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Hybrid Communication Ecosystems in Rural Contexts: Climate Adaptation Media Ecology Through Face-to-Face, Television, and WhatsApp

Vania Utamie Subiakto[1], Veranus Sidharta[2], Cucu Hodijah[3], Sherra Adistiana Rizki Utami[3]

[1]Universitas Sains Indonesia, Indonesia

[2]Bina Sarana Infromatika University, Indonesia

[3]Universitas Sain Indonesia, Indonesia

Correspondence: Vania Utamie Subiakto, Universitas Sains Indonesia, Indonesia.

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Abstract

This article examines a hybrid communication ecosystem in a rural setting vulnerable to climate change and questions how face-to-face conversations, television, and WhatsApp interact to transform climate information into action. Drawing on a qualitative case study in Sukadamai Village, Bogor, we combine semi-structured interviews, participant observation, and WhatsApp conversation analysis, then conduct a reflexive thematic analysis with triangulation. Findings indicate that television provides weather cues, while recurring field conversations serve as verification hubs that contextualize risks, negotiate time, and allocate tasks; WhatsApp complements these routines with rapid coordination alerts. We theorize that adaptation is a cycle of signal-verification actions distributed across interpersonal, mass, and digital channels, structured by organizational norms, trust, role cues, gatekeeping, and soft accountability, that mitigates unequal access and reduces decision latency in the face of rainfall variability. We recommend strengthening offline briefings and forums while incubating the targeted use of WhatsApp within working groups to accelerate alerts and coordinate work without displacing established practices. This study contributes to media ecology and environmental communication by determining the mechanisms by which hybrid networks translate climate signals into appropriate decisions and organizational and interpersonal communication by outlining design implications for information services, facilitation roles, and group chat governance.

Keywords: climate adaptation, communication ecology, hybrid media, organizational communication

1. Introduction

Climate change is causing increasingly unpredictable weather volatility, affecting planting decisions, water availability, and the risk of pests and diseases in food commodities and agricultural production (Arora, 2019; Flack-Prain et al., 2021; Skendžić et al., 2021; Aguais & Forest, 2023; Pizzorni et al., 2024). Recent cross-country evidence shows the real impact of climate change on the rice and horticultural production base as extreme rainfall intensity, floods, and droughts increase yield uncertainty, forcing farmers to delay, change varieties, or even switch commodities to survive (Tabari, 2020; Furtak & Wolińska, 2023; Prajapati et al., 2024; Yang et al., 2024; Yadav, 2025). In Indonesia, this is correlated with a decline in rice production and disruption of the growth phase, thereby increasing the vulnerability of smallholder farmers who rely on seasonal cropping patterns (Ansari et al., 2023). Recent empirical studies on small-scale farmers confirm that adaptation decisions are influenced by a combination of risk perception, access to information, and network support rather than solely by technical agronomic factors (Alim & Anggraini, 2021; Akmalia, 2022; Arifah et al., 2022; Octavia & Kadir, 2023; Hasibuan et al., 2023; Imelda & Hidayat, 2024).

In other words, climate adaptation is socio-technical: decisions do not arise in a vacuum, but are negotiated through communication among farmers, extension workers, and other local actors. Furthermore, recent mapping of rainfall variability and trends confirms long-term changes in rainfall patterns and regional heterogeneity, which calls for more refined and responsive climate information systems down to the village level (Eze et al., 2021; Habte et al., 2023; Shigute et al., 2023). In such a situation, climate communication becomes a determining social infrastructure, especially climate information services (Kayusi et al., 2024). Recent evaluations show that forecast accuracy and acceptability of climate information services correlate with socio-economic benefits for farmers. However, challenges arise in their accuracy, local relevance, and distribution to end users. Their adaptation impact is weakened when information services are slow, unreliable, or inappropriate for local contexts. Therefore, a platform that accelerates the flow of reliable information and facilitates two-way feedback is crucial (Bizo et al., 2024).

In the realm of rural digital communications, the adoption of chat apps like WhatsApp (WA) shows great potential as a community neural network, combining speed, social proximity, and ease of sharing content such as text, photos, videos, and voice notes (Thakur et al., 2017; Vagrani et al., 2020; Bueno-Roldan & Röder, 2022). Cross-context studies show that farmers and extension workers increasingly use chat apps to share videos of cultivation practices, discuss solutions synchronously/asynchronously, and curate knowledge based on field experience (Thakur et al., 2018; Bhatt, 2020; Sharma et al., 2024; Gwelo, 2025). This mechanism strengthens horizontal peer-to-peer learning and shortens the distance between scientific knowledge, local knowledge, and daily decisions on the ground (Coggins et al., 2025).

In several developing countries, social media, including WA, democratizes the flow of agricultural knowledge for smallholders, bridging the access gap, opening up a space for quick questions and answers, and strengthening the position of farmers in the previously top-down information ecosystem (Sandeep et al., 2020; Nwaizugbo, 2021; MadhuShekar et al., 2023; Mulaudzi et al., 2024; Ramavhale et al, 2024; Uy et al., 2024). The impact extends beyond simply disseminating information and fosters curation practices, social verification, and more equitable collaboration among local actors. This evidence confirms that social media serves as a new form of social capital, supporting the resilience of farming communities amidst climate uncertainty. Meanwhile, the resilience dimension, defined as the capacity to absorb shocks, adapt, and transform, is not solely derived from agricultural technology but is strongly supported by communication networks and social capital (Daigle, 2020; Bathaiy et al., 2021; Chaudhuri et al., 2021; Bruce et al., 2021). In this regard, networks of trust, mutual support, and network-based information exchange are crucial in driving adaptation decisions. When farmers are connected in an active network, they tend to receive risk warnings earlier, adopt innovations more quickly, such as tolerant varieties and adjusted planting schedules, and are more resilient in coping with the psychological stress of crop failure (de Brito et al., 2024).

