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Rural Business Environments, Information Channels, and Farmers' Pesticide Utilization Behavior: A Grounded Theory Analysis in Hainan Province, China

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Abstract: Rural business environments and informational sources play a pivotal role in shaping the dynamics of pesticide utilization in the agricultural sector. This study investigates the intricate mechanisms through which these environments impact farmers' pesticide utilization practices and elucidates the key factors within rural business environments and information channels that influence such behaviors. By identifying effective strategies to promote judicious pesticide use among agricultural practitioners, this research aims to enhance the government's ability to provide precise guidance to farmers, ultimately contributing to the preservation of ecological integrity. Employing grounded theory in conjunction with a series of comprehensive interviews with 32 cowpea farmers to gain firsthand insights, our investigation yielded the following key findings: (1) the enhancement of rural business environments has mitigated the impact of neighborhood influences on farmers' pesticide use behavior; (2) farmers predominantly base their pesticide choices on verifiable information; (3) the influence of pesticide retailers on farmers' pesticide use has significantly increased. Based on these findings, a dual-pronged approach is proposed. First, there should be sustained commitment to bolstering rural infrastructure, enhancing the entrepreneurial climate in rural regions, and fostering market liberalization. Second, it is imperative to disseminate advanced pesticide knowledge, demarcate effective information, and intensify dissemination efforts.

Keywords: pesticide utilization behavior; information channels; rural business environments; grounded theory

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1. Introduction

Pesticides are widely used globally because of their recognized efficacy, ability to act quickly, and cost-effectiveness in managing agricultural pests. However, the continuous excessive use of pesticides has resulted in notable ecological imbalances, pollution of agricultural environments, and degraded food quality and safety [1]. Simultaneously, the application of pesticides contaminates both surface water and groundwater through drainage and runoff, posing a significant threat to water quality and challenging the safety of drinking water [2]. Moreover, agricultural wastewater contributes to the eutrophication of coastal areas, and the residual overuse of pesticides contaminates the soil, threatening the existence of birds, fish, and various other animal and plant species, thereby endangering biodiversity [3–6]. The United Nations has noted in the Sustainable Development Report 2023 that the world is currently facing the largest extinction event since the demise of the dinosaurs [2]. Given these concerns, scientists have directed their attention toward comprehending the scientific aspects of pesticide application by farmers, as they constitute the primary agents responsible for pesticide utilization. Several studies have investigated various factors influencing farmers' pesticide application practices. These factors can be categorized into internal determinants, such as literacy, sociocultural values, household income distribution, and personal cognition [7–12]. Additionally, external factors have been examined, such as technical training, agricultural policies, and cooperative associations [13–18].

Producers' conduct is inherently molded by the prevailing business environment [19]. Consequently, several academic studies have undertaken an examination of the influence exerted by diverse business environments on farmers' productivity-related behaviors. Farmers' decisions regarding the adoption of new technologies, application of fertilizers, and farmland transfer procurement of agricultural planting insurance are significantly influenced by these factors [20–26].

Research on how rural business environments affect farmers' pesticide use is still limited. The World Bank defines the business environment as a broad range of external conditions businesses face at different stages [27]. These conditions, unique to each country, include foundational institutional elements and factors influencing enterprise operations in market economies [28]. Crucial aspects like political, economic, and market environmental factors, as well as legal and policy frameworks, infrastructure, and public service provisions, are essential in this context [29–31]. Our study examines the Chinese context, analyzed through a macroeconomic perspective. Decision making in rural businesses necessitates extensive information. The individual behavioral decision-making model shows that subjective norms, influenced by information, direct human behavior [32,33]. Research highlights the neighborhood's crucial role in disseminating information, significantly affecting farmers' pesticide use [34]. Farmers often rely on experienced neighbors for insight and advice [35], underscoring the importance of local communication networks in influencing pesticide application methods. Information sources include agricultural technology service center staff, other farmers, pesticide sellers, the Internet, and various mediums [36–38]. Although farmers trust government-affiliated technicians, the irregular frequency of training limits their impact [39–41]. In China, pesticide retailers adhere to licensing measures and regulations, requiring a minimum secondary school degree or 56 h of related education. Retailers must be well-versed in pesticide management, ensuring the safe use of pesticides. Government supervision, inspections, and training further regulate retailers. Optimizing the rural business environment significantly impacts the quality and quantity of these services. A comparison with global practices reveals varied approaches. The EU focuses on integrated pest management (IPM), enforcing farmer training and stringent pesticide approvals [42]. The U.S. Environmental Protection Agency (EPA) regulates pesticide use, providing educational resources and certifications for safe handling [43]. India offers practical training for efficient pesticide application [44]. These international models present diverse strategies for pesticide management, offering insights to improve China's regulatory system and ensure safer pesticide applications.

Given this context, scholars advocate for the incorporation of qualitative methodologies to gain a comprehensive understanding of farmers' decision making in pesticide usage within these varied regulatory environments. This approach aims to delve deeper into the cognitive processes, sources of information, and factors influencing farmers' behavior [45–48]. Although there is a lack of qualitative studies focusing on farmers' pesticide use behavior, recent scholarly efforts have begun exploring broader aspects of farmers' production behavior using a grounded theory methodology. For instance, this approach has been applied in studying the adoption of sustainable agricultural practices among coffee farmers in Vietnam [49], identifying key obstacles in the uptake of water conservation techniques [50], and examining credit behavior in digitized farmer cooperatives [51]. These studies highlight the potential for qualitative research to enhance our understanding of how regulatory environments and information sources impact farmers' pesticide-related decisions.

The literature reviewed above establishes a foundation for understanding the business environment's and information's impacts on farmers' pesticide usage, aiding in the selection of a suitable research design. However, acknowledging several potential limitations is crucial. The degree to which the business environment affects farmers' pesticide use continues to be a topic of ongoing debate. Currently, there is limited systematic research on the business environment's impact in this specific context. Consequently, additional research is necessary. Additionally, while many studies focus on rice, wheat, peanut, and cotton cultivation, there is comparatively less research on vegetable farming. Research into potential disparities in the business environment, especially concerning crop-specific pesticide use by farmers, warrants careful consideration. Moreover, most current research predominantly utilizes structured questionnaires to collect extensive data, followed by econometric modeling to analyze the results. However, the inherent limitations of structured questionnaires, such as restricted options for farmers, might not fully capture the complexity of their perspectives, potentially affecting the accuracy of the results.

The central research question of this paper examines the impact of the rural business environment and information channels on farmers' pesticide usage behavior. This study aims to develop a theoretical framework that elucidates the influence of rural business environments and information channels on farmers' pesticide usage, using qualitative methods and grounded theory analysis. This framework will offer a theoretical basis for governmental formulation of pesticide policies and measures. This research has two key dimensions. First, it guides farmers towards rational pesticide use, thereby protecting the ecological environment and fostering sustainable agricultural development. Second, it theoretically enriches and expands upon existing theories, as detailed below.

This study offers two significant contributions to the existing literature. A notable aspect is the diverse range of vegetable crops and their susceptibility to prevalent pests and diseases. However, research on the behavioral patterns of vegetable farming practitioners, especially in cowpea cultivation, is sparse. This study substantially enriches the current research in this area. Additionally, this study employs grounded theory to analyze unstructured data, investigating how dynamic business environments affect individual pesticide use in vegetable cultivation. As a result, we thoroughly investigate how business environments impact farmers' pesticide application, offering empirical evidence that deepens our understanding of farmers' behavior in these contexts.

2. Materials and Methods

Grounded theory facilitates the exploration of novel theories through rigorous procedures of systematic data collection and analysis [52]. Considering the complex dynamics surrounding farmers' pesticide use, as examined in this study, it is imperative to employ a research approach firmly rooted in the building of theoretical frameworks. Consequently, we used a grounded theory methodology. This approach facilitates the exploration of farmers' pesticide decision-making processes, allowing for the identification of influential elements and underlying mechanisms while minimizing the impact of preconceptions. The findings of this study demonstrate a noteworthy degree of scientific rigor and reliability.

