, and potential yield reductions often constitute major barriers in the transition toward sustainable agriculture [5].

Kare Subdistrict, Madiun Regency, represents an area with substantial potential for the implementation of integrated goat–coffee farming systems. The region is not only recognized as a center of smallholder coffee plantations but also has a significant goat population,

enabling mutually beneficial integration. Nevertheless, farmers' levels of tolerance toward the use of synthetic inputs within this system remain varied, reflecting underlying psychosocial dynamics that have not yet been fully understood empirically.
Based on these conditions, this study aims to analyze the effect of Green Livestock Action on tolerance toward synthetic inputs in integrated goat–coffee farming systems, as well as to examine the mediating roles of Environmental Self-Identity, Eco-Guilt, injunctive norms, descriptive norms, and perceived risks and constraints. By integrating behavioral approaches with integrated farming systems, this study is expected to provide a more comprehensive understanding of the factors that encourage or hinder the transition toward more sustainable agricultural practices at the farmer level.

2 Materials and methods

2.1 Research Design and Approach

This study employed a quantitative research design with an explanatory approach to analyze the causal relationships among Green Livestock Action, psychosocial variables, and tolerance toward synthetic inputs in integrated goat-coffee farming systems. This approach was selected to test a behavioral model developed based on the Theory of Planned Behavior (TPB). Data analysis was conducted using Structural Equation Modeling based on Partial Least Squares (PLS-SEM). This method was chosen because it can accommodate models with multiple latent constructs and reflective indicators, does not require strict assumptions of data normality, and is well suited for field survey based research with a moderate sample size [5].

2.2 Study Area and Period

The study was conducted in Kare Subdistrict, Madiun Regency, East Java Province, Indonesia. The location was selected purposively, considering that Kare Subdistrict is one of the centers of smallholder coffee plantations integrated with goat farming and possesses agroecosystem characteristics relevant to the implementation of integrated farming systems. The research was carried out from August to September 2025, covering the stages of preparation, data collection, and data processing.

2.3 Population and Sampling Method

The population of this study comprised all farmers implementing integrated goat–coffee farming systems in Kare Subdistrict, Madiun Regency. Respondents were selected using a multistage sampling method, resulting in a total of 100 respondents. The first stage involved the selection of East Java Province as the study area, followed by the selection of Madiun Regency, and finally Kare Subdistrict as the research location. Respondents were drawn from farmers who actively manage coffee farming and raise goats within a single integrated production system [6].

2.4 Types and Sources of Data

The data used in this study consisted of primary and secondary data. Primary data were collected through surveys and structured interviews using questionnaires administered to farmer respondents. Secondary data were used as supporting information and were obtained

from scientific publications, Statistics Indonesia (BPS), data from the Livestock Service Office, and reports from farmer groups in Kare Subdistrict.

2.5 Data Collection Methods

Data were collected using three main methods: surveys, interviews, and documentation. Surveys were conducted to obtain quantitative data on the research variables using questionnaires based on a five-point Likert scale. Interviews were carried out by referring to the questionnaire to clarify respondents' understanding of each statement. Documentation was used to support field data through the collection of photographs and relevant documents related to integrated goat-coffee farming activities.

2.6 Variables

The independent variable in this study was Green Livestock Action, defined as a livestock management system oriented toward resource-use efficiency and environmental impact reduction. The mediating variables included Environmental Self-Identity, Eco-Guilt, injunctive norms, descriptive norms, and perceived risks and constraints. The dependent variable was Farmers' Self-Tolerance Toward the use of synthetic inputs in coffee farming. Each variable was measured using reflective indicators developed based on a review of the literature and adapted to the local context. All indicators were measured using a five-point Likert scale, ranging from strongly disagree to strongly agree.