In the context of Sukadamai Village, Bogor, the ecological setting of West Java, which has recently experienced increasing rainfall variability, demands a communication mechanism that: (a) is agile in disseminating early warnings and cultivation recommendations, (b) recognizes differences in access and capacity between groups such as young and senior farmers, rice paddies and horticulture, and (c) connects with external actors such as extension workers, village officials, and markets. Recent hydrometeorological evidence in Java reinforces this urgency: rainfall patterns are shifting and heterogeneous, so that micro-decisions about when to sow, transplant, or change crops increasingly depend on precise and timely local information (Nawiyanto et al., 2024). On the other hand, European farmers' adaptation behavior studies show that whether to adapt is often the result of a social calculus that weighs norms, risk perceptions, and institutional capacity in addition to technical factors. This lesson helps understand decision-making dynamics at the farmer group level in Indonesia. WA can facilitate deliberation, negotiating priorities, and the development of practice norms compatible with local risks (de Boon et al., 2024).

Based on this knowledge gap, the research "Integrating WhatsApp into Hybrid Communication for Farmers' Resilience in Adapting to Climate Change: A Case Study in Sukadamai Village, Bogor" is positioned to map the communicative function of WA, including the dimensions of climate information, weather, adaptation techniques, coordination of cooperation, logistics of results, learning and sharing of practices, and psychosocial support while assessing information governance, accuracy, source curation, and community-based verification mechanisms so that the benefits of Climate Information Services are truly converted into more appropriate farming decisions by identifying barriers and inequality of participation that affect information equity within the group; and formulating practical implications for the design of climate communication strategies that are sensitive to the village context and able to strengthen collective resilience.

2. Method

2.1 Design, Paradigms, and Units of Analysis

This research uses an intrinsic qualitative case study design with an interpretive constructivist paradigm (Creswell, 2018; Yin, 2018). The focus is understanding how and why WhatsApp-based communication practices support farmers' resilience to climate change. The unit of analysis is group-level communication practices, namely interactions in WhatsApp groups, offline coordination connected by digital messages, and communication artifacts mapped along four dimensions: (a) climate information, adaptation techniques, (b) cooperation and coordination, logistics of results. (c) collective learning and sharing of practices, and (d) psychosocial support. This approach allows researchers to interpret the community's meanings, norms, and governance of socially constructed information.

2.2 Data Research Location

The research was conducted in Kuripan Hamlet, Sukadamai Village, Dramaga District, Bogor Regency, an agrarian region with high rainfall variability and limited irrigation, prompting a shift in some farmers from rice to horticulture. In this context, WhatsApp has become the primary communication channel for weather warnings, work coordination, and the exchange of cultivation practices. This socio-ecological setting is relevant for examining how climate information is transformed into micro-decisions on sowing times, changing planting schedules, and diversifying commodities through fast, affordable, and networked communication processes.

Figure 1. Research Location, Sukadamai Village, Bogor Regency

2.3 Participants

Informants were selected using purposive sampling, consisting of farmers active in farmer WA Groups (WAGs), experienced climate impacts, willing to be interviewed, and permitted data blurring, using snowball sampling until theme saturation was achieved. A total of 11 active farmer informants with experience ranging from 6 to 25 years were selected.

Table 1. Research informants

No	Informant Name	Work	Age (Years)	Long Farming (Years)	Location
1	Udin	Active Farmers	52	15	Sukadamai Village
2	Adang	Active Farmers	53	15	Sukadamai Village
3	Sahim	Active Farmers	50	20	Sukadamai Village
4	Omang	Active Farmers	43	18	Sukadamai Village
5	Opik	Active Farmers	49	15	Sukadamai Village
6	Arsa	Active Farmers	53	25	Sukadamai Village
7	Ujang Suganda	Active Farmers	75	15	Sukadamai Village
8	Mirta	Active Farmers	45	6	Sukadamai Village
9	Rusdi A.S	Active Farmers	60	9	Sukadamai Village
10	Agus	Active Farmers	45	20	Sukadamai Village
11	Ace	Active Farmers	43	20	Sukadamai Village

Source: Research data (2025).

2.4 Data Collection and Analysis Techniques

Data were collected through (a) in-depth, semi-structured face-to-face interviews according to informant preferences with probes on four dimensions; (b) limited participant observation to capture the context of interactions, roles of figures, and decisions related to the weather; and (c) analysis of WA conversations over a timeframe agreed upon by members, including relevant text messages, photos, videos, and voice notes. Analysis using Reflexive Thematic Analysis: data familiarization includes initial coding, grouping codes into themes on four dimensions, namely, information governance, barriers or inequalities, review of themes with cross-source triangulation (interviews, observations, WA), and negative case analysis, naming complete themes with representative quotes, mapping implications to farmer decisions. Validity is maintained through the credibility of method and source triangulation, member checking summaries of informant findings, transferability of the description of the context of Kuripan Village and examples of communication artifacts), dependability (audit trail: instruments, analytical decision logs, codebook versions), as well as confirmability of reflective memos and management of researcher bias.

3. Results

3.1 Communication Channel Profile

Sukadamai Village is located in a tropical zone with high rainfall, relatively fertile soil, and agro-ecological conditions supporting agriculture while requiring vigilance regarding daily weather dynamics. In the context of climate change adaptation, the communication architecture for farmer resilience in Sukadamai still relies on natural face-to-face interactions at daily meeting points on the embankments during work breaks, at the patrol post, or on the porch because smartphone ownership and digital literacy are not yet widespread. Television (TV) serves as a quick reference for weather forecasts.

