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Prioritisation of Distress Coping Strategies for Farm Households in the Cauvery Basin, India- Analytical Hierarchy Process

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Research Article

Keywords: Agrarian distress, Coping strategies, Analytical hierarchy process, Cauvery basin, Farmer suicides

Posted Date: November 13th, 2026

DOI: https://doi.org/10.21203/rs.3.rs-11502433/v1

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Additional Declarations: No competing interests reported.

TITLE PAGE

Prioritisation of Distress Coping Strategies for Farm Households in the Cauvery Basin, India- Analytical Hierarchy Process

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Acknowledgements

We thank the ICAR- Indian Agricultural Research Institute for providing research facilities. We are grateful to the farmers of the Cauvery River Basin for their valuable response during the data collection and grateful to the Division of Agricultural Extension, ICAR-IARI, for their support.

Prioritisation of Distress Coping Strategies for Farm Households in the Cauvery Basin, India—Analytical Hierarchy Process

Abstract

Agrarian distress in the Cauvery basin of southern India has culminated in a high incidence of farmer suicides, yet little is known about how farm households cope with it. This study prioritised the distress-coping strategies of farm households in the suicide-prone districts of Mysuru and Mandya in the upper basin (Karnataka) and Tiruvarur and Nagapattinam in the lower basin (Tamil Nadu), via the analytical hierarchy process (AHP). Twenty strategies under four domains (farm-level, institutional, livelihood and financial) were structured into a three-level hierarchy, and the pairwise judgments of 400 randomly selected farmers, elicited on Saaty's 1–9 scale, were aggregated by the geometric mean; every comparison matrix was consistent (consistency ratio < 0.10). Financial coping emerged as the most important domain (0.31), followed by institutional (0.25), livelihood (0.23) and farm-level adaptation (0.21). Asset selling and informal borrowing were the foremost strategies overall (0.08 each), followed by crop insurance, livestock rearing and formal credit (0.07), whereas personal savings and health schemes ranked last (0.01). The results show that households cope by drawing down their assets and incurring high-cost debt rather than by adapting their farming, and that institutional support, namely crop insurance, employment guarantee work, and relief measures, is the principal external buffer. Timely institutional credit and insurance, assured water availability, assured remunerative prices for their produce, marketable alternative crops, and stronger health and education safety nets are needed to move households from erosive coping to resilient adaptation.

Keywords: Agrarian distress; Coping strategies; Analytical hierarchy process; Cauvery basin; Farmer suicides

1 Introduction

Agriculture continues to sustain the livelihoods of the majority of rural households, engaging 54.6% of the country's workforce (Census of India 2011) and accounting for nearly 17.9% of the gross value added at current prices (National Statistics Office 2025). Investment in agriculture and the allied sector also yields high returns: every rupee invested in agricultural research and education is estimated to return ₹13.85 (Ministry of Finance 2022-23). However, these aggregate gains have not translated into secure livelihoods for the farmers who generate them. While agriculture demonstrably contributes to national food security and economic growth, structural vulnerabilities continue to undermine the welfare of those who sustain it. Paradoxically, the sector remains marked by widespread distress, particularly among small and marginal farmers (Kennedy and King 2014).

In this study, a distressed farmer is operationally defined as one who experiences repeated income losses and psychological stress arising from crop failure, weather uncertainty, high cultivation costs,

market fluctuations or failed investments, which impair the ability to meet financial obligations and household needs; such farmers may face humiliation from moneylenders or creditors and, in the absence of effective coping mechanisms, may contemplate or commit suicide. The gravity of this outcome is evident in India, where suicides in the farming sector (farmers and agricultural labourers) totalled at least 394,000 between 1995 and 2023, underscoring both the severity and the complexity of agrarian distress (Shagun 2025). As reflected in the definition above, such suicides seldom stem from a single cause; rather, they result from the interplay of inadequate resources, poverty, unemployment, social isolation, indebtedness, limited access to credit, crop failure, falling crop prices, and environmental stressors such as failure of monsoons, recurring drought, erratic rainfall, weather uncertainties, and weak institutional support systems (Kaur and Mehra 2018; Merriott 2016; Pouchepparadjou et al. 2025). The cumulative impact of these stressors leads to poor mental health and emotional breakdowns among farmers (Bomble and Lhungdim 2020). Farmer distress, therefore, is not just an economic condition but also a multidimensional crisis that affects overall well-being, dignity, and, in extreme cases, life itself (Reddy et al. 2021).

