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Developing multi-dimensional societal-level strategies to mitigate farmer distress in India: insights from a fuzzy Delphi expert consensus

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Introduction: Farmer distress in India stems from a complex interaction of economic, social, environmental, legal, and psychological challenges. Addressing it requires a multidimensional, evidence-based policy response. The present study was conducted to identify and validate expert-driven strategies for mitigating farmer distress at the societal level across five domains, namely production, psychological, marketing, financial, and legal.

Methods: The study involved the Fuzzy Delphi Method, a hybrid of the Delphi technique and fuzzy set theory to systematically aggregate expert judgments and reduce ambiguity in consensus-building. A total of 61 strategies were identified using the Delphi method, spanning the five domains, which are rated on four criteria, i.e., ease of application, cost-effectiveness, relevance, and alignment with Sustainable Development Goals and national policy frameworks.

Results: After conducting fuzzy analysis, which resulted in a more robust and balanced consensus, out of 61 total strategies identified and evaluated, 47 strategies (77.0%) achieved expert consensus and were accepted based on dual criteria: threshold value ($d \leq 0.2$) and expert agreement percentage ($\geq 75\%$). The top-ranked strategies included cooperative marketing initiatives, low-cost subsidised life insurance, strengthening market intelligence, provision of community centres, access to legal aid clinics or counselling services, and soil testing and distribution of soil health cards on a regular basis. Rejected strategies highlighted the limitations of rural banking services and microfinance, administrative transparency measures, government interventions in regulated markets, and stigma-reduction campaigns.

Discussion: The validated strategies provide a coherent and multi-sectoral policy roadmap for institutional strengthening, technology deployment, marketing feasibility, financial access, and legal empowerment. The strategies provide actionable insights for policymakers in providing evidence-based, feasible, and integrated solutions for farmer distress in agriculture.

KEYWORDS

consensus building, expert judgement, farmer distress, fuzzy Delphi method, mental health networks

1 Introduction

Agriculture continues to form the primary employment base for most rural households in India and contributes approximately 18.2% of the country's GDP at the current prices (PIB, 2023). Despite agriculture's substantial economic contribution and its documented high return on investment, with every rupee invested in agricultural research generating Rs. 13.84 in returns (Ministry of Finance, Government of India, 2023), the sector remains paradoxically afflicted by widespread distress, particularly among small and marginal farmers. This contradiction underscores a critical disconnect: while agriculture demonstrably contributes to national food security and economic growth, structural vulnerabilities continue to undermine the welfare of those who sustain it, thus becoming prey of phenomena of farmers' distress. The distress is defined as the challenges faced by the farmers and rural communities in terms of economic, social, and political factors due to low productivity of crops, fluctuations in prices, indebtedness among them, lack of access to credit facilities, etc. (Chaithanya et al., 2024). In Haryana, farmer indebtedness is a significant cause of distress, with small and marginalized farmers facing disproportionate challenges in accessing institutional credit. This forces them to rely on non-institutional sources with high-interest rates, perpetuating a cycle of debt and financial strain (Jakhar et al., 2023). In Uttar Pradesh, the agrarian distress is exacerbated by the high cost of farming inputs, market volatility, and inadequate credit facilities. The state has seen a significant rise in farmer suicides, attributed to indebtedness and financial instability (Lal and Singh, 2024).

The story does not end here at the fact that distress is simply the result of the aforementioned factors, but over the last decades, the neoliberal policies of agriculture, the changes occurring in the climate, and increase in the cost of production due to the rise in factor costs have collectively made the farmers vulnerable to these issues (Deshpande and Arora, 2010). Yet, these issues cannot be viewed in isolation. Over recent decades, the combined influence of neoliberal policy reforms, escalating input and living costs, and accelerating climate change has emerged as a complex web of interrelated systemic pressures. Neoliberal policies, which are basically characterized by market deregulation and reduced state intervention, create conditions where the rising costs of essential services and climate change impacts are experienced as mutually reinforcing systemic pressures (Saad-Filho and Feil, 2024). The adoption of these policies has reduced direct government support for small and marginal farmers, thus exposing them to price volatility and diminishing bargaining power (Sonwale and Kadam, 2022; Mishra A., 2020). Additionally, continuous increases in the cost of seeds, fertilizers, and labor have further eroded farm profitability, intensifying indebtedness and restricting access to credit facilities (Anjum, 2021). At the same time, climate change amplifies these economic challenges and adds to the precariousness of already vulnerable rural households (Deshpande and Arora, 2010; Chaithanya et al., 2024). The Cauvery Delta region in Tamil Nadu has experienced persistent monsoon failures, leading to severe water scarcity and crop failures. This has resulted in a notable increase in farmer suicides (Vignesh and Karthikeyan, 2017; Sabarisakthi, 2019). Consequently, these forces do not act in isolation but reinforce each other, compounding agrarian distress and undermining the long-term sustainability and resilience of rural livelihoods in India (Sonwale and Kadam, 2022; Mishra A., 2020). Policy interventions, viz., minimum support prices, loan waiving policies, etc., have produced limited and short-lived relief (Reddy and Mishra, 2010). According to the studies (Jones et al., 2023; Kroll, 2022), the distress in the farming community

further leads to chronic depression, anxiety attacks, and attempt to suicide in many cases. The consequences of this distress are not contained within the individual farmer but spread to families and entire communities (Mishra, 2022). Such widespread suffering impacts rural stability, as farm households struggle to remain productive and can ultimately threaten India's national food security by reducing the agricultural labor force and hampering crop output. Therefore, resolving farmers' distress remains pivotal, not only for the welfare of farm households but also for sustaining rural communities and ensuring a reliable food supply at a macro level (Chakrabarti et al., 2018). Addressing this issue requires a holistic and multi-pronged approach which includes improving the credit access, insuring the crop against weather uncertainties, modernizing the agricultural inputs, and strengthening the cooperatives and farmer producers organizations as well (Bhoi and Dadhich, 2019). According to a study done by Kaur et al. (2016), farmers' distress arises from a series of tangled factors, such as economic, social, environmental, and psychological factors. All the given factors interact with each other so much that it becomes difficult to separate and analyze them independently. Furthermore, the distress varies from one region to another depending upon factors such as the size of landholdings, climatic conditions, cropping patterns, etc. A review done by Kaur et al. (2016) reported that many farmers affected by these problems are not ready to participate in the studies or reveal the extent of distress. Moreover, factors that contribute to the farmer's distress are not static but dynamic (Mishra, 2023). As for the data available on websites, secondary information is fragmented or outdated, which is not reliable for the studies. Moreover, it extends far beyond an individual or occupational issue—it represents a profound societal challenge with wide-ranging economic, social, and psychological implications. The prolonged suffering of farmers triggers a chain reaction that weakens rural households, fragments community networks, and endangers national food security (Mishra, 2022). Such agrarian distress often manifests in reduced productivity, increased indebtedness, rural migration, and growing social unrest, all of which obstruct inclusive and sustainable development (Reddy and Mishra, 2010; Chaithanya et al., 2024). Recognizing it as a collective societal concern, rather than an isolated agrarian crisis, is indispensable for realizing the Sustainable Development Goals and ensuring equitable and long-term rural wellbeing (Food and Agriculture Organization of the United Nations (FAO), 2018). To address the multi-dimensional nature of farmer distress, sophisticated methodological approaches are required that synthesize diverse expert perspectives and generate evidence-based and consensus-driven solutions. Traditional research methodologies often fail to capture the complexity and interconnectedness of factors contributing to farmer distress. Innovative methodologies such as the Delphi method have shown particular effectiveness in agriculture for synthesizing multi-disciplinary viewpoints and generating actionable recommendations (Sturla et al., 2024; Adams et al., 2022a,b; Larsen K. et al., 2019). Therefore, innovative, integrative approaches are needed to synthesize diverse expert perspectives.