Broadcast information is then translated locally through short conversations in the fields into practical decisions for farmers regarding activities such as when to sow, transplant seedlings, or delay planting. Meanwhile, WhatsApp occasionally appears as a supplementary tool used by many farmers with mobile phones to connect with news, remind them of schedules, or forward information to extension workers. This mixed pattern forms an information network embedded in the rhythm of fieldwork, maintaining practical coordination and psychosocial support, while reducing reliance on infrequent formal meetings. Based on the informants' statements, the following excerpts enrich our understanding of these communication patterns.

> *"We communicate by phone, but we meet more often in person in the fields; we chat about the weather almost every day" (Informant Udin).*

> *"I don't have a cell phone, so we usually get weather information from TV; we also talk more directly in the fields" (Informant Opik).*

> *"I don't have a cell phone; we rely on daily meetings; we rarely have regular gatherings, and TV is our main source of weather" (Informant Omang).*

> *"Sometimes we talk via WhatsApp, but we meet more often in the fields. During the dry season, I watch the news and rely on natural instincts, but I also often get information from extension workers" (Informant Agus).*

From these statements, the farmer communication ecosystem in Sukadamai is hybrid, strong in face-to-face and TV settings, and slowly growing online through WhatsApp. The flow of practice is relatively consistent. Initial information from TV or extension workers is quickly discussed in the field, followed by micro-decisions such as changing sowing schedules, transplanting seedlings, delaying planting, and strengthening social support during times of risk. In certain situations, such as sudden rain when some farmers are away from the exact location, WhatsApp is a supporting channel for disseminating brief news or field photos from members with mobile phones.

However, its role remains less dominant than established and trusted face-to-face chat. Therefore, the most realistic strategy for strengthening communication resilience is not to replace existing offline mechanisms, but rather to expand their reach by maintaining daily face-to-face forums as centers for verification and small-scale deliberation, while incubating the use of WhatsApp within the core group that already has devices to expedite warnings and coordination, especially when the weather changes rapidly and decisions must be made within hours.

3.2 Climate Information

The climate information architecture in Sukadamai is multi-level and highly contextual. TV serves as a quick reference and for daily weather orientation. BMKG (Meteorology, Climatology, and Geophysics Agency) access is partial for some farmers with mobile devices, intuition from natural signs is used to weigh micro-decisions in the field, and reference figures, such as extension workers, serve as filters of meaning and reinforcers of trust. These flows do not operate in isolation but are linked by face-to-face meetings at daily meeting points. There, broadcast or digital information is confirmed against micro-conditions such as afternoon wind humidity, flooding history, and seed readiness, then translated into practical decisions.

Thus, the system's strength lies not in the sophistication of the medium, but in the rhythm of repetitive conversations inherent in fieldwork. The digital WhatsApp channel occasionally expedites brief updates when devices are available. From the perspective of farmers with mobile devices, informants Udin and Omang described the hybridity of channels and the dominance of field discussions. For farmers without mobile phones, informant Opik emphasized the combination of TV and offline conversations as the backbone of information flow.

> *"We communicate by phone, but we meet more often in person in the fields to chat about the weather every day. I have a cell phone, and sometimes I check the BMKG (Meteorology, Climatology, and Geophysics Agency) or watch the news, but for rapidly changing weather, I usually watch TV first and then briefly discuss it with my friends to make quick decisions" (Informant Udin).*

> *"I don't have a cell phone, so I usually get weather information from TV, and we also talk more directly in the fields. If the sky is heavy and the wind changes, we delay sowing or move the seedlings to a safer time" (Informant Omang).*

> *"I don't have a cell phone; we rely on daily meetings; we rarely have large regular gatherings, and TV is our main source of weather. Almost every day, we have a short chat about the weather during breaks, and we also share tasks if we need to close water channels or speed up the harvest" (Informant Opik).*

This statement demonstrates that even without a formal agenda, communities are building informal early warning systems based on frequent communication habits enough to coordinate small but impactful actions. On the other hand, Agus demonstrates the transition to digital channels as a complement and the importance of information authority from extension workers.

"Sometimes I talk via WhatsApp, but I meet more often in the fields. During the dry season, I watch the news and sometimes rely on my natural instincts. To be sure, I also often get information from extension workers or local figures before deciding to delay planting or change my watering pattern" (Informant Agus).

Thus, the statements from these four quotes demonstrate a hybrid and multi-tiered climate information ecosystem. The flow of information begins with TV as a daily orientation trigger, which is easily accessible and cost-free, supplemented by partial access to the BMKG (Meteorology, Climatology, and Geophysics Agency) for mobile-device farmers. It is then translated and verified through brief face-to-face discussions to adapt to the micro-land context. In certain situations, WhatsApp is a complementary channel for delivering quick updates, brief reminders, or forwarding information to extension workers when members are not in the exact location. However, its role remains subordinate to established and trusted offline conversations. Above all, intuition from natural signs serves as a practical compass to bridge information gaps, while local extension workers act as filters of meaning and sources of decision legitimacy. This chain forms an informal early warning system: TV-BMKG-intuition signals, offline verification, micro-decisions, field actions, and feedback to the network.

3.3 Adaptation Strategies

Farmers' adaptation strategies in Sukadamai are generally driven by three main constraints: limited irrigation water, the cost of fertilizer inputs, seeds, and tools, and weather uncertainty. Therefore, adaptation options are low-tech, inexpensive, and culturally familiar. Four prominent strategies support each other as a unified adaptation portfolio: (1) intercropping to spread biological and price risks; (2) alternating commodities according to the season (dry vs. wet) and water availability; (3) manual watering as an emergency solution during dry periods when irrigation networks are unavailable; and (4) water conservation through simple storage, plot prioritization, and accelerated harvesting when risks increase.