The Cauvery River supplies drinking water, irrigation, and electricity, and it has sustained the livelihood and food security of a large farming population in its basin, estimated at 4.4 million people (Brema et al. 2021). However, the region is now in agrarian distress. The failure or delay of monsoon rains, recurrent drought, untimely water releases, floods and cyclones, and market failure that leaves farmers with falling and unremunerative prices have eroded farm incomes (Ashwini 2018; Sabarisakthi 2019; Vignesh Kumar and Karthikeyan 2017; George et al. 2021; Adityan et al. 2026). The basin in Karnataka and parts of Tamil Nadu is semiarid, with average annual rainfall of 600–800 mm (Chidambaram et al. 2018), so farmers depend heavily on timely monsoon rains and on water released from upstream, while siltation, declining capacity and quality of water bodies, and the discharge of untreated waste have further reduced the water available for cultivation (Sharma et al. 2024). Small and marginal farmers, whose capacity to cope with these shocks is limited, are pushed into debt and, in the worst cases, end their lives (Kennedy and King 2014; Kumar 2020). This distress is reflected in the data of the National Crime Records Bureau (NCRB), which recorded 2,423 suicides in the farming sector (1,425 farmers and 998 agricultural labourers) in Karnataka and 631 (67 farmers and 564 agricultural labourers) in Tamil Nadu in 2023 (NCRB 2025).

In the upper basin, Mandya and Mysuru districts of Karnataka cultivate commercial crops such as sugarcane and tobacco and depend heavily on canal and rain-fed irrigation. Commercial crops require many resources for cultivation, and farmers often borrow money for cultivation; however, farmers remain weak actors in value chains dominated by traders and manufacturers, and they are exposed to falling and unremunerative prices for their produce (Ashwini 2018; Deshpande 2002). A decrease in rainfall compounds this market risk. The upper subbasin recorded a 17.31% rainfall deficit from 2000–2023 (India Meteorological Department 2023). Moreover, untimely and inadequate water

release from the dam, canal sedimentation, and rising labour costs constrain production (Venkataramana et al. 2020). These regions are heavily affected by farmer suicides; victim households rely heavily on high-interest noninstitutional credit for the cultivation of commercial crops and become indebted when crop failure or distress sales occur (Kumar 2020).

In the downstream Tiruvarur and Nagapattinam delta districts of Tamil Nadu, 90% of small and marginal farmers depend on the northeast monsoon and water released from Karnataka. Delayed southwest monsoon rains and late upstream releases disrupt the sowing of paddy, and prolonged northeast monsoon rains now extend into the harvest season and cause damage (Adityan et al. 2026). Farmers have altered sowing practices and cropping patterns in response to water stress (Nair et al. 2024). The delta is also highly exposed to Bay of Bengal cyclones. Cyclone Gaja occurred in 2018 and made landfall in Nagapattinam and Tiruvarur, severely damaging approximately 40% of the vegetation and crops, and the cyclone caused significant rice and coconut losses across coastal districts of the delta (George et al. 2021; Sawant et al. 2019). Repeated cyclones, droughts, and heatwaves deplete farmers' adaptive capacity before households can recover (Balaselvakumar and Hemavarthinii 2026). Groundwater dependence and aquifer salinisation add to this stress (Prayag et al. 2023), and water scarcity and drought remain the principal drivers of farm crises and suicides in the delta region (Sabarisakthi 2019; Vignesh Kumar and Karthikeyan 2017).