2.1. Study Areas

This study was conducted from October 2021 to February 2022 in three cowpea-growing villages: Chengdong Village, Sanya City, Hainan Province, China, and Paiqi and Baoqiu Villages, Ledong Lizu Autonomous County (See Figure 1 for the specific location diagram). The legume known as cowpea (Vigna Unguiculata) is widely cultivated across many continents, including Africa, Asia, Europe, and the Americas. The plant species has garnered attention in tropical areas because of its ability to provide affordable sources of protein to a broad range of consumers and generate consistent economic benefits for farmers [53]. Cowpea cultivation in Hainan has gained prominence as an important agricultural practice, principally because of its consistent and favorable economic outcomes [54]. According to the Hainan Bureau of Statistics (2020), the cowpea cultivation area in Hainan was approximately 20,000 hectares in 2020, resulting in an annual production of over 5 million tons. The tropical environment of Hainan, characterized by elevated temperatures and humidity, makes it vulnerable to pests and diseases [55]. This susceptibility is particularly evident in cowpea crops [56]. According to Boukar et al. (2019) [56], pests and diseases can substantially affect the productivity and quality of cowpea crops. Thrips, a prevalent agricultural pest, can cause substantial reductions in cowpea yields, ranging from 20% to 80% [57], and in certain cases, yield losses can reach up to 100% [58]. Farmers employ the strategy of using pesticides often and intensively to alleviate economic losses. Nevertheless, this agricultural practice has given rise to concerns regarding the accumulation of elevated levels of pesticide residues in cowpeas and environmental pollution. These concerns, in turn, have engendered challenges in effectively overseeing the quality and safety of this vegetable. Zhang et al. (2022) [55] report that a Hainan Province investigation discovered 26 pesticide residues in cowpea samples from Ledong County and 21 from Sanya City.

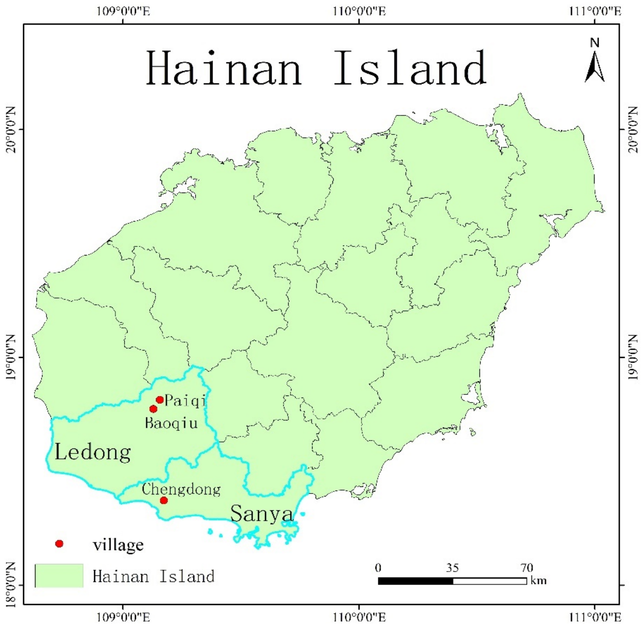

Figure 1. Study areas.

This study employed three key principles of theoretical sampling to ensure the scientific validity and rationality of the data [52]. First, the principle of typicality guided the selection of Hainan cowpea farmers as the research subjects. Cowpea stands out as a specialty and economically significant crop among the northern transported vegetables in Hainan Province, with an annual planting area constituting over 10% of the total winter vegetable cultivation in the province. Second, to ensure content suitability, cowpea farmers from Sanya City and Ledong Lizu Autonomous County, the primary regions for Hainan cowpea cultivation, were selected. Within these regions, Chengdong Village in Yazhou District, Sanya City, represents a relatively developed, highly mechanized, and centralized farming area in Hainan. However, the farmers reside in relatively dispersed areas within Paiqi Village and Baoqiu Village in Ledong County. These two villages are characterized by hilly terrain with fragmented arable land, facilitating the selection of samples for controlled experiments. Finally, guided by the principles of convenience and accessibility of data acquisition, three villages were selected: Chengdong, Baoqiu, and Paiqi. This decision was based on two key factors. A preliminary investigation revealed a high level of readiness among the farmers in these villages to engage in cowpea cultivation. Second, the earlier phases of this project facilitated strong connections between the research team and the local leaders and residents of these villages, streamlining the interview process and enhancing data accessibility. Consequently, after thorough evaluation, Chengdong, Baoqiu, and Paiqi villages were chosen for the survey.

2.2. Data Collection

2.2.1. Research Design

The data collection process was meticulously designed to foster active collaboration among the farmers during the interviews. Compensation ranging from USD 82 to 137 per household was allocated to contracted farmers to mitigate the repercussions of labor loss. The sequence of events was as follows.

The contracting process was initiated in mid-October 2021, during which the research team employed a random selection method to designate contracted farmers. This selection process was based on a numerically ordered roster of cowpea farmers provided by the local cadres in each village. A total of 32 farmers were enlisted, and each was assigned a unique identification number. Subsequently, a correspondingly numbered plate was affixed to each cowpea planting location. This facilitated subsequent interviews and data recording. According to the contractual provisions, the contracted farmers were obligated to participate in periodic interviews conducted by the research team. Additionally, they were required to maintain contemporaneous records of their pesticide acquisition and usage, encompassing specific details such as the types of pesticides employed, quantities administered, and proportions of distribution.

In response to the prevalence of low literacy levels among the farmers, the research methodology in this study involved conducting individual interviews to enhance comprehension and provide farmers with ample time for reflective and comprehensive responses. A consistent cohort of farmers was interviewed multiple times at various stages of cowpea production to ensure data accuracy and effectiveness.

Prior to the commencement of the household surveys, the research team provided extensive training to its members. In November 2021, the research team administered household questionnaires to 32 cowpea farmers. This facilitated a comprehensive understanding of the farmers' backgrounds and assessed their involvement in activities related to the procurement, usage, and communication of cowpea pesticides.

The study methodology involved field observations and interviews. During the cowpea cultivation period, the research team conducted four field visits to cowpea planting sites. During these site visits, the researchers observed the progress of cowpea crop cultivation and pest management strategies implemented by contracted farmers. To gain insight into the genuine perspectives of farmers concerning their decision-making processes related to pesticide behavior, field interviews were conducted with the farmers.

2.2.2. Dynamic Updates to Survey Content and Interview Guidelines

By conducting extensive literature analysis and engaging in rigorous group discussions, we carefully identified and selected survey components closely aligned with our research inquiries. The study encompasses an investigation into the following aspects: the personal characteristics of cowpea farmers, familial dynamics, the rural business environment, information accessibility, the rationale behind pesticide procurement, and the decision-making process pertaining to pesticide acquisition and utilization, as well as the methods and timing associated with pesticide application. Importantly, our interview format was flexible, allowing for continuous revisions whenever fresh insights or concerns arose during the research interviews, field observations, and practical applications.

2.2.3. Data Collection

The study team conducted a sequence of four methodical interviews with the contracted farmers, all of which were duly documented with the farmers' explicit assent. Subsequently, the team members meticulously transcribed the audio recordings of each interview verbatim. All uncertainties or ambiguities in the transcriptions were effectively addressed through thorough re-listening or conversations with the interviewees via telephone. Superfluous components, such as laughter and pauses, were eliminated. After each transcription, the group members immediately initiated a thorough examination, fostering discussions with the mentor and fellow team members to identify any emerging concerns or insights that occurred during the procedure. These conversations reached their apex with the implementation of additional surveys conducted with the farmers aimed at delving deeper into the many issues they faced. Over a period exceeding four months, a comprehensive collection of surveys and intermittent interviews was systematically arranged, resulting in a substantial corpus of oral text data, including over 80,000 words. The dataset presented here served as the primary source for this study.