This portfolio is not linear, but instead flexibly adapts to daily signals from TV news, sky observations, and extension workers, which are verified through brief conversations in the fields. In intercropping, farmers combine fast-growing crops like vegetables with more drought-tolerant crops like tubers and bananas to spread the risk of pests and weather, while maintaining cash flow. This practice is linked to organic inputs of homemade compost, manual tools such as hoes and hoses, and a work rhythm that allows rapid adjustments in small plots.

The commodity substitution was carried out with simple yet effective logic. Bananas and tubers were planted during the dry season because they were more water-tolerant. Cucumbers and vegetables were planted during the rainy season because they tolerated humidity. Manual watering by carrying water from the storage house was difficult, but it was the backbone when there was no piped water system. This was usually accompanied by prioritizing watering for high-value plot seedlings and accelerating harvesting to avoid damage. Above all, water savings were managed through reorganizing the work schedule for back-planting seedlings, changing schedules, collecting rainwater in mini reservoirs, and taking turns watering among members. As an illustration of the intercropping strategy and the logic of saving capital and spreading risk, the following informant's statement describes the practice.

> *"We intentionally intercrop so that if one crop is affected by pests or bad weather, the others can still help. We combine fast-growing vegetables with tubers and bananas, which are more drought-resistant. We make our own compost and water them simply with a pole or a hose attachment" (Informant Udin).*

> *"During the dry season, I plant bananas or tubers because they require less water; when it rains, I switch to cucumbers or vegetables. We keep a few seedlings so we can quickly replace them if the weather changes" (Informant Agus).*

> *"There's no irrigation yet, so if the water is far away, we carry it from the house or reservoir; sometimes we use a hose attachment. If the land is below the water source, lifting it is difficult, so we prioritize important plots, such as seedlings or valuable crops" (Informant Omang).*

> *"Water is key. Now we conserve water by collecting rainwater, taking turns watering, and sometimes we accelerate the harvest if the risk increases. In the future, we need piping, even if it's simple, so we don't carry it far and water it more regularly" (Informant Opik).*

The statements of these four informants imply that water is the primary lever shaping the entire adaptation portfolio, from intercropping choices and commodity rotation decisions to manual irrigation and water conservation practices. In other words, these seemingly diverse strategies are actually structured on a water-first logic: water availability determines what to plant (bananas/tubers during dry periods; cucumbers and vegetables during wet periods), how to care for them (manual watering with a hoe or hose, rainwater harvesting, alternating watering), and when to execute decisions (delaying sowing, changing the schedule, accelerating harvest). Intercropping diffuses the biological and price risks while maintaining cash flow when pests or weather anomalies disrupt one commodity. At the same time, input and labor costs encourage culturally familiar, low-tech options (compost, hoes, simple reservoirs) because they are proven to be fast, inexpensive, and compatible with the scale of smallholder farming in Sukadamai.

This portfolio is not linear but flexible and iterative, following the daily signals farmers perceive: TV and BMKG information, observations, and news from extension workers. These signals are then socially verified to adjust for micro-land conditions such as ditch depth, soil moisture, and plot position relative to water sources. From this rapid verification, micro-decisions emerge: delaying sowing, transplanting seedlings, replacing crops, concentrating water on high-value plots, or accelerating harvesting to prevent further damage. The cycle is simple yet effective: signal detection, flash deliberation, water allocation, action, and feedback. Feedback then enriches collective practical knowledge, such as the most drought-tolerant intercropping pairs or the threshold of safe rain-free days for replanting, allowing for more precise subsequent decisions without incurring significant costs.

From a governance perspective, practices such as rotating watering, prioritizing valuable commodity seed plots, and home- and garden-scale rainwater harvesting create internal equity mechanisms to maximize the impact of limited water and energy. However, the hope for simple piped irrigation remains strong, seen as a leap in efficiency, reducing the burden on farmers, stabilizing irrigation schedules, and opening up other technical options, such as gravity drip irrigation. This transition is realistic if undertaken in stages, starting with short-distance pilots of core plot water sources, accompanied by water-saving protocols, organic mulch to suppress evaporation, raised beds for rain runoff, and a threshold for accelerated harvesting when risk increases.

Within this framework, WhatsApp, if available, can be a reminder for shift schedules, broadcast full or nearly empty reservoir conditions, or provide quick notifications when the weather suddenly changes. It remains a complement, not a substitute for offline deliberations. Thus, the adaptation strategy in Sukadamai is not simply a collection of tips, but rather a water-based collective learning system that continually calibrates itself to climate signals, working capacity, and market opportunities, realizing practical, equitable, and scalable resilience as simple infrastructure like piping expands.

3.4 Main Obstacles

In addition to the adaptation strategies already implemented, farmers in Sukadamai Village face four main interrelated obstacles that form a bottleneck in farming decisions: (a) limited irrigation water, (b) input costs for fertilizer, seeds, and tools, (c) work capacity eroded by age and energy, and (d) uncertainty about crop prices. Water constraints become the root cause when supplies are minimal, time and energy are wasted on watering, other work is delayed, and costs increase. If, at the same time, market prices fall, the risk of loss is even greater. As an introduction to field experience, informant Omang states that lacking a water network forces exhausting but unavoidable choices.

> *"There's no irrigation system yet, so if the water is far away, we carry it from the house or reservoir; sometimes we use a hose. If the land is below the water source, lifting it is difficult, so we choose important plots first, like seedlings or valuable crops" (Informant Omang).*

This statement emphasizes that irrigation determines what is watered, when it is done, and how much effort is expended. On the cost side, rising prices for fertilizer, seeds, and the need for hoses and drums force smart savings such as increasing compost, phased purchases, or pooling equipment. Work capacity, especially among aging farmers, encourages prioritization and cooperation. Finally, price fluctuations mean a successful harvest plus a reasonable price, so phased harvesting, quality sorting, or commodity rotation are key to maintaining margins.