Agrarian distress in the Cauvery basin is exacerbated by multiple phenomena. Strategies are therefore needed to assist in coping with and adapting to a wide range of stressors that affect small-scale agriculture, which is a source of food and livelihood for rural communities. To address this, the coping and adaptation strategies used by farmers should be prioritised to identify those that farmers can implement with positive benefits. Coping refers to short-term responses to the impacts of stressors, whereas adaptation refers to longer-term adjustments to more permanent changes (Van der Geest and Warner 2015). Coping is oriented towards survival, is not continuous, is motivated by crisis, often degrades the resource base, and is prompted by a lack of alternatives (Daze et al. 2009). Adaptation is continuous, oriented toward long-term livelihood security, uses resources efficiently and sustainably, involves planning, combines old and new strategies/knowledge, and is focused on finding alternatives (Daze et al. 2009). Farmers must make decisions to exploit the potential benefits and reduce the deleterious impacts. These decisions involve choices between various coping and adaptation options (Willows et al. 2003). Even though all farmers experience the same weather stimuli, there is great diversity in the ways each farmer copes with weather variability and the factors that drive decisions to adapt (Jain et al. 2015). Therefore, this study sought to understand multicriteria decision-making regarding the adoption of different coping and adaptation strategies by the farming community in suicide-prone areas of the Cauvery basin. In this study, the analytical hierarchy process (AHP), a multicriteria decision-making tool, was used to identify the most suitable coping and

adaptation strategies for dealing with these stressors. The findings of this study should help policymakers formulate distress-mitigating adaptation plans for the Cauvery basin.

2 Materials and methods

2.1 Study area

The Cauvery River Basin is one of the most important river systems in southern India. It supports irrigated agriculture, the drinking water supply, hydropower generation and the livelihoods of a large agrarian population. The Cauvery River is an east-flowing river of Peninsular India, and its basin extends across Karnataka, Tamil Nadu and Kerala and the Union Territory of Puducherry, covering approximately 2.7% of the country's total geographical area. It is considered the fourth largest river in southern India. Rising in the Western Ghats, it flows for approximately 800 km across the Mysore Plateau before forming an extensive delta along the eastern coast and draining into the Bay of Bengal. The present study was conducted in 2026 in the upper basin in Karnataka and the lower basin in Tamil Nadu (Fig. 1). These regions were purposively selected because of the high incidence of suicides in the farming sector reported in 2023 (2,423 cases in Karnataka and 631 in Tamil Nadu; NCRB 2025).

2.2 Sample size and sampling technique

A multistage sampling procedure was adopted for the study. First, data on farmers' deaths and suicides in the Cauvery basin districts of Karnataka and Tamil Nadu for the ten-year period 2016–2025 were obtained through applications under the Right to Information (RTI) Act, 2005. From these data, the two districts in each state that reported the highest number of farmer suicides were purposively selected: Mysuru and Mandya in Karnataka and Tiruvarur and Nagapattinam in Tamil Nadu. Second, two blocks were randomly selected from each district. Finally, 50 farmers were randomly selected from each block, resulting in a total sample of 400 farmers.

Primary data were collected via pretested structured and semi-structured interview schedules, observation methods, participatory rural appraisal techniques, and focus group discussions.