2.3. Data Analysis

Following the research methodology outlined by Corbin and Strauss (1990) [59], we used NVivo 11 software to analyze the collected oral text data. The first stage of open coding entailed a thorough analysis of the primary material, scrutinizing each word, deconstructing significant assertions, and attributing the first notions to crucial nodes. The aforementioned notions were later classified, combined, and abstracted to develop equivalent categories. The third phase, known as principal axis coding, examined the relationships between the categories. This process established connections between the categories and determined the most relevant category for the study topic, ultimately producing the central category. During the concluding phase of selective coding, a comprehensive theoretical framework was developed to reveal the interconnectedness of the main categories and subcategories.

2.4. Validity

Textual materials were subjected to many coding iterations and underwent significant deliberation among a broad group of study team members. This strict methodology ensured that no conceptual elements were unintentionally disregarded throughout the coding procedure, enhancing the scientific robustness of the category system. Additionally, a portion of the data was set aside for a theoretical saturation test to enhance the study's credibility.

This study upholds the principles of objectivity by refraining from making presumptions about pre-established research hypotheses or theoretical analytical frameworks. Instead, it employed a participatory observational methodology. In the initial phase, descriptive observations were conducted to gather fundamental data on the farmers' pesticide use systematically. These observations unveiled that the rural business environment has witnessed enhancements, and modern-day farmers have gained access to a multitude of reliable sources for acquiring knowledge on the judicious utilization of pesticides. Interestingly, the observed influence of neighborhood factors on farmers' pesticide practices appeared to diminish, challenging established conventions. This observation prompted us to formulate the initial research question. Subsequently, the inquiry evolved into a more comprehensive exploration of the subject matter through targeted observations, resulting in a more focused scope of investigation centered on the methods employed by cowpea farmers in their pesticide utilization practices during production and cultivation processes. Ultimately, the researchers employed a systematic approach to gather additional information selectively through specific observations.

3. Results and Interpretation of Findings

3.1. Sample Description

The research involved a sample of 32 cowpea farmers identified as either household leaders or spouses who played a significant role in household decision-making. Table 1 presents the descriptive statistics of the participants. Notably, the sample comprises a greater proportion of male farmers. The observed sex distribution is consistent with the prevailing home dynamics in rural China, where men predominantly take on the role of procuring and making decisions about pesticides, whereas women typically help with the application of pesticides. Consequently, most farmers who were interviewed were male.

Table 1. Basic information of sampled farmers.

Variables	Classification	Rates (%)
Gender	Male Female	75 25
Age	20–39 40–59 ≥60	31.25 59.38 9.37
Educational level	Primary school and below Junior high school Senior high school and above	28.13 46.88 24.99
Planting years	<10 years 10–30 years ≥30 years	25 43.8 31.3
Planting area	0–2 ha (excluding 2) 2–4 ha (excluding 4) ≥4 ha	78.13 12.5 9.37
Income level in the village	Less General More	12.5 46.9 40.6
Annual wage income from labor	≤USD 0 USD 0–1370 (excluding 1370) USD 1370–6850 (excluding 6850) USD 6850–13,700	46.9 9.4 28.1 15.6
Number of household vehicles (Electric bicycle/motorcycle/car)	1–2	68.8
	≥2	31.2
Participation in vegetable cultivation training	Yes	37.5
	No	62.5
Access to information on vegetable cultivation through social medium, etc.	None Occasionally Frequently	43.8 40.6 15.6
Frequency of communication with neighborhoods	No or less communication Generally Frequently	9.4 50 40.6

Additionally, the team compiled data on the sample farmers' basic cowpea cultivation practices to analyze the cost–benefit ratio of cowpeas across various farmers. This analysis supports further investigation into varying pesticide use behaviors among the farmers, which could influence income disparities. These statistics are presented in Table 2.

Table 2. Basic information on cowpea planting.

Variables	Classification	Rates (%)
Villages	Paiqi Village in Ledong County Baoqiu Village in Ledong County Chengdong Village in Sanya City	34.38 31.25 34.37

Table 2. *Cont.*

Variables	Classification	Rates (%)
Planting area	0–0.5 ha (excluding 0.5)	75
	0.5–1 ha (excluding 1)	15.6
	≥1 ha	9.4
Pesticide input	<USD 3000/ha	56.1
	USD 3000–6000/ha (excluding 6000)	28.2
	USD 6000–9000/ha (excluding 9000)	15.7
Total cost	<USD 5000/ha	6.3
	USD 5000–10,000/ha (excluding 10,000)	56.1
	USD 10,000–15,000/ha (excluding 15,000)	25
	USD 15,000–20,000/ha (excluding 15,000)	6.3
	USD 20,000–25,000/ha (excluding 25,000)	6.3
Yield	<10,000 kg/ha	12.5
	10,000–20,000 kg/ha (excluding 20,000)	28.1
	20,000–30,000 kg/ha (excluding 30,000)	28.1
	30,000–40,000 kg/ha (excluding 40,000)	28.1
	40,000–50,000 kg/ha (excluding 50,000)	3.2
Cowpea planting income	<USD 10,000/ha	18.8
	USD 10,000–20,000/ha (excluding 20,000)	34.4
	USD 20,000–30,000/ha (excluding 30,000)	31.3
	USD 30,000–40,000/ha (excluding 40,000)	12.5
	USD 40,000–50,000/ha	3

3.2. Results of Grounded Theory

The collected data underwent rigorous processing involving various coding techniques, including open, spindle, and selective coding. The following procedures were implemented to arrange and condense the ideas and classifications methodically while establishing connections among various conceptual categories. The coding table (see Table 3) provides a detailed presentation of the full data processing method. To improve clarity, the coding table was designed to exclude certain instances of the original assertions and precise descriptions of the conceptual categories. Instead, the emphasis is on elucidating the interconnectedness among the various conceptual categories. Details of each interviewed participant can be found in Appendix A.

Table 3. Code list for neighborhood effects on farmers' pesticide use behavior.

Selective Coding (8 Categories)	Core Coding (20 Categories)	Open Coding (76 Categories)
Personal experience	Rich personal experience	a1: Extensive years of production experience, knowledgeable about pesticide application. a2: Familiar with diseases, pests, and pesticides. a3: Able to diagnose symptoms and recommend appropriate treatments. a4: Aware of which pesticides are highly effective.
	Limited personal experience	a5: Lacks knowledge in pesticide mixing and application. a6: Limited experience in pesticide application. a7: Has not developed personal expertise. a8: Achieves poor results with personal pesticide use.
Neighborhood communication	Frequency of communication	b1: Does not engage in experience-sharing with neighbors. b2: Rarely seeks knowledge from fellow villagers. b3: Prefers to cultivate their crops independently.
	Scope of communication	b4: Does not share with unfamiliar individuals. b5: Shares information about pesticide usage among friends. b6: Relatives and friends recommend pesticides to each other.
	Willingness to communicate	b7: Seeks advice from skilled growers. b8: Consults neighbors who use different pesticides. b9: Farmers who do not understand seek mutual communication.
	Communication feedback	b10: Lacks gratitude. b11: Fears criticism and refrains from teaching.
	Communication barriers	b12: Neighbors lack understanding and do not inquire. b13: Different pesticide use makes it unsuitable for learning.
Pesticide store salesmen	Assured effectiveness	c1: Pesticide stores sell pesticides based on feedback from farmers. c2: Pesticide stores avoid selling pesticides with poor feedback from farmers.
	Experienced pesticide store salesmen	c3: Pesticide store salesmen are knowledgeable professionals. c4: Neighbor's experience is influenced by advice from pesticide store salesmen. c5: Pesticide store salesmen have more extensive experience than farmers. c6: Pesticide store salesmen have expertise in various pesticides and their applications.
	Information provision in communication	c7: Farmers acquire pesticide information from pesticide store salesmen. c8: Communication primarily occurs when visiting pesticide stores. c9: Pesticide store salesmen organize pesticide application training.
Other channels	Limited alternative information channels	d1: There is no pesticide information-sharing platform. d2: Limited access to pesticide information through television. d3: Farmers have not explored or purchased pesticides online. d4: The agricultural technology extension center provides insufficient training. d5: I am having difficulty understanding the expert's explanation.
Quality of communication	Expected communication content	e1: Provides information about the type of pesticide. e2: Recommends pesticide stores. e3: Discusses pesticide knowledge and techniques. e4: Inquires about the dosage of pesticides. e5: Engages in discussions about which pesticide is better. e6: Asks for the specific name of the pesticide.
	Experience retention	e7: Unable to provide helpful advice. e8: Withholds specific names. e9: Keeps some experiences to themselves. e10: Skilled farmers rarely share their experiences. e11: Teach others casually. e12: Reluctant to pass on secret recipes. e13: Unwilling to see others prosper.

