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Understanding Farmers' Multi-channel Communication Preference in West Bengal Using Association Rule Mining

Soumyadeep Thakur[1] and Debabrata Basu[2]

[1]Dept. of Agricultural Extension, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, West Bengal (721 436), India
[2]Dept. of Agricultural Extension, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal (741 252), India

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Corresponding soumyadeepthakur519@gmail.com

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ABSTRACT

The present study was conducted during October, 2025 at Bandh Nabagram village, Sriniketan block, Birbhum district, West Bengal, India to investigate communication behaviours of fifty farmers using Association Rule Mining (ARM). ARM is a data mining technique to identify probabilistic relationships among channels such as Krishak Bandhu, social media, Television, Radio, Agricultural Officers/KVK, and Local Input Dealers. Field-level agricultural communication was inherently complex, as farmers rely on multiple channels whose usage patterns and interdependencies vary across individuals. Each farmer's channel usage was encoded as a transaction, allowing ARM to generate association rules, with strength and relevance quantified through support, confidence, lift, leverage, and conviction. The analysis revealed sixty-two combinations of communication channel usage among respondent farmers. Support values ranged from 0.46 to 0.54, indicating frequent co-usage of certain channels. Confidence values spanned 0.46 to 1, highlighting deterministic and complementary pairings. Lift (1–2.17) and leverage (0–0.248) identified synergistic combinations exceeding random expectations, while conviction (1–∞) highlighted highly reliable predictive relationships. Notably, combinations such as Radio with Agricultural Officers/KVK and social media with Krishak Bandhu demonstrated perfect predictability, emphasizing their importance in extension design. The findings underscored farmers' multi-channel information-seeking behaviour and indicated that integrated digital and interpersonal strategies optimized knowledge dissemination. Policymakers and extension agencies prioritized impactful channel combinations, enhanced adoption of innovative practices, and designed context-specific interventions in rural West Bengal. Future research was suggested to examine temporal dynamics, larger populations, and emerging digital tools.

KEYWORDS: Association rule mining, communication, channels, probabilistic relationships

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1. INTRODUCTION

Field-level agricultural communication operates within a highly complex and pluralistic environment in which multiple information channels coexist and farmers' preferences vary widely across socio-economic and contextual settings (Madhushekar et al., 2024, Mtega, 2021). Farmers seldom depend on a single source of information; instead, they navigate a mosaic of formal, informal, interpersonal, mass media and digital channels to access agricultural knowledge (Mtega, 2021; Bhaskara and Bawa, 2021; Colussi et al., 2024). Consequently, understanding communication behaviour requires more than identifying channels in isolation. It necessitates examining how channels co-occur, interact and reinforce one another within farmers' information networks, including farmer-to-farmer exchanges and social media mediated interactions (Begho and Ogisi, 2025; Colussi et al., 2024). Ignoring these interdependencies risks extension strategies remaining fragmented and misaligned with farmers' actual information-seeking practices (Mtega, 2021; Wang et al., 2023).

Effective dissemination of agricultural information is critical for enhancing farmers' knowledge, strengthening decision-making and accelerating the adoption of improved technologies and practices (Goeb et al., 2025; Giulivi et al., 2022; Wang et al., 2023; Khatri et al., 2024, Pandey and Rai, 2024). While traditional extension systems relied primarily on interpersonal channels such as extension personnel, lead farmers and input dealers (Suleiman et al., 2021; Abukari et al., 2021; Begho and Ogisi, 2025; Wang et al., 2023), contemporary rural communication landscapes now integrate radio, television, mobile phones, interactive voice response, smartphone applications, videos, SMS and web-based platforms (Verma et al., 2024; Khatri et al., 2024). Evidence consistently showed that these channels operate in complementary and interdependent ways, shaping how information is accessed, trusted and acted upon (Mtega, 2021; Goeb et al., 2025; Giulivi et al., 2022; Begho and Ogisi, 2025). Understanding these interactions is therefore essential for designing efficient, context-specific extension strategies that integrate interpersonal, community-based and ICT-enabled approaches (Giulivi et al., 2022; Begho and Ogisi, 2025; Wang et al., 2023; Khatri et al., 2024).