According to Frewer et al. (2011), the Delphi technique is appropriate where the problem is ill-structured, and the data available are scattered or scarce. Although the traditional Delphi methods have been widely accepted as an effective tool and have been used in a wide range of applications, problems of ambiguity and uncertainty in experts' opinions still remain. The measurement of human judgement is considered to be an emotional, complex, perceptual, subjective, and personal phenomenon, involving many domains of an individual's life experience. In general, classic rating scales (e.g., 5- or 7-point Likert scales) inherently consider crisp numbers to measure human thinking. The Fuzzy

Delphi Method (FDM) was developed to overcome this problem through the combination of fuzzy theory and the classical methodology.

2 Materials and methods

2.1 Delphi

The word 'Delphi' originated in Greece (Palmer, 1969). It was the name of the Greek town where the temple of Apollo is situated, and was once home to the oracle. The Delphi method was originally created by the RAND Corporation in the United States in the 1950s. According to Hasson et al. (2000), the main purpose of the Delphi method is to acquire the most reliable consensus from a group of experts using iterative questionnaires together with controlled opinion feedback. The Delphi method differs from other qualitative methods, as it is used as a tool to build consensus among a panel of selected participants to forecast assumptions or develop a particular concept (Dalkey and Helmer, 1963; Linstone and Turoff, 1975; Grisham, 2009). The method uses multiple iterations or feedback processes to develop a consensus on a specific topic (Hsu and Sandford, 2007). Basically, the Delphi method is a systematic way to extract opinions from experts on a topic and, ultimately, to reach consensus.

3 Steps used under Delphi for the present study

3.1 Number of experts

The size of the expert panel depends on the complexity of the problem, the homogeneity (or heterogeneity) of the panel, and the availability of resources. There is no standard size of the panel members and varies from 10 to 1,000 (typically between 10 and 100) in published studies (Nasa et al., 2021) (since the topic of research is controversial and knowledge on this topic is limited and debatable, we have selected 70 experts).

3.1.1 Selection of experts

The Delphi method requires an appropriate panel size, diverse representation of members from different specialties, and geographical distribution. Agricultural researchers from the Institutes of the Indian Council of Agricultural Research (ICAR), academicians, and KVK officials across different states of the country were solicited for this study. We contacted all experts via email. Research questionnaire design as well as data collection was performed using online Google Forms. Experts' email addresses were collected from institutional websites, personal contacts, and social media communications.

3.2 Selection of domains

The first stage of Delphi rests on innovative suggestions generated from selected experts. This is generally done through providing open-ended stimulus and guided cues. It allows for the collection of diverse opinions while minimizing the chaos of unstructured brainstorming (Yousuf, 2007; Humphrey-Murto et al., 2020). Thus, the experts were

provided with cues in the form of domains of farmers' distress. Given the multifaceted nature of the phenomena of farmers' distress, strategic inputs to solve it were grouped into five broad domains based on previous studies (Chaithanya et al., 2024; Jakhar et al., 2023; Reddy et al., 2021; Kolhe and Bhat, 2025; Mathur and Shah, 2025). These will ensure that strategies are both holistic and grounded.

3.2.1 Importance of selected domains

3.2.1.1 Production domain

It is vital as it addresses the direct agrarian factors—such as soil health, input accessibility, and climate resilience, which fundamentally impact farm output and sustainability. There are different factors, such as climate variability and resource access, that directly impact crop yields, necessitating monitoring to enhance resilience (Reddy et al., 2021).

3.2.1.2 Financial domain

This domain is essential because economic activities and financial stability determine a farmer's ability to invest in productive resources, manage risks, and promote the overall livelihood security of farming households. Several factors, such as economic pressures, including debt and credit access, significantly affect farmers' mental health and decision-making, highlighting the need for financial literacy and support systems (Kolhe and Bhat, 2025).

3.2.1.3 Marketing domain

This domain is included due to the central role that market access, fair prices, and input/output policies play in determining farm incomes. Without efficient marketing systems, farmers are vulnerable to exploitation and chronic losses. It has been observed that digital transformation in agricultural marketing can improve market access and price discovery, addressing issues of market volatility (Mathur and Shah, 2025).

3.2.1.4 Psychological domain

It recognizes the significant influence of sociocultural and behavioral factors on farmers' decisions and wellbeing, including issues such as family pressure, mental health, and coping mechanisms. Psychological factors, such as stress from financial burdens, influence farmers' behaviors and decision-making processes (Kolhe and Bhat, 2025).

3.2.1.5 Legal domain

It provides a framework for resolving disputes and ensuring farmers' rights and entitlements are protected through legal awareness and institutional mechanisms. Understanding legal frameworks helps farmers navigate land rights and access to resources, which is essential for sustainable practices (Lamba et al., 2024).

3.3 Selection of criteria for evaluation domain-specific strategies

The second Delphi round involves screening and grouping of innovative strategies unearthed from the first round of Delphi and sending them for further evaluation in a structured form to the experts. It provides a structured way for participants to express

their level of agreement or importance regarding each item, facilitating the consensus-building process (Niederberger et al., 2024; Perrin, 2022). The criteria of ease of application, cost effectiveness, relevancy, and alignment to national policies/programs/SDG goals are essential for designing and implementing strategies that effectively address farmer distress, ensuring that solutions are practical, sustainable, and contextually appropriate, as observed in previous studies.

3.3.1 Importance of selected criteria

3.3.1.1 Ease of application

This is critical in ensuring that proposed strategies are user-friendly, accessible, and can be easily adopted by farmers from diverse backgrounds. It has been studied that the perceived ease of using new agricultural technologies significantly influences farmers' willingness to adopt innovations and directly impacts adoption behavior (Zhang et al., 2024a,b). When technologies or interventions are user-friendly and accessible, they facilitate spontaneous dissemination and rapid uptake among farming communities, thereby reducing barriers to implementation (Read et al. (2024).

3.3.1.2 Cost-effective

This criterion is important in situations where financial constraints are prevalent, and the risk of over-expenditure can itself be a source of distress. It has been observed that financial constraints and overwhelming debt burdens are primary contributors to farmer distress (Mishra, 2023); strategies must be economically viable for both farmers and implementing agencies.

3.3.1.3 Relevancy

In addressing farmer distress, the strategies that are not sufficient must resonate with the needs and priorities of the farming community (Norizan, 2003). The agricultural sector in India is characterized by heterogeneity in resource endowment, market access, and climatic conditions (Singh and Singh, 2020), which necessitates that strategies be assessed for their contextual fit and adaptability.

3.3.1.4 Alignment to national policies/programs/SDG goals

This criterion is necessary to synchronize interventions with ongoing government efforts and global frameworks, which will facilitate scaling-up, policy coherence, and funding opportunities. The strategies should support broader goals, such as food security and environmental sustainability, aligning with national policies and the Sustainable Development Goals (SDGs) (Philip et al., 2025).

3.4 Number of iterations

The number of iterations depends predominantly on the degree of consensus sought by the researchers, and can vary from three to five (Delbecq et al., 1975; Ludwig, 1994). This view is supported by Cyphert and Gant (1971), Brooks (1979), Ludwig (1994), and Custer et al. (1999), who considered three iterations as normally sufficient to reach a consensus and to gather the necessary information. Hallowell and Gambatese (2010) also encouraged researchers to use at least three

rounds to determine the reasons for outlying responses in the third round.