2.7 Theoritical Framework and Hypothesis

This study draws upon the Theory of Planned Behavior (TPB) and the Norm Activation Model (NAM) [7]. Both frameworks posit that pro-environmental behaviors are driven by internalized identity, moral obligation, and perceived norms. Environmental Self-Identity reflects how farmers perceive themselves as environmentally responsible individuals. Eco-Guilt refers to feelings of remorse when violating environmental norms. Injunctive and Descriptive Social Norms influence farmers through what others approve and what others actually do. Perceived Risk and Constraints determine how external or psychological barriers limit behavioral change. GLA is hypothesized to indirectly reduce synthetic input tolerance through these psychosocial mediators. The direct path from GLA to tolerance is expected to be insignificant or even positive, meaning that livestock integration alone is insufficient to alter behavior without psychosocial reinforcement.

3 Results and discussion

3.1 Descriptive Statistics

The analysis of 100 samples indicates that the respondents were predominantly male (97%), while female farmers accounted for only 3% of the total sample. This finding suggests that integrated coffee-goat farming activities in the study area are largely managed by male farmers. In terms of educational attainment, none of the respondents reported having no formal education or incomplete elementary education. Most respondents had completed high school or its equivalent (69%), followed by those with junior high school education (31%). This relatively adequate educational background may facilitate farmers' understanding and adoption of environmentally friendly agricultural practices.

Table 1. Respondent profile (n = 100)

Characteristic	Value	
Gender	Male	97%
	Female	3%
Education	Not in School/Not Completed Elementary School	0%
	Elementary School/Equivalent	0%
	Junior High School/Equivalent	31%
	High School/Equivalent	69%
Age	<20 years	0%
	20-30 years	0%
	30-50 years	31%
	>50 years	69%
Type of Business	Small Scale (<10 birds)	85%
	Medium Scale (10-30 birds)	13%
	Large Scale (>30 birds)	2%
Agrochemical Use	Never	83%
	Rarely	9%
	Often	7%
	Always	1%

Regarding age distribution, no respondents were below 30 years of age. Farmers aged over 50 years constituted the largest proportion (69%), while those aged 30–50 years accounted for 31%. This indicates that integrated coffee–goat farming is predominantly carried out by older farmers, highlighting potential challenges related to generational succession. Based on the scale of farming operations, the majority of respondents operated on a small scale (<10 goats), representing 85% of the sample. Meanwhile, 13% managed medium-scale operations (10–30 goats), and only 2% operated on a large scale (>30 goats). This distribution confirms that the farming system is largely dominated by smallholder producers.

With respect to agrochemical use, most respondents reported never using agrochemicals (83%), indicating a strong inclination toward environmentally oriented farming practices. However, 9% reported rare use, 7% reported often using agrochemicals, and only 1% reported always using agrochemicals. These findings suggest that while agrochemical dependence has generally been reduced, a small proportion of farmers still rely on chemical inputs under certain circumstances.

The analysis of Table 2 shows that all constructs in this study meet the criteria for internal consistency reliability. This is indicated by very high values of Cronbach's Alpha, rho_A, and Composite Reliability, all exceeding the recommended threshold of 0.70. For instance, Green Livestock Action (GLA) demonstrates strong reliability ($\alpha = 0.992$; CR = 0.993), while Environmental Self-Identity (ESI) also shows excellent reliability ($\alpha = 0.992$; CR = 0.994). Similarly, Eco-Guilt (EG) presents the highest reliability values ($\alpha = 0.998$; CR = 0.998), indicating that the indicators used consistently represent the construct.

In addition to reliability, the results confirm strong convergent validity, as all constructs achieve AVE values above 0.50, meaning that each construct explains the majority of variance in its indicators. The AVE values range from 0.926 (Farmers' Self-Tolerance/FST) to 0.994 (Eco-Guilt/EG and Descriptive Norms/DN), reflecting very strong indicator convergence. Overall, these findings demonstrate that the measurement model is both reliable and valid, supporting the use of all constructs for further structural model evaluation.