Table 3. *Cont.*

Selective Coding (8 Categories)	**Core Coding (20 Categories)**	**Open Coding (76 Categories)**
Effectiveness of pesticide application	Effectiveness implication	f1: Adding sugar to the pesticide enhances thrips elimination. f2: Morning pesticide application improves pest control effectiveness. f3: Using a manual sprayer ensures effective application to flowers. f4: Inquire with pesticide store owners about optimal application and mixing. f5: Fewer pests result in higher quality and yield, leading to better prices.
	Priority of effectiveness	f6: If it works, we accept it. f7: If we find it effective, we will use it. f8: The main consideration is effectiveness. f9: We purchase what works well.
	Basis for judgment	f10: We judge based on others' experiences. f11: We assess based on our own experiences. f12: We consult the pesticide store for recommendations on effective pesticides. f13: We consider the label, as a good label indicates good effectiveness.
Decision outcomes	Insignificant neighborhood effect	g1: Neighborhood influence is present but minimal. g2: Farmers are unlikely to adopt pesticide recommendations from neighbors. g3: Neighbor recommendations have little impact on pesticide usage. g4: Neighbor experiences also originate from pesticide stores. g5: Farmers are more inclined to choose pesticide stores.
Business environment	Transport condition	h1: Cycling to the pesticide shop is a convenient option. h2: Frequently, residents travel from the village to the county town to purchase medications. h3: The road directly leads to the doorstep. h4: The road is now fully paved with concrete.
	Internet access	h5: Frequently engage with Jitterbug content. h6: Have internet TV installed at home. h7: Mobile phone internet access is highly convenient.
	Market supervision	h8: Markets conduct pesticide residue testing. h9: Pesticide stores refrain from selling counterfeit products. h10: Cowpeas with excessive pesticide residues undergo disposal.

Data source: Interviews with farmers in Sanya City and Ledong Lizu Autonomous County, Hainan, conducted from October 2021 to February 2022.

3.3. Validity Test

Saturation is commonly identified by a decrease in the generation of novel codes and the emergence of redundant instances within the primary dataset [52]. The process of achieving theoretical saturation was accomplished through a thorough examination of recently acquired data. The reserved data are meticulously encoded and subjected to rigorous analysis. Throughout this systematic procedure, no novel concepts or categories emerge, thereby indicating that the theoretical framework has reached a point of saturation.

The second facet pertains to reliability testing. This study commenced with the implementation of a peer-review process. Two graduate students who possessed a strong command of qualitative research methods but lacked familiarity with the specific study at hand were assigned the responsibility of coding a subset of the textual data. Their primary responsibility was to evaluate the preceding coding procedure and outcomes, detect any deficiencies, and offer valuable criticism. Subsequently, a validation test was conducted by comparing the coding outcomes of the two graduate students with those in our study in accordance with the procedure reported by Gioia et al. (2013) [60]. The level of agreement in coding between our study and the two graduate students was 0.85, which exceeds the acceptable threshold of 0.8; hence, the programming used in our research demonstrated strong reliability.

3.4. Analysis of Results

The findings of this study reveal that as the rural business environment advances, farmers predominantly acquire information regarding environmentally friendly pesticide usage through a variety of sources, including personal experience, interactions with neighboring farmers, visits to pesticide stores, and other informational channels, which inform their decision-making process. In their pursuit of optimizing economic benefits, farmers predominantly base their decisions on their expectations of pesticide efficacy. However, due to variations in communication quality, farmers sometimes encounter challenges in accurately assessing the expected pesticide effects based on the available information, necessitating the exploration of alternative methods until they acquire information indicating relatively favorable outcomes. The impact of neighborhood interactions on farmers' pesticide utilization progressively diminishes as a result of multifaceted factors. Furthermore, following the application of pesticides, farmers gain valuable insight into the actual effects, enhancing their personal experience and facilitating the collection of information for future reference, thereby aiding in the assessment of expected effects and informed decision-making. To enhance the clarity of our analysis and demonstrate the relationship between our coding technique and grounded theory, we provided extracts from the original interview comments.

3.4.1. Personal Experience

> "*Those of us who cultivate cowpea annually tend to have varying degrees of experience*". No. 20211016A02

> "*I'm not quite skilled at applying pesticides yet, so I still have a lot to learn from my neighbors*". No. 20211218A10

Farmers' individual experiences are important, as they represent an essential resource for acquiring invaluable insights into pesticide application. These experiences profoundly influence the decision of producers regarding pesticide use. However, it is imperative to acknowledge the inherent diversity of these experiences. A subset of agricultural professionals has invested considerable time and effort in comprehensively understanding pest management strategies and responsible pesticide utilization. They possess substantial practical expertise, enabling them to effectively manage pest and disease challenges through prudent and strategic pesticide application, coupled with valuable judgment experience. Conversely, another subset of farmers recognized the limitations imposed by their personal experiences in the field. This results in an information deficit and a lack of a clearly defined framework for optimizing pesticide efficacy. Consequently, these farmers often achieve suboptimal outcomes in their pesticide applications, leading them to seek more knowledge. This observation has also been corroborated by other studies [61–64].

3.4.2. Neighborhood Communication

> "*They won't really teach you, some of them are a bit conservative. If you're not well-acquainted, they might not share their knowledge*". No. 20211016A11

> "*We all use different pesticides, so I can't just use the same one you do when I see you using it. It's pretty unusual for us farmers to suggest to each other which pesticides to use*". No. 20211218A07

> "*Sometimes, when you try to help out your neighbor by suggesting a better pesticide, they might still complain about the results after using it*". No. 20211218A24

The exchange of information within a community plays a pivotal role in facilitating farmers' acquisition of essential pesticide knowledge. However, it is imperative to emphasize that the extent of these exchanges among neighboring farms remains somewhat limited. Several veteran farmers displayed a reticence to share information, indicating a preference for exclusive engagement with individuals they had developed strong affiliations with. Certain farmers exhibit a preference for engaging exclusively with individuals with whom they have established close relationships and abstain from divulging information to individuals they perceive as external to their social circles. Moreover, a cohort of agricultural practitioners opted for autonomous cultivation of their crops. They maintained the belief that disparities in pesticide usage between themselves and their neighboring counterparts rendered mutual learning infeasible. Alternatively, they perceived that neighboring farmers lacked the skills required for productive discourse. Divergent viewpoints underscore the limitations of informal interactions among neighbors, diminishing the efficacy of information transmission to farmers. This phenomenon aligns with prior scholarly research [29,65,66].

3.4.3. Pesticide Stores Salesmen

> "*Regarding information and knowledge about pesticides, we mostly learn it from the pesticide store. You see, if someone gives the lowdown to them pesticide store salesmen about a pesticide being no good, they ain't gonna stock it no more*". No. 20211016A08

> "*If pesticide shop owners want to make a buck in this business, they better suggest better pesticides and how to use them. Otherwise, no one's gonna want to buy pesticides from them*". No. 20211016A13

> "*After the pesticide guy suggests a pesticide, he says if you use it like he tells you, and something goes wrong, he'll swap it out or pay for the damage. So, you'd definitely go with what he recommends*". No. 20220210A29

Pesticide retailers, guided by their mission and unwavering commitment, provide essential pesticide advisory services to farmers at a reasonable cost. Further, given their principal mandate of marketing and distributing pesticides, these enterprises boast an extensive understanding of pests and pesticides, attesting to their noteworthy level of professional acumen. Moreover, pesticide stores serve as focal hubs for dissemination of pesticide-related information. As farmers interact with their counterparts, they gain substantial and valuable insights and subsequently share these insights with fellow farmers who visit these establishments for pesticide procurement. This reciprocal exchange of information is facilitated by farmers' expertise and personal experience. Consequently, two salient outcomes emerge. First, pesticide establishments accumulate a wealth of information and garner favorable feedback concerning the efficacy of recommended pesticide use, establishing a commendable reputation among farmers. Second, farmers accrue significant amounts of valuable information through interactions with pesticide establishments. Thus, the influence of pesticide retailers on farmers' pesticide-related behavior is a substantial determinant. This finding aligns with those of previous studies, as documented by Bhandari et al. (2018) [67], Jin et al. (2015) [68], and Lekei et al. (2014) [69].