On the other hand, cost constraints arise in layers: rising fertilizer and seed prices, additional equipment such as hoses and drums, and the opportunity cost of manual watering, delaying other tasks. Under these conditions, farmers are forced to make daily decisions full of compromises: adjusting fertilizer dosages, postponing equipment purchases, increasing homemade compost, and concentrating on maintenance on the most valuable plots to maintain cash flow. As an introduction to field experience, here is an explanation from informant Opik regarding the logic of water costs faced by farmers every day.

> *"Water is key. Now we conserve water by collecting rainwater, rotating irrigation, and sometimes speeding up harvests if the risk increases. But fertilizer and seeds are also expensive; we often reduce the dosage, use homemade compost, or postpone purchasing equipment" (Informant Opik).*

This statement emphasizes that water conservation strategies do not stand alone; they are always linked to water availability, capital availability, and minimum yield targets that are still acceptable. Meanwhile, farmers' work capacity is directly related to age, water load, and health conditions. These factors determine the area cultivated, the irrigation intensity, and the response speed to changing weather conditions. During the dry season, water needs increase, while energy decreases. Consequently, decisions are made to reduce the area, concentrate energy on priority plots, and rearrange work schedules. Field experience shows adjustments are made through task allocation, simple tools, and watering schedules to avoid rapid energy depletion. As Ujang Suganda explained, physical capacity influences daily strategies.

> *"My energy isn't what it used to be. If I have to carry water a long distance, I divide the work among the younger ones or reduce the area. It's better to focus on the seed plot first, then the rest will follow" (Informant Ujang Suganda).*

This statement emphasizes the prioritization logic: high-value seeds and crops are prioritized, while other plots await a safe time or additional labor support. Delegation to younger members ensures the continuity of heavy work without interrupting the planting cycle. Meanwhile, reducing the area prevents losses due to inadequate maintenance. Practical steps such as placing drums near plots, connecting gravity-fed hoses, using small carts, and constructing access routes can reduce transportation needs. In this way, limited labor is not a barrier but a catalyst for designing labor-efficient, productive work patterns despite rapidly changing weather.

On the other hand, price uncertainty shifts the definition of success from simply harvesting to harvesting plus a fair price. Prices fluctuate due to seasonality, simultaneous supply gluts, trader preferences, and transportation costs. Consequently, farmer groups adapting their planting to the weather still have to monitor daily market signals. In practice, price changes often require accelerated harvesting to secure margins, avoid land loss, and reduce the additional costs of labor, water, and prolonged pest control. Common strategies include gradual harvesting, selling some quickly and storing some for a short time if necessary, sorting by A/B/C quality to maximize value, rotating commodities when price trends deteriorate, and diversifying channels, choosing between local collectors and markets offering better prices, to de-concentrate risk. As an illustration of field experience, informant Agus emphasized the logic of decisions that link weather and markets.

> *"We've arranged our planting according to the weather, but when prices drop, it's still difficult. Once, tuber prices dropped so much that we had to harvest some crops early, store others, and switch commodities. So, farming decisions aren't just about the weather, but also market prices" (Informant Agus).*

This statement closes the decision-making cycle: weather signals determine harvest readiness, while price signals determine the timing and volume of the harvest—two variables that must be integrated to ensure that on-farm efforts yield a decent income. Thus, the ecosystem of farming decisions in Sukadamai is ultimately determined by the intersection of four main constraints, reinforcing each other and demanding a coordinated response. The basic logic is that water-first directs what is planted, how it is cared for, and when to harvest; the other three constraints magnify or diminish its impact.

3.5 Learning and Social Support

Farmers in Sukadamai learn from their daily practices and strong social support networks, while formal training occurs sporadically. On their farms and terraces, they conduct micro-briefings before work, check the weather, divide up watering tasks, assess ditch conditions, and test small-scale solutions before expanding to other plots. WhatsApp is occasionally used to remind them of schedules or share photos, but the core of learning remains face-to-face meetings and hands-on demonstrations in the field. When formal training arrives, the dense material needs to be further condensed, demonstrated in the field, and followed up on once or twice to truly embed it into their work habits. The following paragraphs present informants' voices to illustrate this learning pattern, from the discipline of daily coordination, replication of low-cost practices, emotional and action support during crop failures, to the need for post-training mentoring.

As an introduction to the farmers' daily experiences, informant Udin emphasized the importance of a unified rhythm and rapid learning in the field, starting with checking weather conditions, dividing field tasks, who will water, who will monitor for pests, and who will open ditches. Then, they test new methods on a small scale before scaling them up. According to him, a brief coordination on the embankment is enough to unify direction, reduce misunderstandings, and expedite micro-decisions such as delaying sowing, moving seedlings, or speeding up the harvest when signs of risk appear.

> *"Every time we start work, we briefly check the weather, who's watering, and who's checking for pests. We don't do all that for long, just a minute. The important thing is to work together, then we get to work. If a new method emerges, we try it on a small scale first on one plot" (Informant Udin).*

According to informant Udin, after the small trial, the group conducts a quick review of what worked, maintains it, scales it up, modifies it, or discontinues what did not work, and notes important points in simple language so they can be easily remembered and shared with other members. Occasionally, WhatsApp reminds us of schedules or shares photos of trial results. However, the core of learning remains face-to-face, observing firsthand, imitating successful steps, and refining them together until they become work habits that save time, water, and are relevant to local land conditions. This practical evidence is reinforced by informant Opik, who demonstrated the effectiveness of direct observation and low-cost replication.

> *"I learned about intercropping from my neighbors. Seeing it firsthand is quicker to understand than reading thick material. I make my own compost and use whatever tools I have. Gradually, the results become visible" (Informant Opik).*

This series forms a cycle of trial-and-error, value-scale, field examples becoming a concrete curriculum, simple inputs, compost, and simple tools, cost reduction, and collaborative evaluations ensure that only practices that truly work in local water, soil, and labor conditions are expanded to other plots. As a psychosocial support aspect, Informant Omang described how the group supports each other when crops fail or the weather worsens.