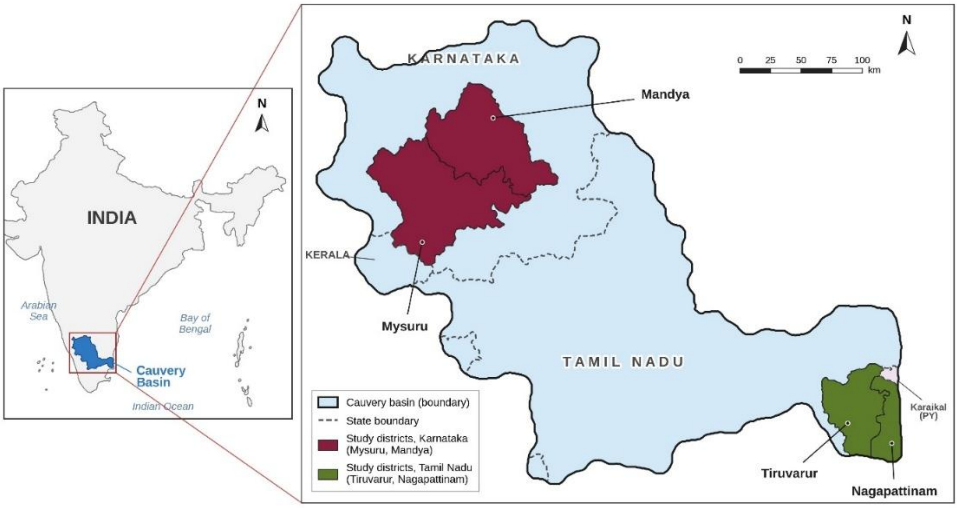


Fig. 1 Location map of the study area showing the selected districts of Mysuru and Mandya (upper Cauvery basin, Karnataka) and Tiruvarur and Nagapattinam (lower Cauvery basin, Tamil Nadu)

2.3 Analytical hierarchy process

The analytical hierarchy process (AHP), developed by Saaty (1980), is a multicriteria decision-making technique that decomposes a complex decision problem into a hierarchy of goals, criteria and alternatives and derives the relative importance of the elements at each level from pairwise comparisons. Because it combines subjective judgments with an explicit test of their consistency, the AHP has been widely used to prioritise options in agriculture, natural resource management and environmental planning (Saaty 2008). In the present study, the AHP was employed to prioritise the coping and adaptation strategies adopted by farm households in the Cauvery basin in response to agrarian distress. The analysis followed six sequential steps, which are presented schematically in Fig. 2 and described below.



Fig. 2 Stepwise procedure of the analytical hierarchy process (AHP) followed in the study

2.3.1 Step 1: Problem modelling

The decision problem was structured as a three-level hierarchy (Fig. 3). The goal of coping with farm distress was placed at the apex (Level 1). The second level comprises four coping domains, viz. farm-level adaptation, institutional adaptation, livelihood adaptation and financial coping. The third level comprises five strategies under each domain, resulting in a total of 20 coping strategies. The strategies under each domain were selected on the basis of the coping and adaptation practices most commonly followed by the sample households.