3.4.1 Round 1

An open-ended questionnaire was used in the first round of the Delphi process based on five domains and four criteria, which were identified during the literature review. After receiving the experts' responses, a structured questionnaire was developed for the next round based on the suggestions received. It was designed to solicit specific information on the research content from the participants (Custer et al., 1999).

3.4.2 Round 2

In the second round, the experts were presented with the questionnaire and asked to rate the items summarized by the researchers from the responses provided from the first round. They were asked to evaluate the strategies on a 5-point scale continuum ranging from 1 to 5 (1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, and 5 = strongly agree). The Likert scale was selected because it is commonly used to collect rated responses (Chalmers and Armour, 2021). Then, the suggestion of Heiko and Darkow (2010) and Norizan (2003) was utilized to evaluate the level of importance and consensus based on quartile deviation (QD), median (M), and interquartile range (IQR). In this study, IQR was used exclusively to assess the level of consensus, whereas QD and M were employed to evaluate both consensus and importance. The strategies with $QD \leq 0.5$, $M \geq 4$ and $IQR \leq 1$ were classified as having high importance with high consensus. The strategies with $0.5 < QD \leq 1.0$, $M \geq 4$ and IQR ranging between 1 and 2 were considered to have high importance with moderate consensus, and strategies with quartile deviation greater than 1.0, a median score of four or higher, and an interquartile range of two or less were interpreted as having high importance but low or no consensus among experts (see Tables 1, 2).

3.4.3 Round 3

After eliminating the strategies according to the criteria, another round of Delphi was conducted since the consensus was not yet achieved. In this round, the accepted strategies were sent to the same set of experts for evaluation on the same procedure followed in round 2. A robust consensus was reached for more than 75% of items after the third round, which is why it was decided to forego further iterations (De Vet et al., 2004). All the steps are briefly described in Figure 1.

4 Fuzzy Delphi

The Fuzzy Delphi Method (FDM) is a variation of the traditional Delphi method that incorporates fuzzy logic to handle uncertainties and ambiguities in expert judgment (Hierro et al., 2021). Kaufmann and Gupta (1988) presented the application of the Fuzzy Delphi technique for forecasting.

According to Mohd Jamil et al. (2014) and Mohd Ridhuan and Nurulrahmah (2020), Fuzzy Delphi consists of the following steps:

- 1 Selection of experts—the same set of experts was used as in the Delphi method.

TABLE 1 Five domains and four criteria related to farmer distress were identified during the literature review.

| SL. No | Domains | Description |
|--------|----------------------|---|
| 1. | Production domain | It refers to the aspects that deal with agrarian factors, factors of production, and the impact of the surrounding ecosystem on agricultural activities. |
| 2. | Financial domain | It has been defined as the aspects that deal with the economic activities related to farm as well as other social and personal matter of their farm family as a whole. |
| 3. | Marketing domain | It refers to the aspects that involve the activities, policies related to the buying and selling of inputs/outputs, and have a direct impact on farmers decision-making about their production activities |
| 4. | Psychological domain | It refers to the aspects that originate from sociocultural factors and affect farmers' behavior their livelihood options, and decision-making regarding various farming-related activities. |
| 5. | Legal domain | It is conceptualized as the aspects that deal with various legal awareness which are needed for the smooth operation of their farming business, as well as various socio-economic difficulties, disputes that transform itself to a legal one requiring intervention from institutional/political/formal authority available. |

| Criteria | Description |
|--|--|
| 1. Ease of application | Ease of application refers to how readily a product, service, or resource can be accessed or obtained by users or consumers. |
| 2. Cost effective | It is defined as achieving the best possible return on resources invested, ensuring that operations are conducted at the lowest cost without compromising quality. |
| 3. Relevancy | It refers to the significance or pertinence of strategy in relation to a specific subject or situation. |
| 4. Alignment to national policies/programmes/SDG goals | It refers to possibilities of the systematic integration of strategies with the national development policies, programs, and Sustainable Development Goals (SDGs) established by the United Nations. |

TABLE 2 Criteria for consensus and importance given by Norizan (2003)* and Heiko and Darkow (2010) (computer competency of in-service ESL teachers in Malaysia secondary schools).

| SL. No | Criteria | Level of importance | Level of consensus | Description |
|--------|---|---------------------|--------------------|-------------------------------------|
| 1. | QD ≤ 0.5, M ≥ 4 and IQR ≤ 1 | High | High | High importance, high consensus |
| 2. | 0.5 < QD ≤ 1.0, M ≥ 4 and 1 ≤ IQR ≤ 2 | High | Moderate | High importance, moderate consensus |
| 3. | QD > 1.0, M ≥ 4 and IQR ≤ 2 | High | Low/no consensus | High importance, no consensus |
| 4. | QD ≤ 0.5, M ≤ 3.5 and IQR ≤ 0.5 | Low | High | Low importance, high consensus |
| 5. | 0.5 < QD ≤ 1.0, M ≤ 3.5 and 1 ≤ IQR ≤ 2 | Low | Moderate | Low importance, moderate consensus |
| 6. | QD ≥ 1.0, M ≤ 3.5 and IQR > 2 | Low | No consensus | Low importance, no consensus |

*IQR was used to evaluate only consensus, while QD and M were used to evaluate both consensus and importance. Source: computer competency of in-service ESL teachers in Malaysia secondary schools.

2 Linguistic scale selection—previous five continuum scale was utilized here too. The set of strategies that were obtained after round three of Delphi was used in this step.

It involves using a Fuzzy Scale, which is a 5-point scale derived from the Likert Scale, to measure the level of agreement among experts. This scale allows for a more nuanced analysis of expert opinions compared to a traditional Likert Scale. The Fuzzy Scale assigns fuzzy values to each Likert scale value, ranging from 0 to 1, to quantify the degree of agreement or disagreement. Table 3 represents the Likert scale, linguistic variable, and triangular fuzzy number.

A triangular fuzzy number (TFN) is a fuzzy number, which is displayed with three real numbers [F = (l, m, u)]. The upper bound

denoted by u is the maximum value of the fuzzy number F. The lower bound denoted by l is the minimum value of fuzzy number F; m is the most probable value of a fuzzy number (Figure 2). The membership function μ(x) of a triangular fuzzy number defines the degree of membership of any value x within the fuzzy set, ranging from 0 to 1, with 1 indicating complete membership and 0 indicating no membership. It is represented as follows:

$$\mu_f(x) = \begin{cases} \frac{x-l}{m-l} & l < x < m \\ \frac{u-x}{u-m} & m < x < u \\ 0 & \text{otherwise} \end{cases}$$