> *"If someone's planting fails, we encourage each other, sometimes joking around to ease the burden. The important thing is to have someone to give brief instructions, like, 'Transfer the seedlings early tomorrow morning, don't forget to open the ditches, and if anyone has time, please check the drainage in the block below.' It makes me feel calmer because I have something to hold on to" (Informant Omang).*

This quote demonstrates that emotional support is always accompanied by concrete technical advice, enabling feelings of anxiety to transform into a coordinated action plan quickly. Lighthearted jokes reduce stress, while brief instructions on transplanting seedlings, opening ditches, and checking drainage speed up field responses without requiring lengthy meetings. This practice also strengthens trust and group cohesion; members feel heard, know what to do, and are confident they have a partner to help when risks arise. Ultimately, this combination of mental reinforcement and practical action maintains a stable work rhythm, avoids panic decisions, and forms the foundation of social resilience that underpins daily farming decisions.

These findings demonstrate that emotional support goes hand in hand with simple, immediately executable technical advice; lighthearted jokes reduce anxiety, while brief instructions on opening ditches, transplanting seedlings, or rotating watering times transform panic into an action plan. Informant Agus explained that training from extension workers exists, but it is infrequent, the material is dense, and there is a lack of follow-up. He emphasized the need for hands-on demonstrations in the field, followed by one or two mentoring sessions, and a memorable summary of steps 1 or 2 to ensure the knowledge sticks. The training material is more quickly adopted into daily work habits with a short, routine, and contextual format. It strengthens the group's confidence to act unison during crises and weather events.

> *"Training from extension workers exists, but it's rare. They provide a lot of material once they arrive. The most memorable experience is a live demonstration in the field, lasting about 20-30 minutes. After that, it's best to have one or two sessions of mentoring to really ingrain it into habits" (Informant Agus).*

This statement suggests that the most effective learning is when it is demonstrative, concise, and repetitive: create a demonstration plot, break the material into 20-30 minute sessions, provide one to two sessions of mentoring, summarize the 1-2-3 steps memorably, assign a peer mentor, and use WhatsApp only as a reminder for schedules and brief notes. With this approach, knowledge does not stop in the classroom but becomes a habit and quickly translates into action in the field. This explanation emphasizes the need for a see-try-follow format, accompanied by one to two mentoring sessions to ensure the material does not stop in the classroom but becomes a work habit. The approach is simple: the extension worker demonstrates the steps in a small plot, the farmer tries them out with available inputs like compost and hose connections, and then the group follows with local adjustments. Afterward, a simple 1-2-3 summary is created, and a reschedule is scheduled to review the results and correct any deficiencies. In this way, sporadic formal training transforms into a short, practical, iterative learning cycle that leads directly to action. To illustrate the cross-generational dimension, here is a role-sharing experience that connects young people with the wisdom of their elders. Informant Ujang Suganda describes how decades of experience meet the energy and speed of young people in the field.

> *"Young people help with the labor. I share my experience on how to observe clouds, wind direction, and*

> *when to transplant seedlings. I focus on monitoring the seedlings and explaining the steps, while they carry water or dig ditches. So we complement each other" (Informant Ujang Suganda).*

This practice ensures knowledge transfer co-occurs with the division of labor, strengthening a sense of community and accelerating the adoption of techniques truly suited to the conditions of the Sukadamai land. Women's involvement in practical learning is also evident. Mirta emphasized the need for simple language and direct examples. To explain women's involvement in practical learning, many crucial tasks, from seeding, light watering, sorting, and simple record-keeping, are handled by women. Therefore, the learning format requires simple language, 1-2-3 steps, and direct examples in the field at times that align with the farmhouse's rhythm, such as after harvest or during the lunch break. Mirta's informant emphasized the importance of concise, demonstrative materials and proximity to readily available tools.

> *"When we have sessions with the ladies, we write down the steps using simple language: 1, 2, 3. It's more convenient if there are examples in the field using the tools we have. WhatsApp is useful for updating schedules or sending photos, but the most effective way is still meeting and practicing together" (Informant Mirta).*

This statement confirms that training for women is most effective when short and regular, based on small-plot demonstrations and visual summaries of simple checklist diagrams and brief mentoring afterward. WhatsApp is used as a reminder, while face-to-face meetings ensure rapid feedback, trust, and adoption of steps that genuinely suit the conditions of the women farmers' equipment, time, and daily workload. Regarding information curation, informant Adang emphasized the importance of joint verification to understand and adapt knowledge to the micro-land context of soil type, water availability, slope, and local pest habits. Adang described a process that begins with reading information via TV, WhatsApp, BMKG (Meteorology, Climatology, and Geophysics Agency), and extension workers, then testing it on a small plot before widespread use.

> *"Sometimes we get information sent online. We read it, but we still check it in the field to see if it's compatible with the soil and water here. If it's not quite right, we modify it together. Usually, we consult the BMKG (Meteorology, Climatology, and Geophysics Agency) or an extension worker first, then try it on a small plot. If it works, we summarize the steps 1-2-3 so it's easier to remember" (Informant Adang).*

This pattern forms a two-step protocol: official sources and field witnesses transforming raw information into usable knowledge. Adang's informant's statement demonstrates knowledge governance based on field testing, not simply copying raw external information. Information is filtered, tested on a small scale, evaluated collectively, and modified to suit the available water, land, and workforce. This process employs a two-source protocol: official sources and field witnesses. The role of the reference figure is to summarize, not monopolize; other members' voices are still heard through brief feedback. With this mechanism, the risk of hoaxes is reduced, inappropriate practices are quickly discontinued, and knowledge is transformed into usable knowledge that is inclusive, cost-effective, and ready to be replicated in other plots. In emergency weather situations when sudden heavy rain, rapidly rising ditch water, or strong winds threaten the learning beds, solidarity in Sukadamai merges into swift action. It usually begins with an informal alarm bell from the neighboring plot or a brief message, followed by a 30–60-second micro-briefing to assign roles: someone clears the ditch and clears the blockage, someone rescues the seedlings and secures the beds, someone diverts the water flow, and someone notifies the extension workers who are far away via WhatsApp. Sahim, the informant, described this pattern as collaborative work, providing a platform for rapid learning in the field.