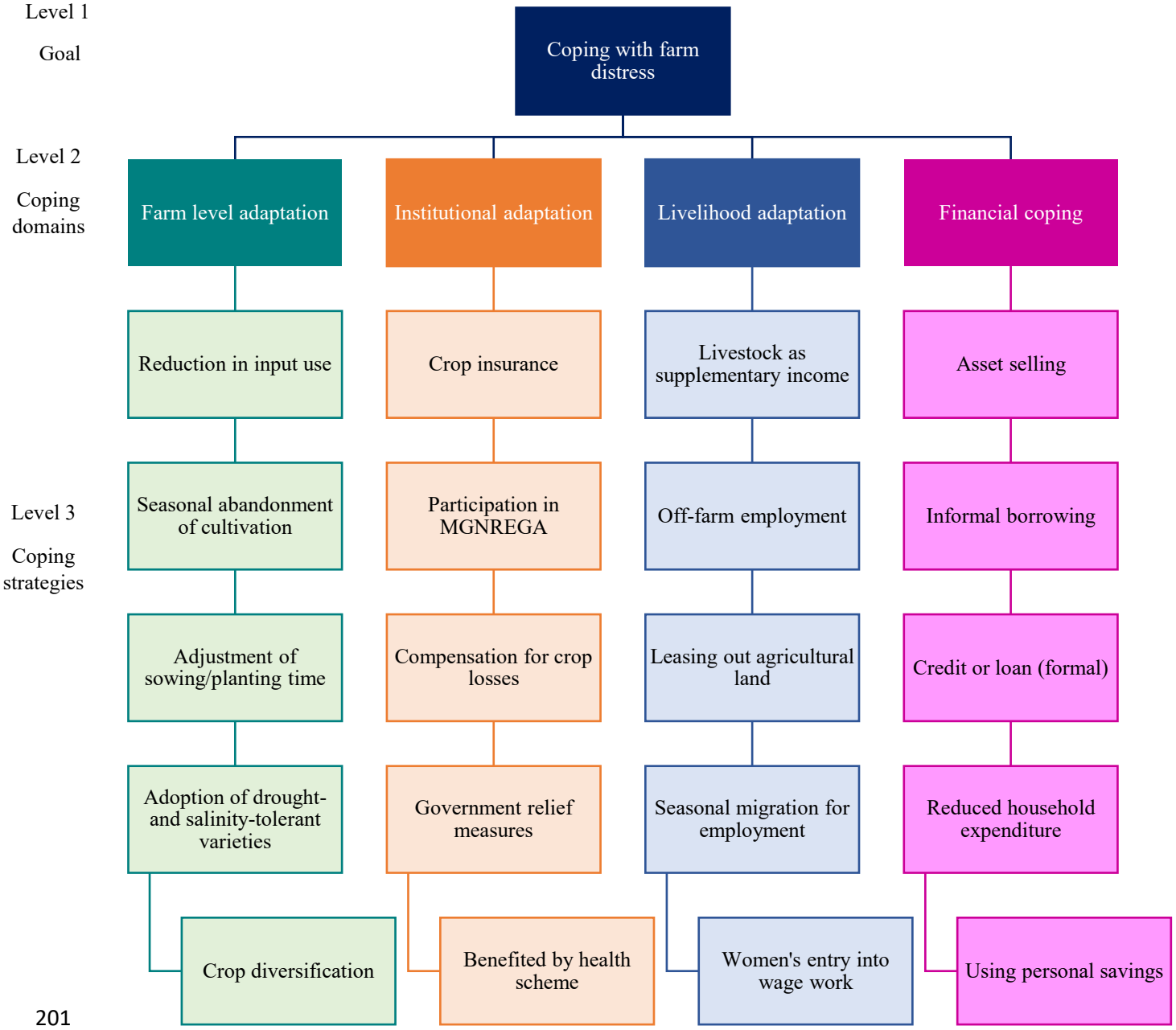


Fig. 3 Hierarchical structure of the AHP model for prioritising the distress-coping strategies of farm households in the Cauvery basin. MGNREGA, Mahatma Gandhi National Rural Employment Guarantee Act

2.3.2 Step 2: Pairwise comparison

Each respondent compared the four domains with one another (six comparisons) and the five strategies within each domain with one another (ten comparisons per domain), yielding 46 judgments per respondent and 18,400 judgments in all. For every set of n elements, the judgments form a square reciprocal comparison matrix A (Eq. 1):

$$A = [a_{ij}] = \begin{bmatrix} 1 & a_{12} & \cdots & a_{1n} \\ \frac{1}{a_{12}} & 1 & \cdots & a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ \frac{1}{a_{1n}} & \frac{1}{a_{2n}} & \cdots & 1 \end{bmatrix} \quad (1)$$

where a_{ij} denotes the relative importance of element *i* over element *j*, with $a_{ii} = 1$ and $a_{ji} = 1/a_{ij}$.

2.3.3 Step 3: Judgmental scale

The judgments were elicited on Saaty's fundamental scale of 1–9 (Table 1), in which verbal expressions of preference are converted into integers according to the intensity of importance of one element over another. A value of 1 denotes equal importance, and 9 denotes the extreme importance of one element over the other, while 2, 4, 6 and 8 are intermediate values. If strategy *i* was preferred over strategy *j* with an intensity of *a*, then *j* relative to *i* was assigned the reciprocal value 1/*a*.