During our field study, we found that pesticide stores significantly influence farmers' decision-making processes regarding pesticide use, surpassing the impact of personal experience and local community communication. Disparities in information collection costs and effectiveness across various channels can be theoretically posited. Farmers with extensive personal experience tend to acquire valuable insight from their practical knowledge. To enhance profitability, farmers frequently seek external sources of supplementary information to aid their decision-making. Individuals with limited personal experience are more inclined to engage with external entities. In the rural Chinese context, which is characterized by close-knit social structures, the expenses associated with interpersonal communication among neighbors are minimal. However, this configuration results in an information surplus within the local community, coupled with farmers' limited knowledge, leading to reduced information effectiveness. Conversely, pesticide retailers exhibit professionalism and reliability in disseminating information. They offer technical advice on pesticide applications, instilling confidence and improving the effectiveness of pesticides. Consequently, farmers tend to favor establishments that sell pesticides.

3.4.4. Alternative Information Channels

"*We don't have any platform in the village for sharing pesticide information. If it's feasible, I'd be willing to invite an expert and cover the costs to have them teach us how to farm better in the future*". No. 20211016A30

"*You see, those experts from the Agricultural Technology Extension Centre, they visit us for lectures quite often. But, I've only been to primary school, and half the time, I don't get what they're saying. Plus, there aren't many of these lectures*". No. 20211218A03

"*Them newfangled computers and mobile phones, I ain't much into 'em. See, when I go ahead and order pesticide on the web and then sit around waitin' for it to come, my cowpeas tend to give up the ghost in the meantime. And I'll be darned if I'm ready to put my trust in the quality and effectiveness of pesticides off the Internet*". No. 20220210A14

Farmers obtain pesticide information through alternative channels, including agricultural extension centers and the Internet. However, many in this region underutilize these sources. Traditional media, like television and web platforms, are less frequently used by farmers or are used mainly for entertainment, possibly due to age and educational limitations. They also often exhibit skepticism towards information from television and the Internet, displaying a reluctance to experiment. In China, agricultural technology extension stations are key authorities in reducing pesticide environmental pollution, promoting advanced technologies, and guiding rational pesticide use. However, due to the large number of farmers and dispersed lands in China, these stations can only offer intensive training once or twice annually. Moreover, training does not include assessments due to the generally older age and lower knowledge level of farmers, with participation being voluntary. The high age and low education level of many Chinese farmers, some of whom are illiterate, hinders their ability to assimilate new knowledge. The prevalent use of oral teaching in these centers makes it challenging for farmers to comprehend and retain information, limiting its practical utility. Consequently, farmers receive limited information. This finding is consistent with studies by Fan et al. (2015) [70], Babu et al. (2015) [71], Ibitayo (2006) [72], and Kiiza and Pederson (2012) [73]. Despite these challenges, farmers continue to express a need for pesticide information, with a majority willing to pay professionals for crucial insight. Government-regulated pesticide stores somewhat compensate for the shortcomings of agricultural technology promotion stations, providing valuable information and aiding in reducing pesticide pollution. To further mitigate pesticide pollution, these stores have established recycling points for pesticide waste packaging, helping to manage waste disposal by farmers.

3.4.5. Communication Quality

"*They'll talk about things like how much to use, what exactly they're using, and where they bought the pesticide*". No. 20211016A09

"*You can't really expect much advice. They just mention the type of pesticide for vegetable growing, and it's not easy to find out the exact name*". No. 20211218A15

"*At times, both our fellow farmers and the experts from the agricultural technology center in the city recommend pesticides that are not readily available in stores, and they often lack information on where to obtain them. Consequently, these suggestions are not practically actionable for us*". No. 20220210A01

Communication quality predominantly pertains to the concordance between farmers' expectations and the substantive content of their dialogues, exerting a substantial influence on farmers' assessments of anticipated pesticide effects within varying information channels. Farmers who engage in these exchanges seek precise information, including specific pesticide names, names of retail outlets selling pesticides, recommended mixing ratios, and application strategies, because these details are considered essential for enhancing pesticide application effectiveness. However, during these interactions, adjacent farmers often exhibit reluctance, while withholding other information, such as explicit brand or product details. Unfortunately, this individualistic approach hinders access to truly valuable information. In addition, personal experience, although valuable, often lacks comprehensiveness, and farmers encounter limitations in accessing information. The information disseminated by agricultural extension centers can be challenging for farmers to comprehend, and the recommended pesticides may frequently remain unavailable through commercial pesticide retailers, thereby giving rise to practical application difficulties. These circumstances collectively contribute to the restricted acquisition of valuable information through various channels, consequently hindering farmers' ability to make more informed judgments regarding the efficacy of pesticide usage. This observation aligns with the findings of scholarly field surveys conducted by Pan et al. (2021) [74], Breetz et al. (2005) [75], and Martini et al. (2017) [76].

3.4.6. Pesticide Application Efficacy

> "*Farmers in the neighborhood might claim their pesticides work, but we must try them ourselves to be sure*". No. 20211016A11

> "*You see, pesticides do a better job in the daytime than at night. Cause during the day, when the flowers are in full bloom, you can target the pests right inside the blossoms and get rid of them thrips directly*". No. 20211218A04

> "*Pesticides with some sugar added for dosing work better against thrips. Using a hand sprayer instead of an electric one helps apply the medicine directly to the flowers and kill the thrips more effectively*". No. 20211218A23

> "*You see, as long as that expensive pesticide can really take out them thrips, I don't mind paying a bit extra for it. The money for the pesticide aren't much when you look at the big picture and what we'll get in the end*". No. 20220210A19

The effectiveness of pesticide application in the management of pests and diseases is subject to various factors, including the choice of pesticides, their dosages, the timing of application, and the type of spraying equipment employed. These factors hold sway over cowpea yield and pricing, consequently leaving a direct impact on farmers' income. As a consequence, farmers actively seek information that can augment efficacy and bolster their overall returns, making their decisions contingent upon such valuable insights. Consequently, pesticide efficacy serves as the primary rationale and ultimate objective for guiding farmers' decisions regarding pesticide use. Pesticide effectiveness can be classified into two categories: anticipated and observed effects. Irrespective of the information source, farmers tend to favor dosage techniques and knowledge that have garnered acclaim for their effectiveness. Nonetheless, the quality of communication introduces complexity into the assessment of the intended pesticide effects. To gauge application effectiveness, farmers must consider a constellation of factors, including pesticide labels, personal experiences, and collective wisdom. Subsequently, farmers base their decisions on their expectations of pesticide efficacy. These findings are congruent with the findings of previous studies [66,77,78]. The actual effects become apparent following the application of pesticides, thereby augmenting personal experience and facilitating subsequent rounds of decision-making.