Table 2. Validity and Reliability Test

Variables	Cronbach's Alpha	rho_A	Composite Reliability	Average Variance Extracted (AVE)
X1.Green Lifestock Action (GLA)	0.992	0.992	0.993	0.960
Y1.Environmental Self Identity (ESI)	0.992	0.993	0.994	0.978
Y2.Eco Guilt (EG)	0.998	0.998	0.998	0.994
Y3.Injuctive Norms (IN)	0.995	0.995	0.997	0.991
Y4.Descriptive Norms (DN)	0.997	0.997	0.998	0.994
Y5.Perceived Risk and Constrains (PRC)	0.997	0.997	0.998	0.993
Z. farmers' self-tolerance (FST)	0.960	0.960	0.974	0.926

Table 3 indicates that all indicators have high outer loading values, confirming that each item strongly reflects its intended construct. The indicators for GLA (X1) show loadings between 0.948 and 0.993, suggesting that livestock integration practices are measured consistently through the six items. Likewise, indicators for ESI (Y1) load strongly on their construct with values ranging from 0.987 to 0.993, indicating that farmers' environmental identity is well captured by the measurement items. These results also imply that the measurement items have strong explanatory power and contribute significantly to construct formation in the model.

Similarly, the indicators of Eco-Guilt (Y2) demonstrate extremely high loadings (0.995–0.999), showing a very strong contribution of each item to the construct. The same pattern is observed for Injunctive Norms (Y3) (0.995–0.996) and Descriptive Norms (Y4) (0.996–0.997), indicating robust measurement of social norm factors. In addition, Perceived Risk and Constraints (Y5) indicators have loadings of 0.996–0.997, while Farmers' Self-Tolerance (Z1/FST) shows strong loadings (0.952–0.970). Since all values exceed the recommended threshold of 0.70, the results confirm that all indicators are valid and suitable for inclusion in the model. Therefore, no indicators needed to be removed, and the measurement model can be confidently used for structural model testing and hypothesis evaluation.

Table 3. Outer Loading

	X1	Y1	Y2	Y3	Y4	Y5	Z1
X1_1	0.982						
X1_2	0.993						
X1_3	0.990						
X1_4	0.984						
X1_5	0.982						
X1_6	0.948						
Y1_1		0.988					
Y1_2		0.993					
Y1_3		0.987					
Y1_4		0.988					

Y2_1			0.997				
Y2_2			0.995				
Y2_3			0.999				
Y2_4			0.997				
Y3_1				0.995			
Y3_2				0.995			
Y3_3				0.996			
Y4_1					0.996		
Y4_2					0.997		
Y4_3					0.997		
Y5_1						0.996	
Y5_2						0.996	
Y5_3						0.997	
Z1_1							0.964
Z1_2							0.970
Z1_3							0.952

3.2 Significant Test

The SEM analysis results indicate that Green Livestock Action (GLA) has a positive and significant effect on several psychosocial constructs. Specifically, GLA significantly influences Environmental Self-Identity (ESI) ($p = 0.000$; $\beta = 0.734$), Eco-Guilt (EG) ($p = 0.000$; $\beta = 0.677$), Injunctive Norms (IN) ($p = 0.000$; $\beta = 0.676$), Descriptive Norms (DN) ($p = 0.000$; $\beta = 0.714$), and Perceived Risk and Constraints (PRC) ($p = 0.000$; $\beta = 0.725$). These results suggest that stronger engagement in pro-environmental livestock integration practices contributes to stronger environmental identity, heightened ecological guilt, stronger normative pressures, and increased perceptions related to risks and constraints.

Furthermore, the analysis shows that GLA has no significant direct effect on Farmers' Self-Tolerance (FST) ($p = 0.078$; $\beta = 0.075$). This indicates that although green livestock integration strongly shapes the farmers' psychosocial mechanisms, it does not directly reduce or explain farmers' tolerance toward agrochemical use. In contrast, ESI has a positive and significant effect on FST ($p = 0.000$; $\beta = 0.246$). Likewise, Eco-Guilt ($p = 0.000$; $\beta = 0.188$), Injunctive Norms ($p = 0.000$; $\beta = 0.223$), Descriptive Norms ($p = 0.000$; $\beta = 0.284$), and Perceived Risk and Constraints ($p = 0.000$; $\beta = 0.225$) also significantly influence FST. Overall, these findings confirm that farmers' self-tolerance is primarily driven by psychosocial factors, suggesting an indirect mechanism whereby Green Livestock Action affects FST through changes in environmental identity, guilt, social norms, and perceived constraints.