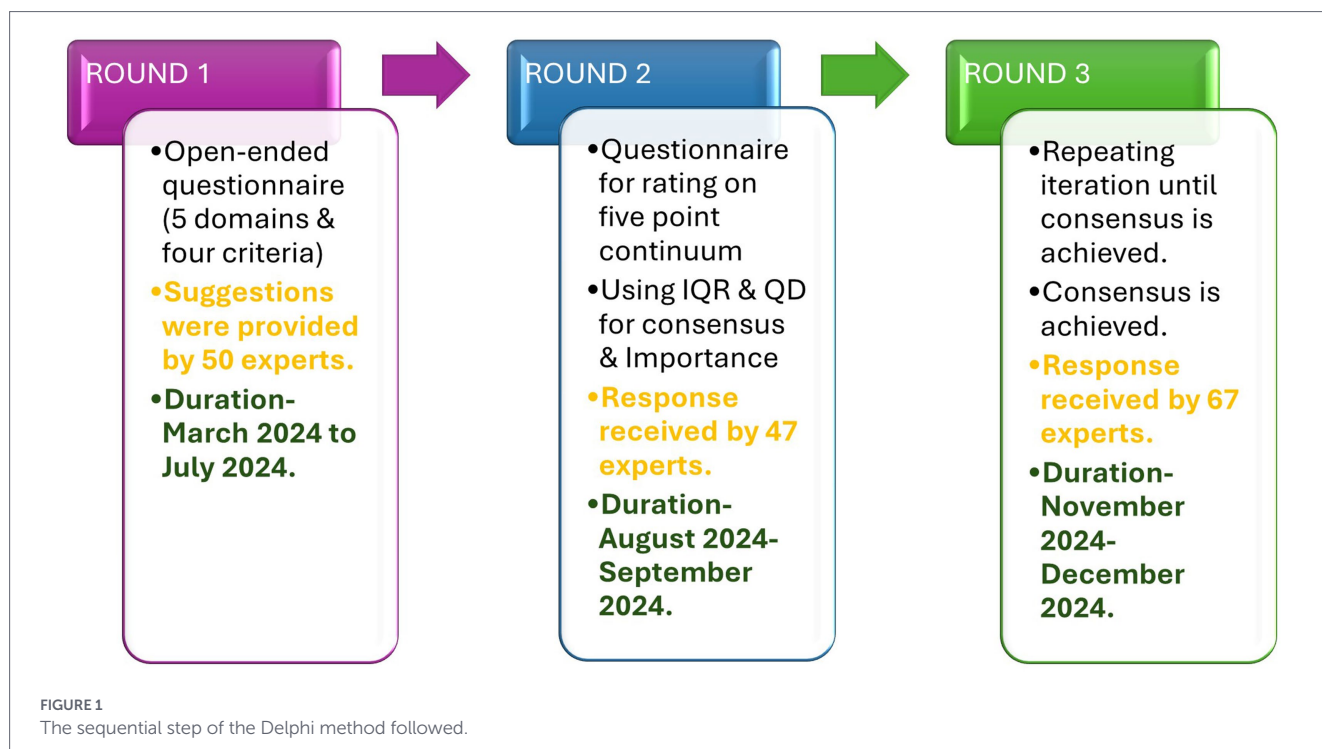


TABLE 3 Likert scale, linguistic variable, and triangular fuzzy number.

| Likert scale | Linguistic variable | Triangular fuzzy number |
|--------------|---------------------|-------------------------|
| 1 | Strongly disagree | 0.0, 0.0, 0.2 |
| 2 | Disagree | 0.0, 0.2, 0.4 |
| 3 | Neutral | 0.2, 0.4, 0.6 |
| 4 | Agree | 0.4, 0.6, 0.8 |
| 5 | Strongly agree | 0.6, 0.8, 1.0 |

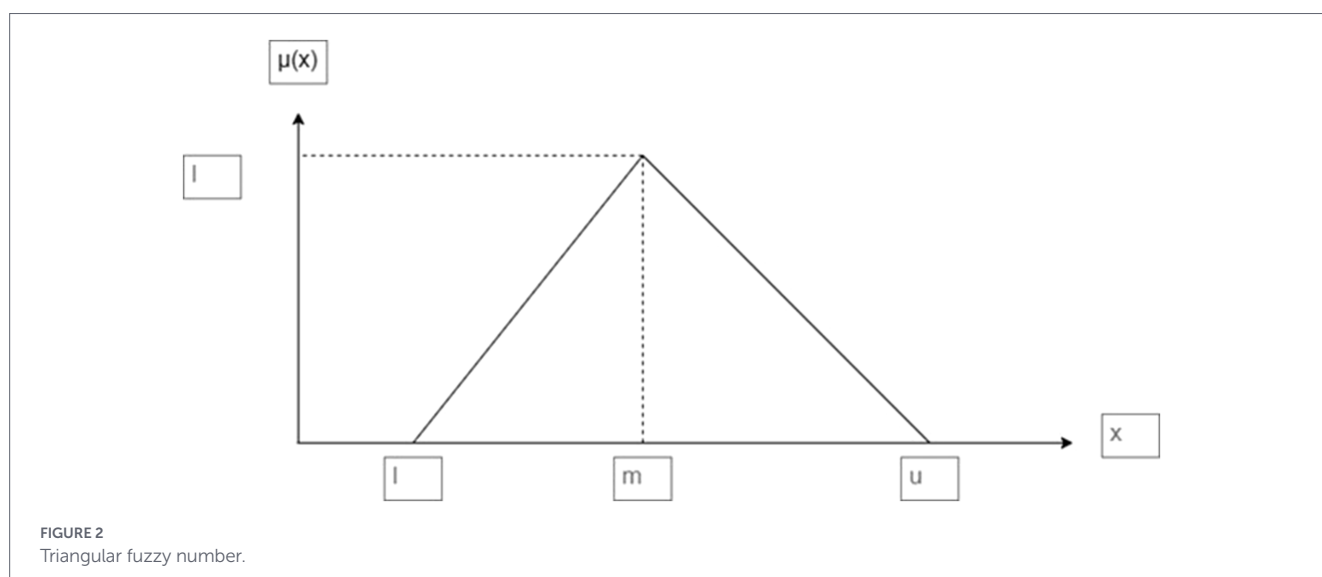
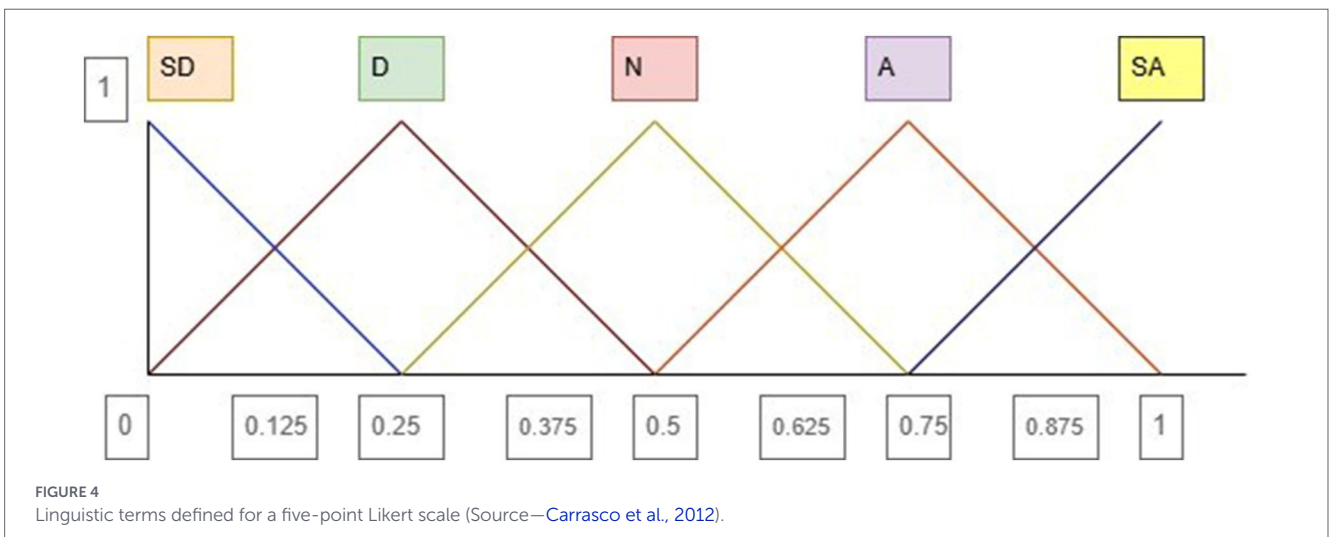
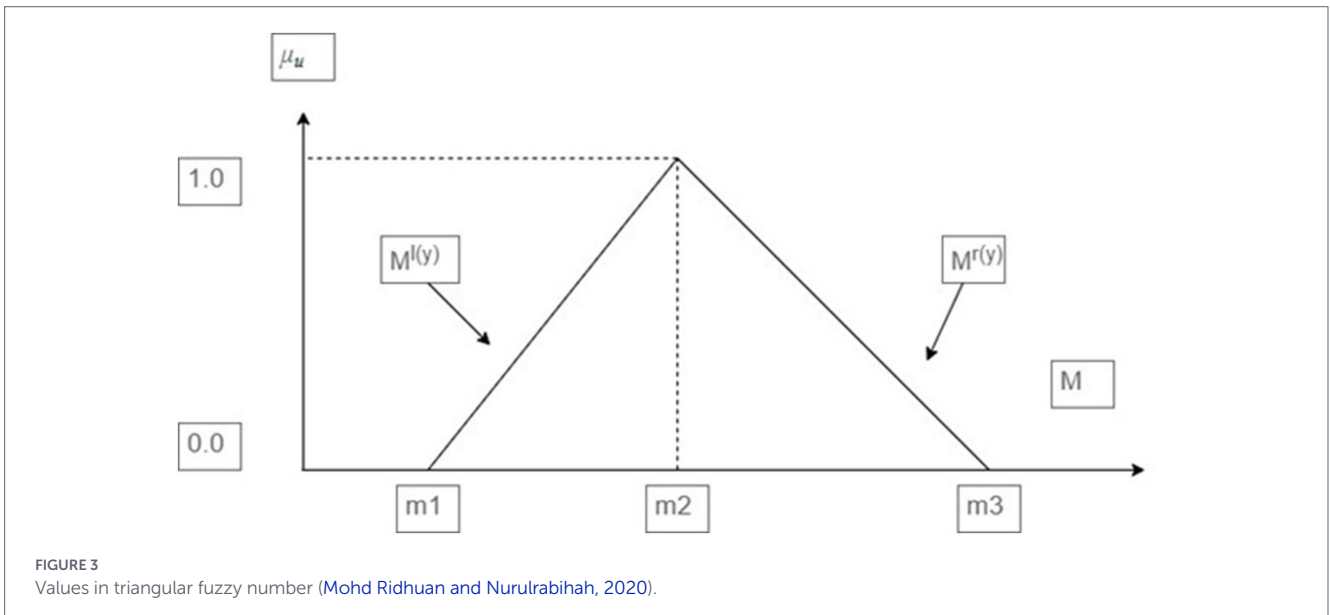