Despite this complexity, much of the existing literature continues to emphasize frequency-based identification of communication channels using descriptive statistics (Mtega, 2021; Abukari et al., 2021; Antwi-Agyei and Stringer, 2021). Such approaches inadequately capture probabilistic relationships, complementarities and cross-channel influences (Isaac et al., 2025; Colussi et al., 2024). Emerging evidence on interdependencies between community-based, interpersonal and mass media channels underscores the need for network- and pattern-oriented analyses, particularly in rapidly evolving institutional and digital contexts and during crises such as pest outbreaks or climate shocks (Abukari et al., 2021; Goeb et al., 2025).

To address this gap, the present study employed Association Rule Mining (ARM), a data mining technique used to uncover meaningful relationships within complex agricultural datasets (Fister et al., 2022; Bhatia and Gupta, 2021; Tasnim et al., 2025). ARM identifies relationships between antecedent channel use and consequent channel adoption, quantified through metrics such as support, confidence, lift, leverage and conviction (Fister et al., 2022; Fister et al., 2025; Agago et al., 2025; Bhatia and Gupta, 2021; Tasnim et al., 2025; Isaac et al., 2025; Colussi et al., 2024). Applied to data from fifty farmers in Bandh Nabagram village, West Bengal, the analysis focused on state-run advisory services, social media, mass media, public extension and local input dealers, reflecting widely observed multi-channel use patterns (Mtega, 2021; Antwi-Agyei and Stringer, 2021). The findings offer actionable insights into high-yield channel combinations and information pathways, contributing to more effective, network-aware agricultural extension strategies in increasingly interconnected rural environments (Wang et al., 2023; Khatri et al., 2024; Bhaskara and Bawa, 2021). The objective of the research to find communication behaviours of fifty farmers using Association Rule Mining demonstrating probabilistic relationships among different channels.

2. MATERIALS AND METHODS

The present study was conducted during October, 2025 at Bandh Nabagram village, Sriniketan block, Birbhum district, West (Kigatiira and Mberia, 2018). Each farmer's usage of communication channels, including Television (TV), Radio, social media, Krishak Bandhu, Agricultural Officers/Krishi Vigyan Kendra (KVK) SMS, and Local Input Dealers, was recorded using a structured interview schedule (Lamptey and Donkoh, 2024). Responses were encoded allowing each farmer's communication behaviour to be represented as a transaction Ti, which is a subset of the universal set of communication channels I. The full dataset, consisting of all fifty farmers, was represented as the set of transactions $T= \{T_1, T_2, \ldots, T_{50}\}$.

The study employed Association Rule Mining (ARM), a robust data mining technique grounded in set theory, probability, and combinatorial analysis, to identify meaningful relationships among communication channels (Malamsha and Nyambo, 2023). ARM generated rules of the form $A \Rightarrow B$, where A represented the antecedent set, B represented the consequent set, and $A \cap B = \emptyset$. The strength and relevance of the rules were quantified using standard metrics. Support measured the proportion of transactions containing both antecedent and consequent, confidence quantified the conditional probability of the consequent given the antecedent, lift measured the strength of association beyond random chance, leverage captured deviation from independence, and conviction measured the degree of implication between antecedent and consequent (Belkadi and Drias, 2023).

To comprehensively explore patterns of information co-usage, the study considered both single-channel antecedents and combinatorial antecedents of up to three channels ($|A|\leq3$), generating complex multivariate association rules (Suleiman and Ikani, 2021). Minimum thresholds for supported and confidence were set empirically to filter out statistically weak rules, producing a robust set of association rules (Malamsha and Nyambo, 2023). The Apriori algorithm was used to identify frequent item sets, a foundational algorithm widely used in agricultural and social science data analytics (Ginting et al., 2019).