3.4.7. Decision-Making Outcomes

> "*I usually don't rely too much on my neighbors' pesticide recommendations. They do have some influence on me, but it's not significant*". No. 20211016A16

> "*My neighbors mostly listen to what those pesticide store folks say. You'll often see him heading to the pesticide store for advice on how to use and apply them*". No. 20211218A27

> "*I choose the pesticide method that yields the best results, whether it comes from a pesticide store clerk, a neighbor, or one of the agricultural extension station experts. I am not selective; my primary concern is achieving effective outcomes*". No. 20211218A31

Farmers' decision-making processes depend on balancing the quality and cost of information from various channels against expected pesticide application outcomes. To maximize agricultural yields, farmers choose pesticide information promising improved outcomes and diligently adhere to the instructions. Local communication provides a cost-effective way to acquire information; however, its quality is often poor, leading to unsatisfactory pesticide application results. As a result, community communication has a limited impact on farmers' decision-making. Conversely, government-regulated pesticide stores require qualified practitioners who offer scientific guidance on pesticide use, aiding farmers in applying pesticides effectively and rationally. Additionally, through partnerships with pesticide companies, these stores provide free training, materials, and videos, facilitating access to effective information and enhancing the economic impact of pesticide use for farmers. This approach also helps reduce pesticide misuse by farmers, indirectly protecting the environment. Furthermore, complying with government regulations, these stores offer recycling points for pesticide packaging, contributing to environmental protection. This practice also improves the farmers' living environment. Consequently, the farmers' preference for pesticide suppliers is understandable. This trend highlights the declining influence of community interactions and the growing importance of pesticide retail outlets. Moreover, these decision-making processes significantly impact the farmers' overall profitability. Thus, farmers increasingly base their pesticide use decisions on information obtained from pesticide stores.

3.4.8. Business Environment

> "*You know, I sometimes even check out how to apply pesticides right on TikTok. And if there's something I can't figure out, I just drop a question in our pesticide shop's WeChat group, and they tell me what to do*". No. 20211016A17

> "*Well, you know, nowadays, everyone's got vehicles, and the roads are fixed up real nice. Sanya's got better-quality pesticides than what we've got here in Ledong. So, it's easy as pie to hop in the car and grab some pesticides*". No. 20220210A10

The business environment influences farmers' decision making regarding pesticide use. Enhancements in the business environment can reduce the costs associated with accessing diverse information channels while concurrently expanding the information resources available to farmers, facilitating more effective information acquisition. Farmers, operating as rational economic agents, engage in a meticulous evaluation of both the cost and quality of information derived from diverse sources, with a discerning eye towards selecting those that promise elevated anticipated gains. Consequently, when pesticides or scientific techniques boasting superior insecticidal effects emerge, farmers' approaches to pesticide application undergo a transformation driven by their rational deliberation. This assertion finds partial validation in the extant literature [79–82].

4. Discussion

4.1. Models of Pesticide Behavioral Choice Mechanisms for Farmers

After conducting a thorough multi-layer coding process and analyzing the results, we developed a detailed model that elucidates the complex mechanisms by which information channels influence farmers' pesticide use decisions, as depicted in Figure 2. For a comprehensive description of the coding process conducted in NVivo 11, please refer to Appendix B. Appendix B comprises two specific figures, namely Figure A1, which illustrates the NVivo open and spindle coding process workflow, and the second figure, Figure A2, which further details the NVivo coding process.

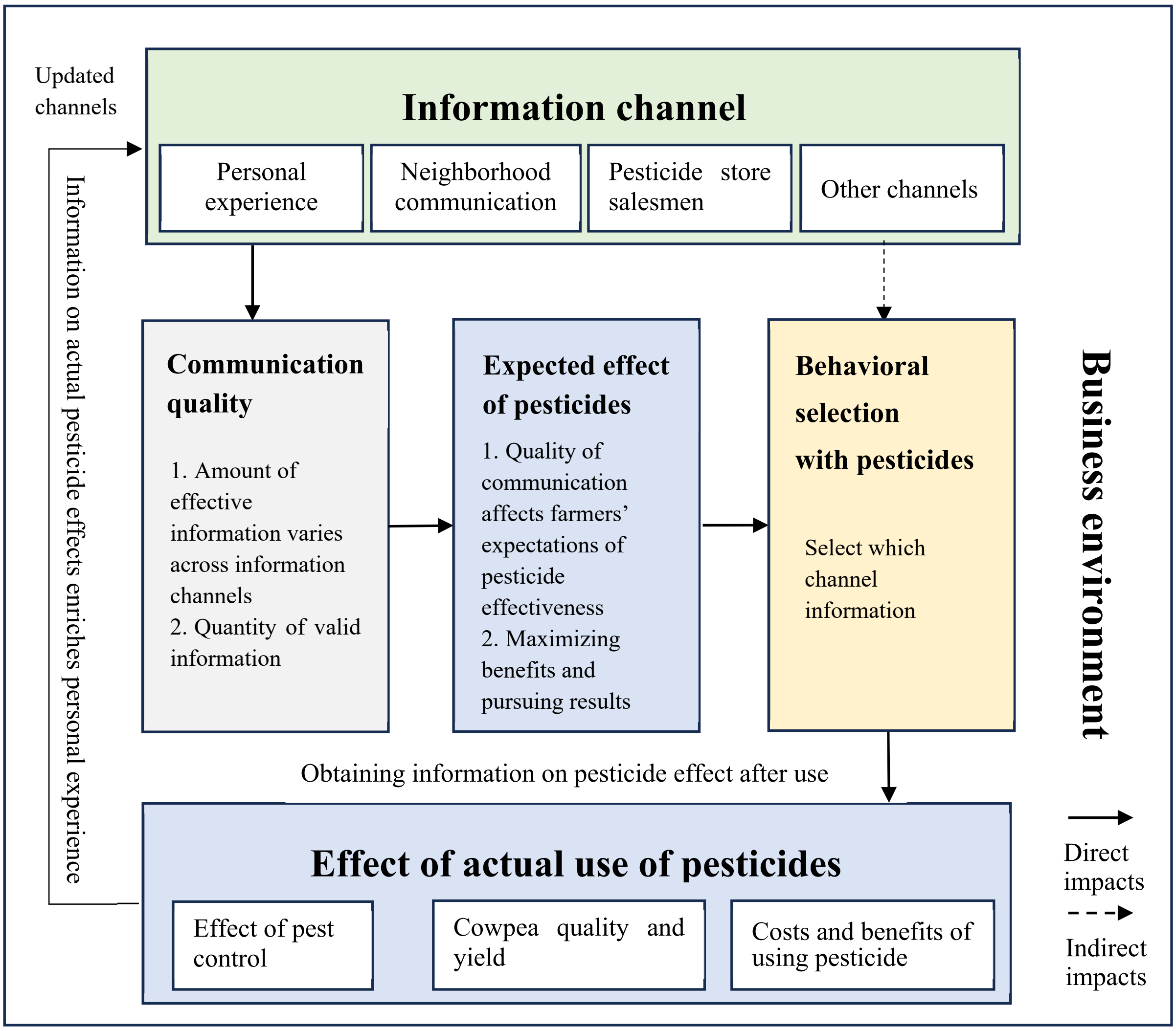

Figure 2. Mechanism of farmers' pesticide behavior choices.

Local communities play a crucial role as an influential source of information that shapes farmers' decision-making processes regarding pesticide use. Farmers typically acquire information regarding potential control strategies for pests and diseases. This involves consulting multiple sources and carefully evaluating the elements of information cost and quality to make informed decisions. Consequently, when the business environment undergoes enhancement and the costs associated with obtaining information are excessively high, individuals may be compelled to make concessions regarding the accuracy or reliability of the information they acquire. Nevertheless, as the prices of information are reduced to a sufficiently low level, farmers engage in a re-evaluation process regarding their selection of communication channels to improve the quality of information. This leads to optimization of the benefits derived from pesticide utilization. Simultaneously, adhering to more scientifically grounded recommendations facilitates farmers in the judicious and environmentally friendly application of pesticides, thereby mitigating agricultural non-point source pollution and promoting environmental preservation.

4.2. Changes in Business Environment Leading to Changes in Farmers' Behavioral Choices on Pesticide Use

The diminishing influence of local peer dynamics on farmers' pesticide use over time is noticeable and is ascribed to advancements in rural business environments. This trend can be attributed to improvements in rural business environments. Consequently, farmers have experienced reduced expenses in obtaining pest control information, coupled with increased information reliability. Thus, farmers adjust their information channel preferences. These conclusions are further supported by He (2022) [83], who administered a survey to vegetable farmers residing in the northern part of Hainan Province, which revealed that 61% of farmers preferred obtaining pesticide recommendations from stores. Contrarily, 10% of farmers relied on advice from known neighbors when making decisions. Pan et al. (2021) [74] examined the impact of different information sources on pesticide expenses among 603 rice farmers in China. The findings reveal that the recommendations provided by pesticide store clerks had a significantly more substantial impact on reducing pesticide expenses compared to alternative sources of information. The findings of our study support these established conclusions.