Figure 3 represents values in a Triangular Fuzzy Number, denoted as $M = (m_1, m_2, m_3)$, where m_1 , m_2 , and m_3 represent the lower, modal (most likely), and upper bounds of the fuzzy set, respectively. The horizontal axis corresponds to the universe of discourse, while the

vertical axis (μ_u) indicates the membership degree ranging from 0 to 1. The membership function increases linearly from 0 at m_1 to 1 at m_2 , and then decreases linearly back to 0 at m_3 . $M^L(y)$ and $M^R(y)$ denote the left and right membership functions of the TFN, respectively,



which define the degree of belonging of a value y within the fuzzy set. The membership function is represented as follows:

$$\mu_M(y) = \begin{cases} 0, & y \leq m_1, \\ \frac{y - m_1}{m_2 - m_1}, & m_1 < y \leq m_2, \\ \frac{m_3 - y}{m_3 - m_2}, & m_2 < y \leq m_3, \\ 0, & y \geq m_3. \end{cases}$$

- 3 Conversion of values—expert responses, which were collected using the Likert scale, were converted to fuzzy scale values through standardized transformation procedures (Benitez et al., 2007). Figure 4 represents the linguistic terms defined for a 5-point Likert scale. This process allows for a standardized method of inputting expert opinions into the FDM framework.
- 4 Calculate the average value—in this step, fuzzy average values (m_1, m_2, m_3) were obtained from the fuzzy scale, which

represent the consensus among experts for each item. Figure 1 illustrates these three values in the triangular fuzzy number.

- 5 Determination of Threshold value—it is the process of determining the threshold value ‘ d ’, which is used to determine whether an item is accepted or rejected based on the level of agreement among experts. A triangular fuzzy number has two conditions, first the value of Threshold (d) ≤ 0.2 . The expert agreement is reached when the resulting value is smaller than or equal to 0.2 (Cheng and Lin, 2002; Chen, 2000).

$$d(\bar{m}, \bar{n}) = \sqrt{\left[\frac{1}{3} \left[(m_1 - m_1)^2 + (m_2 - m_2)^2 + (m_3 - m_3)^2 \right] \right]}$$

- 6 Consensus of experts—it is the process of determining the percentage of agreement for each item and overall items, which provides a quantitative measure of expert consensus. The strategies that achieved $\geq 75\%$ expert agreement are

considered for final acceptance (Chu and Hwang, 2008; Murray et al., 1995).

- 7 Defuzzification process—the fuzzy (A) score value was determined based on the α -cut value of 0.5 (Tang and Wu, 2010; Bodjonava, 2006). If the fuzzy score value (A) was equal to or greater than 0.5, then the strategy was accepted, and if less than 0.5, then the strategy was rejected. The determination of fuzzy (A) score value was made based on the following formula (Cheng et al., 2009; Hsu et al., 2007; Wu and fang, 2011):

$$\text{If } F = (L, M, U), \text{ then } F = \frac{A = (1/3) * (m_1 + m_2 + m_3)}{3}$$

For further rigor, we have used the threshold function: $d_i = \sqrt{[(1/3) [(l_i - l_{\text{avg}})^2 + (m_i - m_{\text{avg}})^2 + (u_i - u_{\text{avg}})^2]}$ with consensus if $d_i \leq 0.2$.

- 8 Fuzzy evaluation process—it involved determining scores (ranking/priority) for each strategy based on the level of agreement among experts. The strategies that do not meet the conditions set by the FDM were rejected. The positioning method involves defining elements based on defuzzification values determined by expert consensus. The element with the highest importance is considered the most critical decision point (Fortemps and Roubens, 1996).

5 Results

This section summarizes the findings of the Fuzzy Delphi Method (FDM) analysis for the strategies of farmer distress based on expert consensus. For each strategy, the table displays the triangular fuzzy numbers (A), threshold values (C), expert agreement percentages (D), fuzzy scores (E), and ranks (F). A total of 61 strategies were identified using the Delphi method. After conducting fuzzy Delphi, out of 61 total strategies evaluated, 47 strategies (77.0%) achieved expert consensus and were accepted based on dual criteria: threshold value ($d \leq 0.2$) and expert agreement percentage ($\geq 75\%$) (see Figure 5).