> *"When it rains heavily and the water rises, we immediately divide the tasks. One team digs ditches and removes blockages, while the other rescues seedlings and strengthens beds that are prone to being washed away. While we work, we remind each other to make the ditches slightly slanted and deeper tomorrow. Those who are far away, we notify them via WhatsApp, while those who are close by immediately intervene. It feels like family" (Informant Sahim).*

This description demonstrates learning-by-doing combined with emotional support, allowing for immediate feedback and minimizing losses, while technical lessons are quickly summarized for steps 1-2-3 in subsequent sessions. However, training time constraints are also evident. Farmers' work hours are busy, with mornings focused on watering and maintenance, short breaks in the afternoon, and evening land closing, making long classes easily clash with work schedules. In response, informant Ace proposed a format that follows farmers' daily routines: short, frequent, and hands-on.

> *"It's difficult to participate in long training sessions; the time overlaps with work. It's better to create a series of short sessions, 20-30 minutes after harvest or during breaks. Small, but frequent sessions with examples in small plots, and then we repeat them the following week" (Informant Ace).*

This proposal implies a micro-training design based on seeing, trying, and following, with 20–30 minute sessions during breaks, demonstrations in small plots, followed by mentoring. With a short, routine, demonstrative pattern, the material does not stop in class, does not disrupt work, and more quickly becomes a habit in the field. To ensure the material is easy to follow and understand, informant Rusdi A.S. highlighted the importance of simplifying and curating the core topics, summarizing them into 1–2–3 steps in everyday language. These are then reread during micro-briefings and posted as group notes or pinned on WhatsApp. He believes that a short, mutually agreed-upon summary is more effective than lengthy, difficult-to-remember material, especially when directly linked to daily tasks such as who waters, checks for pests, clears ditches, and real-life examples in the demonstration plots.

> *"To make it easier to follow, I've condensed the key points into three sentences. I'm not always right we'll discuss it. The important thing is that everyone understands and can implement it. We'll read it again tomorrow when we start work. If there are any changes, we'll revise them together" (Informant Rusdi A.S.).*

This approach creates a vibrant knowledge governance: concise, open to input, and constantly tested and revised in the field, so every member, including those new to the field, has the same practical understanding, and group decisions can be executed quickly, uniformly, and on target. Overall, learning and social support in Sukadamai Village operate as a simple but effective collective engine. It focuses on daily 1-2 minute micro-briefings to align direction, divide tasks, establish small trials, peer-to-peer learning through direct examples in the plots, and concise knowledge curation using 1-2-3 steps recited at the start of each workday. Digital channels like WhatsApp serve as reminders and photo sharing, but face-to-face interaction remains the center of verification and decision-making. The cross-generational dimension of young people, supported by the experience of seniors and the involvement of women, makes knowledge easier to apply. At the same time, reference figures serve to summarize, not monopolize, ensuring inclusive decisions. In weather emergencies, solidarity quickly transforms into rapid action, digging ditches, saving seedlings, and the results are immediately summarized for subsequent improvements.

4. Discussion

This study found that the Sukadamai farmers' communication ecosystem is hybrid. Face-to-face communication through chats on the embankment, verandas, and television for weather forecasts remains the primary channel for daily verification and orientation. At the same time, WhatsApp serves as a complementary channel, accelerating the dissemination of short-term information (photos of land conditions, voice messages, watering schedule reminders, and emergency notifications). Farmers' micro-decisions, including delaying planting, changing commodities, watering schedules, and accelerating harvests, emerge from this mix of information: mass information, field verification, collective decisions, and actions based on a water-first logic, with a focus on water availability as the primary driver of adaptation strategies. WhatsApp accelerates communication when decisions must be made within hours, for example, when receiving a sudden rain warning or photos of flooding in a particular block. However, WhatsApp's effectiveness highly depends on device access and digital literacy. TV and field chats remain the primary reference sources for farmers without mobile phones. In other words, WhatsApp increases reach and speed but cannot replace the social verification function of face-to-face interactions.

The findings also indicate that information from TV, the BMKG, or WhatsApp messages is only adopted after undergoing a rapid verification process in the field a 1–2-minute micro-briefing on embankments or a small pilot test in one area. Plot. This verification process transforms information into practical, actionable decisions, e.g., delaying seedlings, speeding up harvesting. This mechanism explains why the media, which embodies the trust of extension workers and field witnesses, plays a greater role than simply the technical accuracy of the information. Collective resilience emerges from the availability of information and social capital: cooperation, intergenerational division of labor, and emotional support during crop failures. Communication networks (including WhatsApp) facilitate the rapid mobilization of human resources, e.g., assigning shifts for watering or emergency ditch opening, thus minimizing material losses due to climate risks.

Table 2 above summarizes how face-to-face interactions, television, WhatsApp, local intuition, and the role of extension workers complement each other in forming a hybrid communication ecosystem that supports farmer resilience. The table shows that each communication medium has a specific and complementary role. Face-to-face communication remains the center of verification, television serves as initial orientation, WhatsApp accelerates coordination, local intuition provides contextual sensitivity, and extension workers provide technical legitimacy. This combination forms a communication mechanism that flows information, strengthens social solidarity, and accelerates the emergence of micro-farmer decisions relevant to field conditions.