The analysis was implemented in Python 3.11, using pandas for data handling, mlxtend.frequent_patterns for frequent itemset generation via the Apriori algorithm, mlxtend.frequent_patterns.association_rules for computation of confidence, lift, leverage, and conviction, and matplotlib and seaborn for visualization of co-occurrence patterns and rule strengths (Han et al., 2011). This mathematically rigorous approach enabled a comprehensive understanding of information flow among farmers, highlighting interdependencies among communication channels and providing actionable insights for agricultural extension design, policy-making, and targeted knowledge dissemination in rural West Bengal (Iqbal et al., 2023).

3. RESULTS AND DISCUSSION

The association rule mining results provided a comprehensive understanding of how farmers adopted and combined different communication channels. The analysis revealed sixty-two combinations of adopted commination channels showcased in table 1.

Table 1: Association rules of farmers' communication channel usage

Sl. No.	Antecedents	Consequents	Support	Confidence	Lift	Leverage	Conviction
1.	Krishak bandhu	Social media	0.54	0.54	1	0	1
2.	Social media	Krishak bandhu	0.54	1	1	0	∞
3.	TV	Social media	0.5	1	1.851852	0.23	∞
4.	Social media	TV	0.5	0.925926	1.851852	0.23	6.75
5.	Radio	Krishak bandhu	0.46	1	1	0	∞
6.	Krishak bandhu	Radio	0.46	0.46	1	0	1
7.	Ag. officers/ KVK	Radio	0.46	1	2.173913	0.2484	∞
8.	Radio	Ag. officers/ KVK	0.46	1	2.173913	0.2484	∞
9.	Local input dealer	Radio	0.46	1	2.173913	0.2484	∞
10.	Radio	Local input dealer	0.46	1	2.173913	0.2484	∞
11.	Ag. officers/ KVK	Krishak bandhu	0.46	1	1	0	∞
12.	Krishak bandhu	Ag. officers/KVK	0.46	0.46	1	0	1
13.	TV	Krishak bandhu	0.5	1	1	0	∞
14.	Krishak bandhu	TV	0.5	0.5	1	0	1
15.	Local input dealer	Krishak bandhu	0.46	1	1	0	∞
16.	Krishak bandhu	Local input dealer	0.46	0.46	1	0	1
17.	Local input dealer	Ag. officers/ KVK	0.46	1	2.173913	0.2484	∞
18.	Ag. officers/ KVK	Local input dealer	0.46	1	2.173913	0.2484	∞
19.	TV, Krishak bandhu	Social media	0.5	1	1.851852	0.23	∞
20.	TV, Social media	Krishak bandhu	0.5	1	1	0	∞
21.	Krishak bandhu, Social media	TV	0.5	0.925926	1.851852	0.23	6.75