A comprehensive assessment of expert feedback was conducted to refine financial strategies relevant to the domain. By applying the Fuzzy Delphi Method, 14 potential strategies were evaluated based on four criteria. Supplementary Table S1 presents the fuzzy Delphi analysis of all the strategies that were asked from the expert with respect to the financial domain. There were a total of 14 strategies finalized, out of which four got rejected. The fifth strategy, named “Promote cooperative marketing initiatives and linkage to cooperative societies,” was highest among consensus based on ease of application. The same strategies were evaluated based on cost-effectiveness, the third strategy, named “low-cost subsidized life insurance to farmers,” was highest in terms of expert agreement, while “Promote cooperative marketing initiatives and linkage to cooperative societies” strategy was ranked highest in terms of both ease of application and cost-effectiveness. The strategies “Provision of credit guarantee schemes with better availability of credit” and “Low-cost subsidized life insurance to farmers”

were ranked as top most strategies in terms of relevance and alignment to national policies/programs/SDG goals.

Supplementary Table S2 shows the selected and rejected strategies of the marketing domain. The strategies “Organizing regular buyer seller meet by KVK and line department in the particular locality” and “Strengthening market intelligence to enable farmers and to make informed decisions about what to grow, when to sell, and where to sell” were ranked as top strategies to combat farmer distress according to ease of application and alignment to national policies/programs/SDG goals, respectively. The strategy “Better price realization to farmers by directly connecting them to consumers through an electronic platform” achieved the highest overall ranking for both cost-effectiveness and relevancy, highlighting the importance of digital platforms. The single rejected strategy involved government market regulation and monopoly prevention, which failed to achieve consensus across all criteria (25–30% agreement) due to concerns about implementation feasibility and effectiveness at the societal level.

There were a total of nine strategies for the psychological domain. The strategy “Provision of community centers for group discussion, farmers meeting and to attend Agri-related rituals” was ranked top according to ease of application and relevancy, and it also ranked second in terms of cost-effectiveness, whereas the strategy “Organize workshops and campaigns to educate farmers about mental health” was second in terms of relevancy and alignment to programs and policies. It shows the need of community-driven mental health approaches and points out the importance of collective learning. The strategy “Conduct awareness campaigns to reduce stigma around mental health issues” was rejected across all sub-categories, which suggests that intense and mobilizing community-based engagement may not be impactful. The findings further indicate that active involvement may be more effective than merely providing awareness through campaigns.

Supplementary Table S4 represents all the accepted and rejected strategies of the legal domain. It shows that 10 strategies were accepted and two strategies were rejected. The strategy “Providing farmers with access to legal aid clinics or counselling services where they can receive guidance on their rights, entitlements, and legal options” was ranked first in terms of ease of application and cost-effectiveness, whereas it was ranked as the second preferred strategy in terms of alignment to national policies/programs/SDG. The strategy named “Simplify and streamline legal procedures related to land ownership, tenancy rights, and access to government support schemes” was preferred best in terms of relevancy. The strategy “Strengthening land tenure security through legal reforms and ensuring that farmers have clear title deeds or lease agreements” was rejected due to low feasibility and weak consensus. It may indicate that experts are focusing on localized and accessible solutions rather than broader structural reforms.

Supplementary Table S5 represents all the accepted and rejected strategies for the production domain. There were a total of 12 strategies, out of which two strategies were rejected. The strategy named “Cover production risk by providing PMFBY and support schemes like RYTHU BANDHU (Andhra Pradesh) Yojana, KALIA Yojana (Orissa) etc.” was ranked first in terms of cost-effectiveness and relevancy and the strategy was ranked as fourth in terms of alignment to national policies/programs/SDG. The strategy “Soil testing & distribution of soil health cards on a regular basis” was ranked first in terms of alignment to national policies/programs/SDG. The strategies

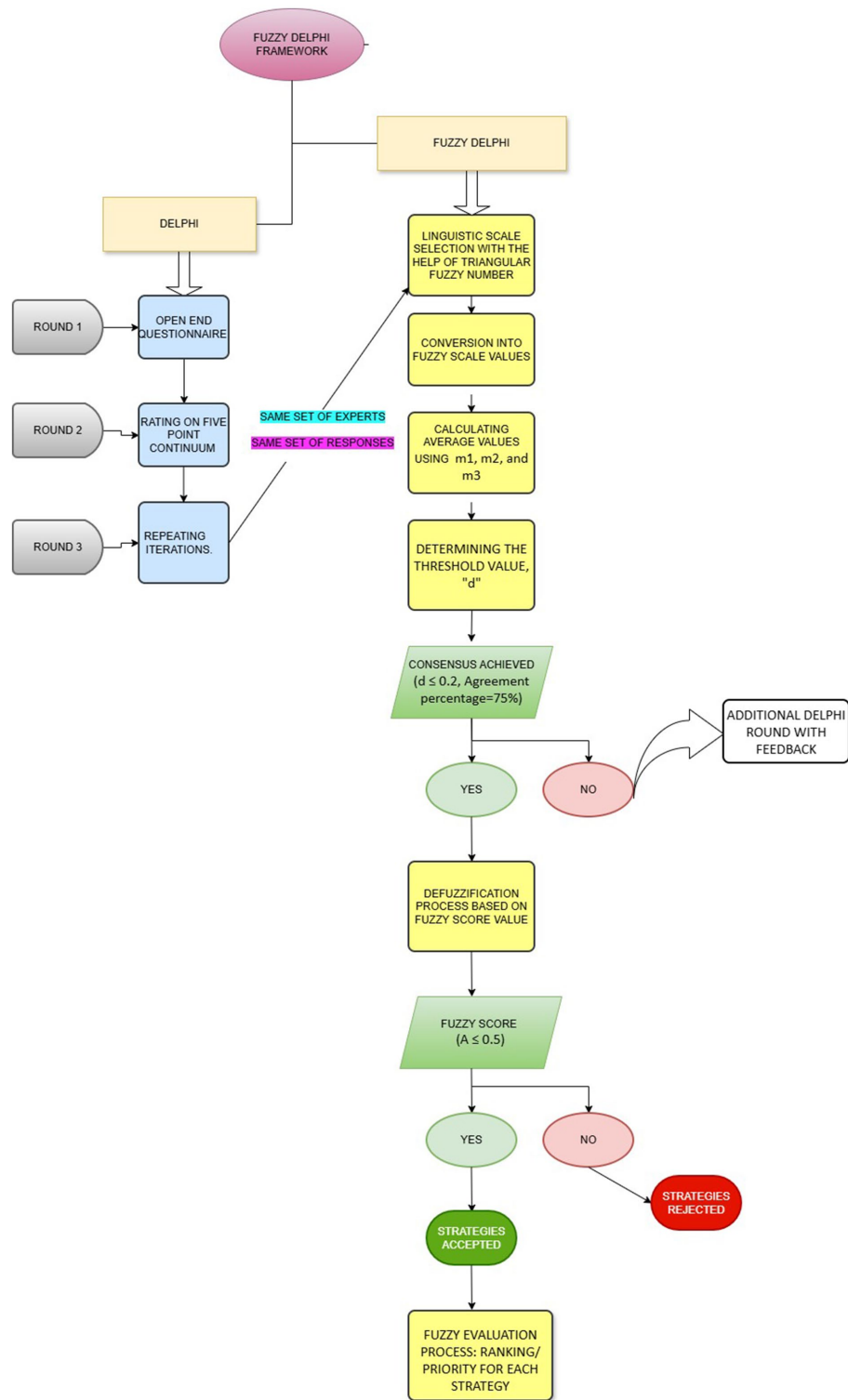


FIGURE 5 The framework developed for the study.

named “Encourage collaboration between farmers, local institutions, NGOs, and government agencies to address common challenges and promote inclusive development” and “Facilitation of information from the nearest KVK or SAU about production technologies, innovative technologies or any other initiative with respect to production domain” were rejected. It may be rejected due to perceived implementation challenges.