Data from China's Second National Agricultural Census in 2006 reveal that in rural market settings characterized by traditional and rural features, transportation infrastructure is often underdeveloped [84]. Notably, 95.5% of all villages were connected to the national highway network, but less than 40% of the highways leading to these villages had paved surfaces, and less than 30% of internal village roads were cemented. These conditions create transportation inconveniences for farmers. Telephones and postal services were the primary means of communication, with telephones accessible in 97.6% of the villages. However, the transmission of external information to rural areas is slow, resulting in a limited information flow. The market infrastructure was inadequate, with specialist agricultural product markets in 23.0% of the townships, and fertilizers were available in only 50.2% of the villages. Moreover, counterfeit and substandard pesticides persist in pesticide markets. According to the 2006 national pesticide market spot-check statistics, the pesticide product quality qualification rate was 84.1%, whereas the label qualification rate was 70.1% [85]. This indicates an ongoing need for regulatory governance and improvements in the pesticide market. Given these market conditions, farmers rely heavily on their local communities as a crucial source of knowledge because of the difficulties in accessing external information.

The Chinese government has been actively working to enhance its business environment. In 2013, the No. 1 Document of the Central Committee introduced the goal of "striving to develop beautiful rural areas" and reinforce rural infrastructure development. Electrification and improved road connectivity in rural and urban centers, stricter regulations in the agricultural production materials market to combat counterfeit products, targeted training programs, and widespread integration of 5G network technology have all been adopted. According to the Bulletin of Main Data of China's Third National Agricultural Census (No. 3) [86] published by the Hainan Bureau of Statistics (2016), noteworthy enhancements have occurred in China's transportation infrastructure. Census data from 2016 reveal that most villages (99.3%) are now connected to highways, with a significant proportion of village roads being paved (76.4% leading into villages and 80.9% within villages). In terms of communication, notably, telephone, television, and Internet services have wide available, with 99.5% of villages equipped with telephones, 82.8% possessing cable television, and 89.9% having access to broadband Internet. These advancements have reduced communication costs and facilitated the acquisition of sophisticated knowledge on pesticides and agricultural resources. In response to the evolving rural business environment, farmers are progressively diversifying their sources of pesticide-related information. These alternative channels encompass pesticide retail establishments, online resources, and agricultural extension institutes, all of which provide cost-effective access to high-quality information. As a result, farmers have begun to transition away from exclusive reliance on local knowledge.

Additionally, in October 2016, China initiated environmental inspections in 20 provinces, including Hainan and Guangdong [87], and imposed penalties on those found responsible for environmental harm. This initiative underscores the imperative of environmentally responsible and rational pesticide application practices, as well as the preservation of ecological integrity. In 2016, Hainan Province issued a draft of the "Amendment to Specific Regulations on Pesticide Management in the Hainan Special Economic Zone" [88], mandating pesticide residue testing for agricultural products. It also imposed sanctions for the failure to establish rapid pesticide residue-monitoring points in farmers' markets. Furthermore, Sanya City conducted inspections of over 1300 pesticide retail shops within its jurisdiction and intensified its sampling procedures for both conventional pesticides and agricultural produce, such as melons and vegetables. These measures require farmers to not only curtail the quantity of pesticides employed, but also to administer them judiciously. Consequently, this practice contributes to a partial mitigation of agricultural non-point source pollution stemming from excessive pesticide application and serves to safeguard ecological integrity.

Henceforth, it is imperative for farmers to exercise prudence in their pesticide-related decisions and endeavor to employ pesticides with an emphasis on environmental sustainability and rationality. Nevertheless, the pool of knowledge among neighboring farmers regarding environmentally friendly pesticide use remains limited, thereby failing to adequately address the decision-making requisites of farmers. In spite of the wealth of pertinent expertise available at agricultural extension centers, its acquisition is encumbered by high costs and accessibility challenges. Furthermore, farmers exhibit low confidence in web-based information sources, impeding their ability to procure pesticides promptly. In stark contrast, pesticide retail establishments boast a reservoir of professional knowledge concerning environmentally friendly pesticide use, offer accessible information channels, and present fewer practical hurdles, making them the preferred choice for farmers.

However, it is essential to recognize the limitations of this study. Caution should be exercised when applying the study's conclusions to diverse situations, as the primary sample comprised only 32 individuals from three villages in southern Hainan Province. Inherent disparities manifest across diverse academic disciplines and geographic areas concerning the quality of the rural business environment, and these distinctions may, in turn, impact the manner in which various information channels influence the decision-making process of farmers with regard to pesticide behavior. Therefore, these findings should be considered research hypotheses that require validation through extensive data collection at various locations. Notably, this study specifically examined pesticide practices among cowpea producers. Further research is necessary to assess the applicability of these findings to the study of pesticide behavior in other crops, such as vegetables and cereals.

4.3. Comparison with Existing Empirical Studies on Farmers' Pesticide Behaviour

Utilizing grounded theory analysis, our study discerned that the rural business environment significantly impacts farmers' pesticide usage behaviors, primarily by influencing the quality and cost of information from various channels, such as agricultural technology centers, neighboring farmers, and pesticide retail stores. Extensive research, employing both quantitative methods and diverse approaches, has examined the effects of these channels [20,35,53,89]. For example, neighboring farmers have a significant influence [9,22,25], mobile phones and the Internet mainly affect younger farmers [67,80,81], and agricultural technology extension centers exert a greater impact on larger-scale farmers [45,61,68]. However, the existing research often overlooks the reasons behind farmers' varied choices amidst multiple information sources, a gap our study aims to address. One limitation of our research is its reliance on a sample of only 32 cases from the Hainan region in China, which may not fully represent diverse agricultural practices. Future research could employ these findings as hypotheses for broader validation or as a comparative baseline, potentially expanding the geographical scope to enhance the generalizability of the results.

5. Conclusions

Farmers' pesticide practices are complex. Irrational pesticide use can have adverse consequences, underscoring the importance of farmers acquiring knowledge to make informed choices regarding pesticide use. Through the analysis of grounded theory, it was discovered that farmers access information from a range of sources, encompassing neighboring farmers, their personal experiences, pesticide retail establishments, and agricultural extension centers. These sources significantly influence farmers' decisions on pesticide usage.

Farmers predominantly base their decisions on the anticipated pesticide effects conveyed through information sources. Furthermore, with the amelioration of the rural business environment, the influence of neighborhood dynamics on farmers' pesticide utilization has waned, giving way to the increasing prominence of pesticide retail outlets. The involvement of external environmental protection inspectors and pesticide residue testing contributes to encouraging farmers to adhere to the counsel provided by pesticide retailers, leading them to select environmentally friendly pesticides and employ judicious and sustainable pesticide practices, thereby mitigating pollution and preserving the environment. This study presents several recommendations to promote the adoption of environmentally friendly pesticide methods among farmers and foster high-quality agricultural growth.

Firstly, it is crucial to improve the business environment in rural markets. This can be achieved by enhancing infrastructure, streamlining market transactions, and ensuring that farmers have convenient access to market-oriented services while reducing associated expenses. Implementing legislative measures to support a wide range of environmentally sustainable agricultural production technologies is imperative. Trade in rural agricultural retail markets should be governed by stringent regulations.

Secondly, establishing additional channels for farmers to access advanced information, such as organizing training sessions and collaborating with prominent enterprises, can effectively facilitate the distribution of valuable information in rural markets. This approach acknowledges the vital role of cutting-edge and efficient information for supporting farmers. Furthermore, enhancing the dissemination of agricultural production information is essential to help farmers discern pertinent facts related to pesticides, promoting continuous improvements in pesticide practices.

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Institutional Review Board Statement: The study was conducted in accordance with the Declaration of Helsinki and was approved by the Institutional Review Board (or Ethics Committee) of the College of International Business, Hainan University (protocol code 20230921 and date of approval on 21 September 2023).