Table 2. Synthesis of hybrid communication of Sukadamai Village farmers

Communication Medium	Main Function	Practical Example	Strength	Weaknesses / Limitations	Impact
Face to Face (chat in the field/terrace)	Micro condition verification; rapid deliberation; direct learning	1–2 minute micro briefing before work; trial run on one plot; task distribution	High legitimacy; allows for contextual customization; inclusive for those without devices	Limited in space/time; slow if members are separated	Determine the final decision (remove seedlings, watering priority)
Television (news/forecast)	Daily weather orientation, general information source	Watch the forecast; be a discussion starter	Easy to access; free for TV owners	Lack of local detail; not personal	Provides early signals for changes in planting schedules
WhatsApp (WAG)	Quick coordination; emergency notification; photo/voice note sharing; schedule reminders	Send photos of the land, reminders for watering turns, coordinate cooperation, and pin messages.	Fast, multimedia, enables remote coordination	Limited access; risk of overload/hoaxes; weak group administration	Speed up emergency response; remind schedules; expand information reach
Local Institutions and Natural Signs	Practical micro indicators (clouds, humidity)	Observing clouds, afternoon humidity, and the history of flooding	Very locally relevant; immediately usable	Subjective; needs experience	Be a comparison before the decision
Extension Worker & Reference Figure	Meaning filter; information legitimacy; technical assistance	Confirmation of BMKG information; assistance with demonstrations in the field	Increase trust; simplify technical info	Limited frequency of visits	Speed up adoption if accompanied by fever and assistance

Source: Research results (2025)

Furthermore, understanding the hybrid communication ecosystem of farmers in Sukadamai Village not only displays the relationships between communication media but also shows how information flows, is verified, and ultimately influences decision-making at the micro-level. Figure 2 below illustrates the role of face-to-face communication, television, and WhatsApp as complementary communication channels, each with a specific function but working synergistically to shape adaptation mechanisms. This chart shows that face-to-face communication remains the center of social verification, television provides broader weather orientation, and WhatsApp expedites the delivery of urgent news. Thus, this visualization reinforces the understanding that farmer resilience is not simply the result of technical interactions with the land, but rather the product of a dynamic, collaborative, and contextualized communication network tailored to local needs.

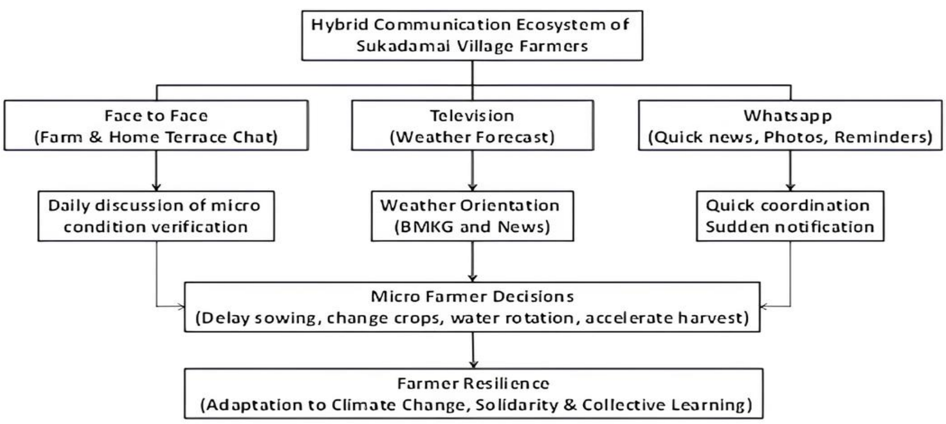

Figure 2. Hybrid communication ecosystem of Sukadamai Village farmers

The Sukadamai farmers' hybrid communication ecosystem diagram clearly illustrates that adapting to climate change is significantly influenced by the quality of communication networks established at the local level. Micro-decisions made by farmers, from delaying sowing, changing crops, managing water cycles, to accelerating harvests, are not the result of a single source of information, but rather the accumulation of interactions between various complementary communication media. Face-to-face communication is the primary platform for testing and verifying information, television contributes to broader weather orientation, and WhatsApp accelerates the distribution of urgent news. This combination demonstrates farmer resilience from the synergy between modern communication technology and deeply rooted traditional practices. Therefore, this diagram emphasizes that communication strategies to support farmer resilience must consider integrating both aspects to ensure more effective, inclusive, and sustainable climate adaptation.

5. Conclusion

This study concludes that resilience in climate-vulnerable rural areas is not merely a result of technological adoption but of how multiple media face-to-face, television, and WhatsApp are interwoven within a single hybrid communication ecosystem. Farmers' adaptive capacity emerges through a continuous signal verification action cycle, where TV broadcasts initiate awareness, interpersonal encounters verify meaning, and WhatsApp messages coordinate collective responses. These interactions are structured by communication norms such as trust, reciprocity, and informal leadership, reflecting how organizational communication practices sustain local participation and reduce asymmetry of access. Conceptually, the study contributes to media ecology theory by explaining how traditional and digital channels co-evolve to maintain informational continuity under environmental uncertainty. It also advances environmental and small group communication research by specifying how everyday talk and lightweight digital exchanges build social verification mechanisms for decision-making. Practically, strengthening offline deliberation spaces and embedding targeted WhatsApp coordination within farmer groups can enhance climate information services without eroding local communication cultures. Thus, hybrid communication ecologies represent a sustainable model for integrating media, trust, and adaptation at the community level.

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Authors contributions

VUS contributed to the conceptualization and writing of the article, VS contributed to determining the methodology and validation. CH did the original draft. SARU managed and collected the research data. All authors read and approved the final manuscript.

Competing interests

All authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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No additional data are available.

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