6 Discussion

6.1 Financial domain

The strategy “Promote cooperative marketing initiatives and linkage to cooperative societies” was prioritized as it occupies a key position in agricultural development, and its network covers 85%

of rural households (Kumar et al., 2015). It demonstrates the transformative potential of collective action in agricultural markets. Cooperative marketing enhances farmers' bargaining power, allowing them to sell produce at better prices and reducing distress from forced sales under unfavorable conditions. Several countries, such as Denmark and Netherlands, have demonstrated how cooperative marketing can transform agricultural sectors by providing market stability, better prices, and reduced transaction costs for farmers (Francesconi and Heerink, 2010). In India, dairy cooperatives such as Amul had successfully created sustainable income streams for farmers while building market linkages (Kumar et al., 2015). By forming cooperatives, farmers can achieve economies of scale, improving their competitiveness in the market (Mahale et al., 2025). The strategy suggesting providing low-cost subsidized life insurance to farmers corresponds with growing recognition of several schemes to combat farmer distress. Government-subsidized programs address market failures by making insurance accessible and affordable, along with premium contributions shared between farmers, state governments, and the central government (PIB, 2025). The subsidized life insurance protects farmers against unforeseen events, reducing the financial burden of crop failures and enhancing their resilience. With the help of insurance coverage, farmers are more likely to invest in innovative agricultural practices, further stabilizing their income (More, 2016).

The strategy "Provision of credit guarantee schemes with better availability of credit" was also emphasized by the experts as enabling farmers to invest in essential inputs and technologies, which enhances productivity and income (Balana et al., 2022; Regassa et al., 2023; Zhang et al., 2025). By providing access to formal credit sources, farmers can avoid resorting to informal lenders who charge exorbitant interest rates, thereby breaking the vicious cycle of indebtedness and distress (Kumari et al., 2025; Narayanamurthy et al., 2025). The strategy named "Providing training and campaigns about financial literacy to farmers" was also prioritized, which aligns with evidence demonstrating positive impacts of financial education on farmer decision-making and credit access (Carpena et al., 2011; Cole et al., 2011). Financial literacy training enables farmers to develop vital skills for sound financial management, such as maintaining accurate records, cultivating savings habits, and making informed credit decisions, all of which are essential for improving farm performance and resilience (Nolan, 2024; Soekarni et al., 2024; Liu et al., 2025). The studies show that financially literate farmers are more likely to apply for government-backed loan schemes, compare credit offers for better terms, understand credit scoring impacts, and invest in productivity-enhancing inputs through formal channels rather than exploitative informal lenders (Agriwise, 2025).

6.2 Marketing domain

The strategies named "Better price realization to farmers by directly connecting them to consumers through an electronic platform" and "Strengthening market intelligence to enable farmers and to make informed decisions about what to grow, when to sell, and where to sell" hold the highest importance in this domain. It shows the importance of digital technologies, which have the potential to reduce farmer distress as they eliminate intermediaries and improve farmer margins. A series of theoretical papers, including Stigler (1961), Salop and Stiglitz (1977), Stahl (1989), and McAfee (1995),

describe models that reveal that when consumers face search costs (it is the time, energy, and money that buyers and sellers in a market expend in trying to find one another to engage in transactions), they may not seek the lowest prices, resulting in price dispersion and reduced market efficiency. There is also a growing empirical literature assessing the effects of improvements in information on both the level and dispersion of prices (Goyal, 2010; Muto and Yamano, 2009). Market information is also critical for the efficient functioning of markets. Market intelligence systems attempt to provide comprehensive information on prices, arrivals, availability, trends, analysis, and regulations, enabling farmers to make strategic production and marketing decisions (Dagar et al., 2021). The most successful case studies include the eNAM platform, which networks existing Agricultural Produce Market Committees (APMC) mandis to create unified national markets for agricultural commodities (e-NAM, 2024). Another strategy, "Organizing regular buyer-seller meet by KVK and line department in the particular locality," was also ranked higher, which shows the importance of KVK in organizing buyer-seller interactions. The promotion and strengthening of Farmer-Producer Organizations (FPOs) was also proposed as a highly effective strategy. It basically helps in improving smallholder market access and boosting farmer incomes in India, which will indirectly help in reducing farmer distress. Several studies have shown that FPO members usually receive better prices and reduced input costs due to bulk procurement and improved bargaining power compared to non-members (NABARD, 2025; Bajaj Finserv, 2024). The strategy "Better price realization to farmers by directly connecting them to consumers through an electronic platform" showcases the benefits of improved price realization, enhanced transparency and trust, and operational efficiency. The AI-driven price predictions and real-time analytics help farmers make informed decisions, leading to better pricing outcomes (Cyril and Nigam, 2025; Mane, 2025). The digital platforms facilitate direct interactions between farmers and consumers, which increases transparency, promotes fair pricing, and eliminates middlemen, thereby fostering trust and reducing price manipulation (Santhosh et al., 2025). The digital platforms streamline logistics, making it easier for farmers to reach consumers without the burden of complex supply chains (Singh et al., 2021; P et al., 2023).

6.3 Psychological domain

The strategies such as "Organize workshops and campaigns to educate farmers about mental health" and "Provision of community centers for group discussion, farmers meeting and to attend Agri-related rituals" were ranked as of high importance for combating farmer distress with respect to the psychological domain. Community centers can serve as hubs for social interaction, which will reduce isolation and provide a space for farmers to discuss shared challenges and solutions (Garrett-Wright and Malin, 2023a,b). The studies suggest that several methods, such as workshops and campaigns, can effectively address mental health issues related to farmer distress. By organizing group discussions and meetings at community centers, farmers can learn about the impacts of stress, warning signs of suicide, and develop communication skills. These initiatives can significantly improve understanding and support for mental health within the agricultural community (Cuthbertson C. et al., 2021). The studies have shown that participation in Farmer Field Schools (FFS) can enhance community acceptance and fulfill belongingness needs, potentially alleviating mental distress among farmers who feel disconnected from

their peers, thus promoting overall mental wellbeing (Charatsari et al., 2018a,b).

6.4 Legal domain

The strategies such as “Providing farmers with access to legal aid clinics or counselling services where they can receive guidance on their rights, entitlements, and legal options” were prioritized as it plays a crucial role in educating and assisting farmers with understanding their rights and navigating complex legal frameworks, which helps to empower them and protect their interests (Rinehart, 2023). Access to counselling services can alleviate stress by offering support in legal disputes, which are often sources of anxiety for farmers (Herlindah et al., 2025). Government interventions, including legal aid clinics and literacy programs, significantly empower farmers by clarifying their rights and entitlements, thereby helping to alleviate distress related to legal uncertainties and rights violations (Boone, 2019a,b). The other strategies such as “Simplify and streamline legal procedures related to land ownership, tenancy rights, and access to government support schemes” and “Implementing legal literacy programmes with the collaboration of NGOs, legal aid organizations, or agricultural cooperatives to teach basic legal concepts, procedures, and how to access legal resources” were given high importance by experts as legal procedures related to land ownership and tenancy rights can be streamlined to reduce bureaucratic hurdles, while collaboration between NGOs, legal aid organizations, and agricultural cooperatives in implementing legal literacy programs can enhance farmers’ understanding of basic legal concepts and resource access, which in turn alleviates psychological stress and supports mental wellbeing (Bojić-Bultrini et al., 2009).