Sl. No.	Antecedents	Consequents	Support	Confidence	Lift	Leverage	Conviction
22.	TV	Krishak bandhu, Social media	0.5	1	1.851852	0.23	∞
23.	Krishak bandhu	TV, Social media	0.5	0.5	1	0	1
24.	Social media	TV, Krishak bandhu	0.5	0.925926	1.851852	0.23	6.75
25.	Ag. officers/ KVK, Radio	Krishak Bandhu	0.46	1	1	0	∞
26.	Ag. officers/ KVK, Krishak bandhu	Radio	0.46	1	2.173913	0.2484	∞
27.	Radio, Krishak bandhu	Ag. officers/KVK	0.46	1	2.173913	0.2484	∞
28.	Ag. officers/ KVK	Radio, Krishak bandhu	0.46	1	2.173913	0.2484	∞
29.	Radio	Ag. Officers/KVK, Krishak bandhu	0.46	1	2.173913	0.2484	∞
30.	Krishak bandhu	Ag. officers/KVK, Radio	0.46	0.46	1	0	1
31.	Local input dealer, Radio	Krishak bandhu	0.46	1	1	0	∞
32.	Local input dealer, Krishak bandhu	Radio	0.46	1	2.173913	0.2484	∞
33.	Radio, Krishak bandhu	Local input dealer	0.46	1	2.173913	0.2484	∞
34.	Local input dealer	Radio, Krishak bandhu	0.46	1	2.173913	0.2484	∞
35.	Radio	Local input dealer, Krishak bandhu	0.46	1	2.173913	0.2484	∞
36.	Krishak bandhu	Local input dealer, Radio	0.46	0.46	1	0	1
37.	Local input dealer, Ag. officers/ KVK	Radio	0.46	1	2.173913	0.2484	∞
38.	Local input dealer, Radio	Ag. officers/ KVK	0.46	1	2.173913	0.2484	∞
39.	Ag. officers/ KVK, Radio	Local Input Dealer	0.46	1	2.173913	0.2484	∞
40.	Local input dealer	Ag. officers/KVK, Radio	0.46	1	2.173913	0.2484	∞
41.	Ag. officers/ KVK	Local input dealer, Radio	0.46	1	2.173913	0.2484	∞
42.	Radio	Local input dealer, Ag. officers/ KVK	0.46	1	2.173913	0.2484	∞
43.	Local input dealer, Ag. officers/ KVK	Krishak bandhu	0.46	1	1	0	∞
44.	Local input dealer, Krishak bandhu	Ag. officers/ KVK	0.46	1	2.173913	0.2484	∞
45.	Ag. officers/ KVK, Krishak bandhu	Local input dealer	0.46	1	2.173913	0.2484	∞
46.	Local input dealer	Ag. officers/ KVK, Krishak bandhu	0.46	1	2.173913	0.2484	∞
47.	Ag. officers/ KVK	Local input dealer, Krishak bandhu	0.46	1	2.173913	0.2484	∞
48.	Krishak bandhu	Local input dealer, Ag. officers/ KVK	0.46	0.46	1	0	1

Table 1: Continue...

Sl. No.	Antecedents	Consequents	Support	Confidence	Lift	Leverage	Conviction
49.	Local input dealer, Ag. officers/ KVK, Radio	Krishak bandhu	0.46	1	1	0	∞
50.	Local input dealer, Ag. officers/ KVK, Krishak Bandhu	Radio	0.46	1	2.173913	0.2484	∞
51.	Local input dealer, Radio, Krishak bandhu	Ag. Officers/ KVK	0.46	1	2.173913	0.2484	∞
52.	Ag. officers/ KVK, Radio, Krishak Bandhu	Local input dealer	0.46	1	2.173913	0.2484	∞
53.	Local input dealer, Ag. Officers/ KVK	Radio, Krishak bandhu	0.46	1	2.173913	0.2484	∞
54.	Local input dealer, Radio	Ag. officers/ KVK, Krishak bandhu	0.46	1	2.173913	0.2484	∞
55.	Local input dealer, Krishak bandhu	Ag. officers/ KVK, Radio	0.46	1	2.173913	0.2484	∞
56.	Ag. officers/ KVK, Radio	Local input dealer, Krishak bandhu	0.46	1	2.173913	0.2484	∞
57.	Ag. officers/KVK, Krishak bandhu	Local input dealer, Radio	0.46	1	2.173913	0.2484	∞
58.	Radio, Krishak bandhu	Local input dealer, Ag. Officers/ KVK	0.46	1	2.173913	0.2484	∞
59.	Local input dealer	Ag. officers/ KVK, Radio, Krishak bandhu	0.46	1	2.173913	0.2484	∞
60.	Ag. officers/ KVK	Local input dealer, Radio, Krishak bandhu	0.46	1	2.173913	0.2484	∞
61.	Radio	Local input dealer, Ag. officers/ KVK, Krishak bandhu	0.46	1	2.173913	0.2484	∞
62.	Krishak bandhu	Local input dealer, Ag. officers/ KVK, Radio	0.46	0.46	1	0	1

The Support metric measured how frequently a combination of communication channels occurred among farmers. In the study, support metric values ranged from 0.46 to 0.54, indicating that nearly half of the surveyed farmers used certain channels together. For instance, Krishak Bandhu along with social media had a support of 0.54, while TV along with social media had 0.50, suggesting that these pairs were widely adopted. Similarly, combinations like Radio along with Agricultural Officers/KVK and Local Input Dealer along with Radio had support of 0.46, reflecting moderate but meaningful co-usage (Figure 1). Higher-order combinations, such as TV, Krishak Bandhu, and social media, also had support of 0.50, highlighting that farmers frequently used multiple channels simultaneously (Akbas et al., 2022). These values emphasized the prominence of face-to-face, social media, and broadcast channels in