Table 4. Research Hypothesis Testing

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics (|O/STDEV|)	P Values	Result
X1.GLA -> Y1.ESI	0.734	0.734	0.036	20.365	**0.000**	**Accepted**
X1.GLA -> Y2.EG	0.677	0.676	0.045	15.052	**0.000**	**Accepted**
X1.GLA -> Y3.IN	0.676	0.676	0.045	15.049	**0.000**	**Accepted**
X1.GLA -> Y4.DN	0.714	0.713	0.041	17.241	**0.000**	**Accepted**
X1.GLA -> Y5.PRC	0.725	0.726	0.038	18.918	**0.000**	**Accepted**
X1.GLA -> Z.FST	0.075	0.073	0.043	1.766	**0.078**	**Rejected**
Y1.ESI -> Z.FST	0.246	0.245	0.031	8.052	**0.000**	**Accepted**
Y2.EG -> Z.FST	0.188	0.190	0.031	6.083	**0.000**	**Accepted**
Y3.IN -> Z.FST	0.223	0.225	0.025	8.828	**0.000**	**Accepted**
Y4.DN -> Z.FST	0.284	0.283	0.029	9.844	**0.000**	**Accepted**
Y5.PRK -> Z.FST	0.225	0.224	0.027	8.364	**0.000**	**Accepted**
X1.GLA -> Y1.ESI -> Z.FST	0.181	0.180	0.025	7.124	**0.000**	**Accepted**
X1.GLA -> Y2.EG -> Z.FST	0.127	0.129	0.025	5.113	**0.000**	**Accepted**
X1.GLA -> Y3.NI -> Z.FST	0.151	0.152	0.022	6.775	**0.000**	**Accepted**
X1.GLA -> Y4.ND -> Z.FST	0.203	0.202	0.024	8.343	**0.000**	**Accepted**
X1.GLA-> Y5.PRK -> Z.FST	0.163	0.163	0.022	7.569	**0.000**	**Accepted**

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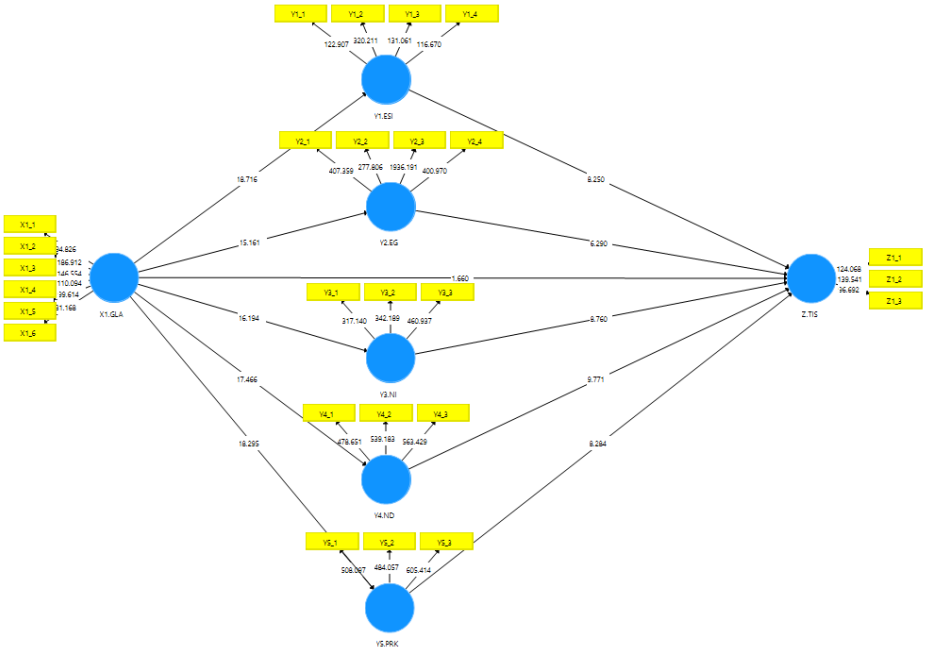

3.3 Discussion

This study examines how Green Livestock Action (GLA) in the goat–coffee integration system shapes farmers' self-tolerance toward synthetic inputs through key psychosocial mechanisms. Overall, GLA is expected to encourage farmers to rely less on synthetic fertilizers and pesticides because the integration system offers practical alternatives (e.g., manure-based fertilizer and circular resource use) that make sustainable practices more feasible in daily farming. At the same time, farmers' responses are not purely technical: the shift also depends on how farmers interpret the practice socially and psychologically within their community context [8].