6.5 Production domain

The strategies named “Introducing cover production risk by providing PMFBY and support schemes like RYTHU BANDHU (Andhra Pradesh) Yojana, KALIA Yojana (Orissa) etc.” and “Soil testing & distribution of soil health cards on a regular basis” were ranked as of high importance. It reflects recognition of risk management as fundamental to addressing farmer distress (Miranda and Farrin, 2012; Mahul and Stutley, 2010). The Pradhan Mantri Fasal Bima Yojana (PMFBY) was launched in 2016, which provides comprehensive crop insurance coverage against non-preventable risks, including droughts, floods, cyclones, hailstorms, pest attacks, and plant diseases from pre-sowing to post-harvest periods (PIB, 2025). PMFBY offers protection against crop losses due to natural disasters, pests, and diseases, which helps stabilize farmers’ incomes, and this scheme has seen a rise in farmer participation, indicating growing awareness and trust in the insurance model (Rudramuni and Venkatesh, 2024). The scheme has achieved significant coverage expansion, with over 5.5 crore farmer applications and claims worth ₹1,07,059 crore distributed since inception (PIB, 2025). The Soil Health Card (SHC) Scheme was introduced in India in 2015, which aims to distribute SHCs to farmers to improve soil health and agricultural productivity. It has been observed that regular soil testing and distribution of soil health cards help farmers optimize fertilizer use, enhancing productivity and sustainability. The studies also show that improved soil health leads to better crop yields, which can further alleviate farmer distress over time (Reddy, 2018).

6.6 Recommendations

Based on the comprehensive Fuzzy Delphi consensus analysis, encompassing 61 strategies across five critical domains, the following recommendations emerge from expert validation patterns, acceptance rates, and rejected strategies.

- 1 Prioritizing cooperative marketing initiatives over conventional banking solutions will empower farmers through collective bargaining power, which will help in enabling them to secure better prices for their produce, access credit at lower interest rates, and obtain quality inputs at bulk prices while eliminating exploitative intermediaries. The validation of subsidized life insurance strategies calls for an umbrella scheme for insurance products that will cover life, health, accident, and crop coverage under unified premium structures.
- 2 Financial literacy programs should be prioritized and tailored to help farmers understand a wide range of available financial tools, credit sources, and savings mechanisms in line with the famous Farmers’ Functional Literacy Program undertaken (FFLP) in 1967. Providing practical skills through participatory methods, such as evaluating loan options, managing personal and farm savings, and navigating insurance and government support schemes, through participatory methods will empower farmers to make informed decisions, strengthen their economic security, and reduce dependence on informal lenders.
- 3 Developing comprehensive market intelligence and AI-powered information networks that can provide real-time market data, demand forecasting, and buyer preferences through farmer-friendly mobile applications with voice-based interfaces in local languages. Simultaneously focusing on creating systematic direct marketing channels by developing farmer-to-consumer digital platforms will include urban farmer markets and cold chain networks, along with quality certification and premium pricing. There is a need for a shift from production-focused to market-oriented delivery that enables farmers to access better prices and reduce dependency on intermediaries.
- 4 Establishing Integrated Agricultural Mental Health Support Systems will include farmer wellness centers in every agricultural block, staffed with trained counsellors, which should operate through existing institutional networks, including cooperatives, self-help groups, and farmer-producer organizations. In addition, mental health education workshops and training programs should be conducted on a regular basis.
- 5 Creation of specialized legal aid systems designed specifically for farmers. This includes establishing farmer courts with simplified procedures, training agricultural lawyers in rural development issues, and creating mobile legal aid units that provide doorstep legal services in rural areas. There should be strong NGO-cooperative collaboration for legal literacy, including permanent partnerships between legal aid organizations and farmer institutions. These networks should develop context-specific legal education materials, conduct regular legal awareness campaigns on farm laws and other proceedings, and provide ongoing

legal support for farmers through trusted institutional channels.

- 6 Soil health card scheme requires transformation from periodic testing to continuous monitoring systems using digital technologies, satellite imagery, and IoT sensors. Soil health cards should evolve into dynamic and real-time advisory systems that provide season-specific recommendations through integrated digital platforms accessible via smartphones and local service centers.
- 7 Transforming existing agricultural service delivery systems into comprehensive farmer support centers that provide integrated services across all five domains. These centers should operate through convergence mechanisms involving government departments, civil society organizations, NGOs, farmer groups, and private sector entities to ensure farmers receive coordinated and comprehensive support.

7 Conclusion

Farmers' distress is an ever-present phenomenon, especially among farmers of developing and underdeveloped countries, given the nature of agriculture, which cannot be equated with any fully commercial operations. The scarcity of resources, given the huge number of people dependent on agriculture in India, and the transformative pressure on farmers from both the family and market sides start and sustain the phenomenon of farmers' distress, which often remains undetected. Thus, instead of becoming reactive to certain farmer distress incidents, which often manifest themselves in the form of self-harm, the policymaker should become proactive to implement strategies to nip it in the bud. The efforts to alleviate distress must therefore emphasize adaptability, inclusiveness, and ongoing stakeholder consultation. This study, through a fuzzy Delphi framework, brings together expert consensus to illuminate pathways that are both evidence-based and contextually grounded. Across the five domains, the financial emerged as the most consistently accepted domain, indicating that financial vulnerability is perceived as the most immediate and critical driver of farmer distress. The validation of 47 actionable strategies across five domains underscores the necessity of integrated policy frameworks rather than fragmented interventions. The findings reveal that sustainable solutions must move beyond temporary relief measures to embrace long-term resilience—through cooperative marketing, inclusive financial protection, strengthened legal support, and community-based mental health systems. The key findings of this study indicate that farmer distress is driven not by a single factor but by the cumulative interaction of market failures, financial vulnerability, legal uncertainty, institutional gaps, and inadequate mental health support. The fuzzy Delphi analysis revealed strong expert consensus on strategies that prioritize collective action, institutional convergence, and preventive support mechanisms, while standalone awareness-based or short-term relief measures showed limited effectiveness. The recommendations proposed in this study directly emerge from these validated findings and are intended to guide policymakers toward integrated, participatory, and long-term interventions that address both the causes and consequences of farmer distress. The present study presents a policy checklist and

dynamic roadmap for strengthening resilience and wellbeing in rural India. Ultimately, this research advocates for a paradigm shift: from viewing farmer distress as an episodic crisis to addressing it as a structural and societal phenomenon demanding collective action. Embedding these expert-driven strategies within national policy can foster a more equitable, resilient, and sustainable agricultural system—where sustainability is measured by both the productivity and wellbeing of farmers.

Data availability statement

The original contributions presented in the study are included in the article/[Supplementary material](#), further inquiries can be directed to the corresponding authors.

Ethics statement

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. Written informed consent from the [patients/participants OR patients/participants legal guardian/next of kin] was not required to participate in this study in accordance with the national legislation and the institutional requirements.

Author contributions

SuR: Formal analysis, Writing – original draft, Software, Data curation, Methodology, Conceptualization, Resources, Writing – review & editing, Investigation. SM: Validation, Writing – original draft, Supervision, Data curation, Methodology, Software, Conceptualization, Writing – review & editing. LK: Data curation, Writing – review & editing. MC: Data curation, Conceptualization, Writing – review & editing. WA: Resources, Writing – review & editing, Validation. BJ: Writing – review & editing, Supervision, Resources. SG: Validation, Supervision, Writing – review & editing. ShR: Supervision, Writing – review & editing.

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Conflict of interest

The author(s) declared that this work was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/fsufs.2026.1735782/full#supplementary-material>

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