Data Availability Statement: In this study, all participants consented to the survey and appropriate permissions were obtained. However, due to privacy and ethical considerations related to the sensitive nature of the data, it is not feasible to publicly share the datasets. Detailed information about the data and methodologies used can be made available upon reasonable request, under strict compliance with privacy and ethical guidelines.

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Conflicts of Interest: The authors declare no conflicts of interest.

Appendix A. Basic Information of Sample Farmers

Table A1. Basic information of sample farmers.

No.	Village	Gender	Age	Education	Planting Years	Cultivated Area (ha)	Income Level in the Village	Worker's Wage (USD/Year)	Number of Household Vehicles (Electric Bicycle/ Motorcycle/Car)	Participated in Vegetable Cultivation Training	Obtain Vegetable Growing Information through Social Medium	Frequency of Communication with Neighborhoods
A01	Pq	M	61	JHS	35	0.8	G	1370	1	Y	Fr	Fr
A02	Pq	M	31	JHS	3	0.6	More	11,781	3	N	N	Fr
A03	Pq	F	53	PB	25	0.6	More	4932	4	Y	O	Fr
A04	Pq	M	36	JHS	7	0.6	G	0	1	N	N	G
A05	Pq	M	30	SHS	10	0.4	More	3288	1	N	N	NCL
A06	Pq	M	65	SHS	28	1.2	Less	0	2	Y	O	Fr
A07	Pq	M	34	JHS	9	0.6	G	1022	1	Y	N	G
A08	Pq	M	67	SHS	32	0.8	More	0	3	N	O	G
A09	Pq	M	32	JC	5.5	0.8	Less	0	2	N	N	Fr
A10	Pq	M	40	JHS	17	0.8	G	0	4	N	N	Fr
A11	Pq	M	50	PB	26	1.2	G	0	1	Y	O	Fr
A12	Bq	Male	44	SHS	24	0.8	G	0	2	Y	N	Fr
A13	Bq	Male	56	PB	32	0.8	Less	0	1	N	Fr	Fr
A14	Bq	Male	59	JHS	35	2	G	411	2	N	O	NCL
A15	Bq	Female	48	PB	26	1.2	More	0	4	Y	N	Fr
A16	Bq	Male	25	JHS	2	1.2	G	0	2	Y	N	Fr
A17	Bq	Male	52	PB	28	0.82	G	1370	2	Y	O	Fr
A18	Bq	Female	36	SHS	8.5	0.8	More	1370	3	Y	N	NCL
A19	Bq	Female	54	PB	30	1.6	G	0	2	Y	O	G
A20	Bq	Male	35	JHS	6.5	1.2	G	1370	2	N	N	Fr
A21	Bq	Male	50	PB	30	3.2	More	3288	2	N	O	Fr
A22	Cd	Male	48	PB	22	1	More	2466	3	Y	O	Fr
A23	Cd	Male	52	JHS	30	1	G	0	1	N	O	G
A24	Cd	Male	34	JHS	7.5	13.4	More	0	3	Y	N	G
A25	Cd	Male	40	JHS	20	0.6	G	0	2	Y	Fr	Fr
A26	Cd	Male	39	JHS	16	1.4	More	9863	2	Y	N	G
A27	Cd	F	55	PB	33	2.2	Less	685	1	Y	Fr	Fr
A28	Cd	F	45	JHS	25	5.7	More	3863	1	Y	O	G
A29	Cd	F	51	JHS	29	4	More	3425	1	Y	O	Fr
A30	Cd	M	43	SHS	21	1.2	Less	0	2	Y	N	Fr
A31	Cd	F	52	JHS	30	1.1	More	8000	3	Y	Fr	Fr
A32	Cd	M	54	SHS	32	2.4	More	7500	3	N	Fr	Fr

Notes: Pq—Paiqi Village; Bq—Baoqiu Village; Cd—Chengdong Village; M—male; F—female; JHS—junior high school; SHS—senior high school; PB—primary and below; JC—junior college; G—generally; Y—yes; N—no or none; O—occasionally; Fr—frequently; NCL—no communication or less.

Appendix B. NVivo 11 Coding Procedure Overview

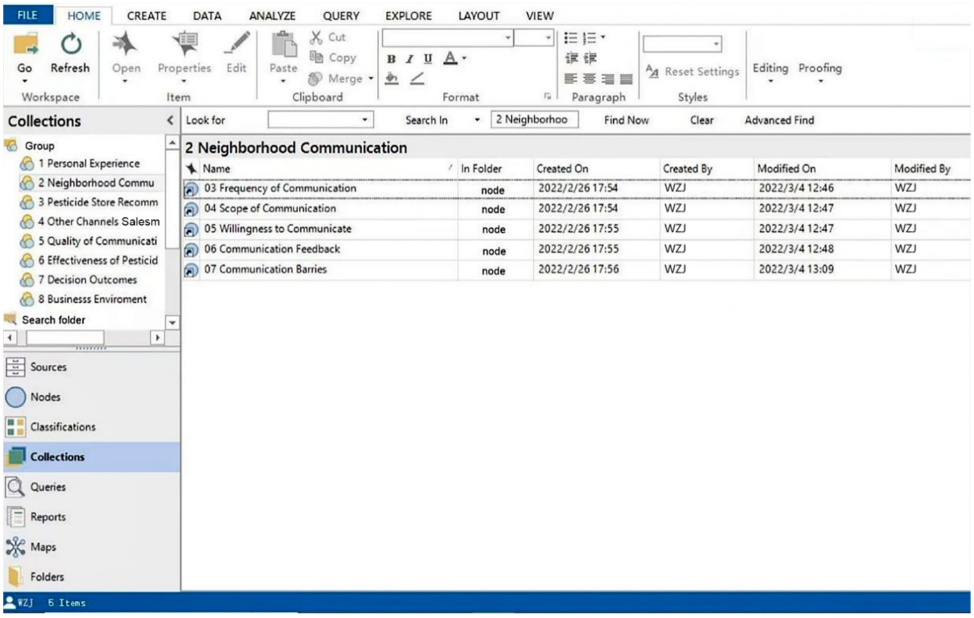

Figure A1. NVivo open and spindle coding process workflow.

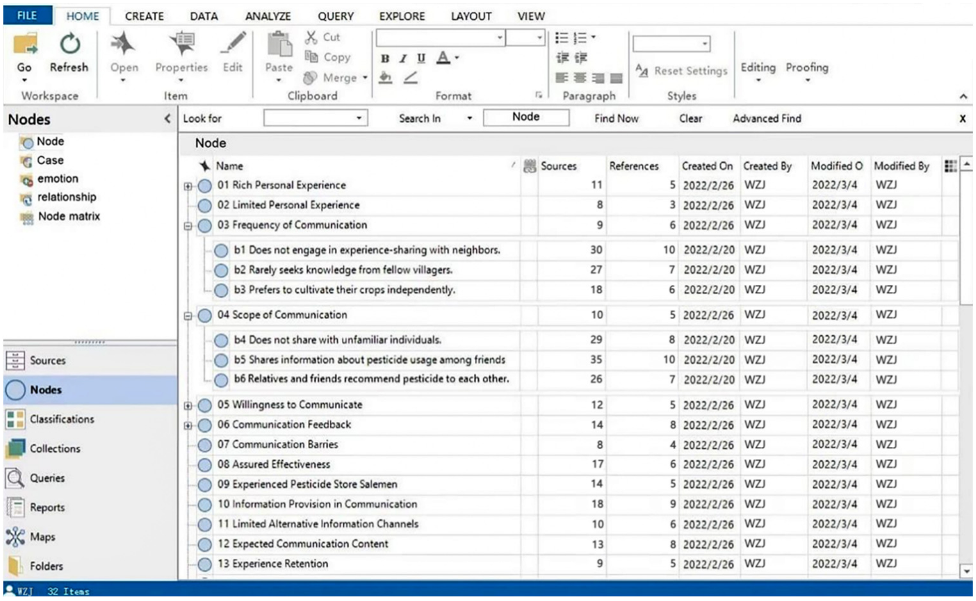

Figure A2. Spindle coding and selective coding processes.

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