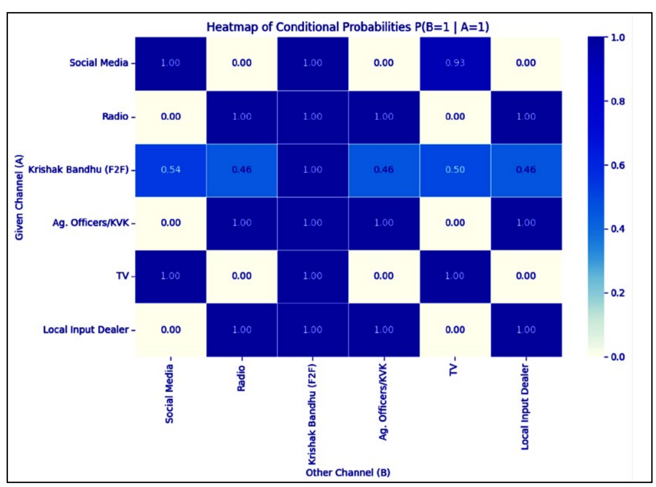

Figure 1: Likelihood of co-usage between agricultural communication channels

agricultural communication networks, consistent with previous applications of association rule mining (ARM) that identified frequently co-occurring variables in behavioural datasets (Istrat and Lalic, 2017).

Confidence reflected the likelihood that a consequent channel was used given the antecedent channel, representing predictability. In the study, confidence ranged from 0.46 to 1 (Figure 2). Deterministic rules included social media along with Krishak Bandhu, Radio along with Agricultural Officers/KVK, and Local Input Dealer along with Radio, all with confidence= 1, indicating that every farmer using the antecedent also used the consequent. Partial predictability was observed for rules like Krishak Bandhu along with social media (confidence=0.54) and Krishak Bandhu along with TV (confidence=0.50), suggesting that these channels were sometimes used independently (Azevedo and Jorge 2007). Confidence analysis highlighted which channels acted as complementary sources of information and which were consistently paired, providing actionable insight for designing multi-channel dissemination strategies, in line with similar findings on the use of confidence as a behavioural indicator in ARM (Zehtabchi et al., 2023).

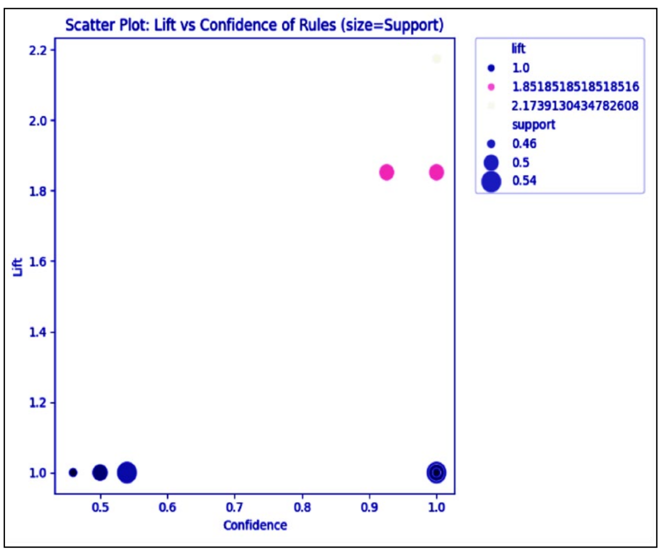

Figure 2: Scatter plot of lift vs confidence of association rules

Lift measured how much more often channels occurred together than expected by chance, with values greater than 1 indicating positive association. Lift values ranged from 1 to 2.17 (McNicholas et al., 2008). For example, Radio along with Agricultural officers/KVK and Local Input Dealer along with Radio had lift of 2.17, indicating a strong positive association, as these channels co-occurred more than twice the expected frequency (figure 1). TV along with social media had lift of 1.85, also showing a strong link, while Krishak Bandhu along with social media had lift of 1, meaning its co-occurrence matched what was expected from individual usage rates. Lift values thus distinguished channel combinations that were synergistic from those that were simply popular, helping identify the most effective pairings for information delivery, a principle emphasized in enhanced evaluation methodologies for ARM (Bao and Mao, 2021; Ganghishetti and Vadlamani, 2014).