In the first pathway, the findings suggest that GLA does not strengthen Environmental Self-Identity (H1), meaning farmers may implement integration mainly for pragmatic reasons (cost efficiency, productivity, or program participation) without necessarily internalizing a "green farmer" identity [9]. However, GLA can still raise Eco-Guilt (H2) because farmers who become more aware of environmental impacts may feel moral discomfort about previous chemical-intensive habits. Likewise, GLA strengthens injunctive norms (H3) when extension agents, group leaders, or local values communicate that sustainable practices are what farmers "should" do, and it strengthens descriptive norms (H4) when farmers observe peers successfully applying integration and reducing chemical reliance. In addition, greater involvement in GLA can increase perceived risks and constraints (H5) because farmers directly experience barriers such as extra labor, uncertainty during transition, and the need for technical capability [10].

Regarding the outcome, GLA positively influences farmers' self-tolerance toward synthetic inputs (H6) in the sense that integration creates a more sustainable production logic that can shift farmers' acceptance of chemical dependence farmers see workable substitutes and begin adjusting their input decisions [11,12]. Beyond the direct effect, psychosocial factors also matter, farmers with stronger Environmental Self-Identity (H7) tend to align behavior with their self-concept and thus become less accepting of heavy synthetic use;

farmers with higher Eco-Guilt (H8) are more motivated to correct behavior by reducing chemicals; and stronger injunctive (H9) and descriptive norms (H10) can pressure or encourage farmers to follow environmentally approved and commonly practiced patterns. Conversely, when perceived risks and constraints rise (H11), farmers may remain more tolerant of synthetic inputs because chemicals are viewed as the "safer" short-term option to protect yields and reduce uncertainty [13].

Finally, the mediation logic explains how GLA can work indirectly. Even if identity is not always triggered strongly, Environmental Self-Identity can mediate (H12) when repeated sustainable practices eventually become part of farmers' self-definition, which then reduces acceptance of chemical dependence [14]. Eco-Guilt mediates (H13) because GLA increases awareness and moral evaluation, and guilt then pushes behavioral adjustment. Socially, injunctive norms (H14) and descriptive norms (H15) mediate because the diffusion of GLA through groups and visible peer behavior creates social obligation and social proof that shape farmers' tolerance patterns [15]. Meanwhile, perceived risks and constraints mediate (H16) because the more farmers engage with GLA, the more they may perceive barriers; these perceived barriers can either slow down the reduction of synthetic inputs or keep farmers anchored to chemical use as a risk-management strategy. In short, this study shows that transitioning to greener goat-coffee integration is not only about technical adoption, but also about identity, emotions, social influence, and the practical barriers farmers face in real conditions.

4 Conclusion

This study concludes that Green Livestock Action (GLA) in the goat–coffee integration system plays an important role in shaping farmers' psychosocial conditions, including environmental self-identity, eco-guilt, injunctive norms, descriptive norms, and perceived risks and constraints. However, GLA does not directly influence farmers' self-tolerance toward synthetic inputs, suggesting that technical and environmentally oriented practices alone are not sufficient to shift farmers' behavioral tolerance toward agrochemical use. Instead, farmers' tolerance is primarily driven by psychosocial mechanisms, where stronger identity, guilt awareness, and social normative pressures significantly influence tolerance toward synthetic inputs. Additionally, all psychosocial variables successfully mediate the relationship between GLA and farmers' tolerance, indicating that GLA contributes indirectly by strengthening internal and social factors that shape behavioral decisions. Therefore, promoting sustainable integrated farming requires not only encouraging green livestock practices but also improving farmer awareness, strengthening pro-environmental identity, leveraging social support systems, and reducing perceived risks and constraints to ensure long-term adoption and consistency of environmentally friendly farming practices.

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