Leverage represented the difference between the observed co-occurrence and what would be expected if channels were independent. Leverage values ranged from 0 to 0.248. Rules with high leverage included Radio along with Agricultural Officers/KVK and Local Input Dealer along with Radio (leverage=0.248), showing a substantial positive deviation from independence, indicating meaningful combined usage. Conversely, rules like Krishak Bandhu with social media had leverage of 0, suggesting their co-occurrence was entirely explained by individual usage frequencies (Azevedo and Jorge 2007). Moderate leverage values, such as TV along with social media (0.23), highlighted combinations that were slightly more informative than expected by chance, helping prioritize channel pairings with the most incremental impact on farmer outreach, reflecting ARM's utility in detecting statistically meaningful co-occurrence patterns (Figure 3) (Akbas et al., 2022).

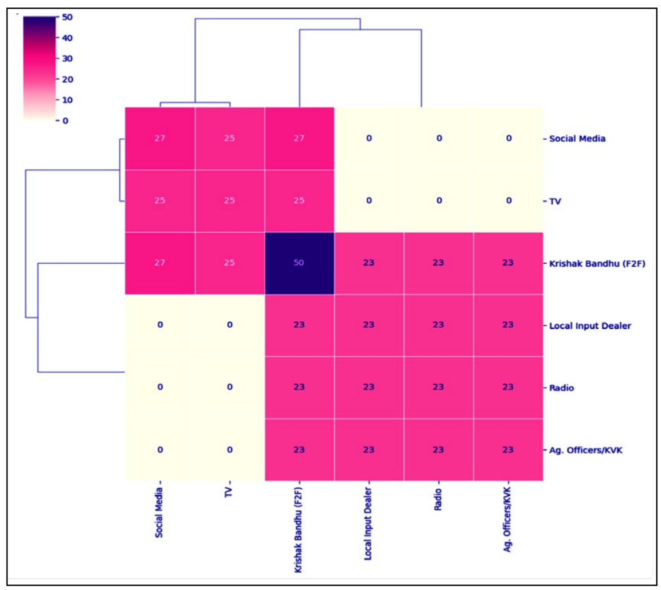

Figure 3: Clustered heatmap of channel cooccurrence

Conviction evaluated the degree of implication from antecedent to consequent, indicating predictive reliability. Conviction values ranged from 1 to infinity (∞). Rules like social media along with Krishak Bandhu and Radio along with Local Input Dealer had conviction of infinity, showing perfect predictability, as the consequent always occurred when the antecedent was present. Rules such as social media along with TV and Krishak Bandhu, social media along with TV had conviction of 6.75, indicating strong, though not perfect, predictive power. In contrast, Krishak Bandhu along with social media had conviction of 1, reflecting a neutral relationship despite moderate co-usage. Conviction thus highlighted which channel pairs or combinations were highly reliable for predicting farmers' communication behaviour, supporting targeted extension interventions, in alignment with prior studies using conviction to assess directional predictability (Bao and Mao, 2021).

4. CONCLUSION

Farmers in Bandh Nabagram village relied on digital, mass media, and interpersonal channels for agricultural information, showing distinct co-usage and interdependence. Association Rule Mining revealed frequent, predictive combinations like Krishak Bandhu with social media and Radio with Agricultural Officers/KVK. Metrics such as support, confidence, lift, leverage, and conviction underscored reliable and complementary pairings. Findings emphasized synergistic communication behaviours, suggesting integrated multi-channel extension strategies to maximize outreach, enhance adoption, and optimize resources, with future scope for broader, evolving analyses.

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