Table 1 Saaty's fundamental scale for pairwise comparison (Saaty 1980, 2008)

Intensity of importance	**Definition**	**Explanation**
1	Equal importance	Both elements contribute equally to the objective
3	Moderate importance	Experience and judgment slightly favour one element over the other
5	Strong importance	Experience and judgment strongly favour one element over the other
7	Very strong importance	One element is favoured very strongly over the other; its dominance is demonstrated in practice
9	Extreme importance	The evidence favouring one element over the other is of the highest possible order of affirmation
2, 4, 6, 8	Intermediate values	Used when a compromise between two adjacent judgments is needed
Reciprocals (1/2…1/9)	Inverse comparison	If element *i* receives one of the above values compared with element *j*, then *j* receives the reciprocal value compared with *i*

2.3.4 Step 4: Aggregation of judgments

The individual comparison matrices of the 400 respondents were combined into a single group matrix for each comparison set by aggregating individual judgments (AIJ) through the geometric mean (Eq. 2). The geometric mean is the recommended aggregation rule for the group AHP because it preserves the reciprocal property of the comparison matrix (Aczél and Saaty 1983; Forman and Peniwati 1998):

$$a_{ij}^{G} = \left(\prod_{k=1}^{K} a_{ij}^{(k)}\right)^{\frac{1}{K}} \quad (2)$$

where $a_{ij}^{(k)}$ is the judgment of the *k*th respondent, a_{ij}^{G} is the aggregated (group) judgment and *K* is the number of respondents (400).

2.3.5 Step 5: Determination of the consistency ratio

Each aggregated matrix was normalised by dividing every entry by its column total, and the priority vector *w* was obtained as the row mean of the normalised matrix (Eq. 3). The principal eigenvalue, λ_{max}, was then estimated (Eq. 4), and the consistency of the judgments was assessed through the consistency index (CI) and the consistency ratio (CR) (Eqs. 5 and 6):

$$w_i = \frac{1}{n}\sum_{j=1}^{n} \frac{a_{ij}}{\sum_{i=1}^{n} a_{ij}},\ i = 1, 2, \ldots, n \quad (3)$$

$$\lambda_{\max} = \frac{1}{n}\sum_{i=1}^{n} \frac{(Aw)_i}{w_i} \quad (4)$$

$$\mathrm{CI} = \frac{\lambda_{\max} - n}{n-1} \quad (5)$$

$$\mathrm{CR} = \frac{\mathrm{CI}}{\mathrm{RI}} \quad (6)$$

where w_i is the priority of element *i*, $(Aw)_i$ is the *i*th element of the product of the comparison matrix and the priority vector, *n* is the number of elements compared, and RI is the random index, which is taken as 0.90 for $n = 4$ and 1.12 for $n = 5$ (Saaty 1980). A CR below 0.10 indicates an acceptable level of consistency; all the comparison matrices in the present study satisfied this criterion (Tables 2 and 3).

2.3.6 Step 6: Calculation of priorities

The priority vector of the domain matrix provides the weight of each domain, and the priority vectors of the four strategy matrices provide the local priority of each strategy within its domain. The overall (global) priority of a strategy was obtained by multiplying its local priority by the scaling factor, i.e., the weight of the domain to which it belongs (Eq. 7), so that the overall priorities of all 20 strategies sum to unity:

$$\mathrm{OP}_{ij} = \mathrm{SF}_j \times \mathrm{LP}_{ij} \quad (7)$$

where OP_{ij} is the overall priority of strategy *i* in domain *j*, SF_j is the scaling factor (priority weight) of domain *j,* and LP_{ij} is the local priority of strategy *i* within domain *j*. The strategies are then ranked in descending order of overall priority.

3 Results and discussion

3.1 Priority weights of the coping domains

The relative importance that the sample households attached to the four coping domains is presented in Table 2 and Fig. 4b. The aggregated domain matrix returned a λmax of 4.03, a CI of 0.009 and a CR of 0.010, indicating a high degree of consistency in the pooled judgments. Financial coping emerged as the most preferred domain (0.31), followed by institutional adaptation (0.25), livelihood adaptation (0.23) and farm-level adaptation (0.21). The primacy of financial coping indicates that households in the basin respond to distress chiefly through immediate monetary measures, such as the sale of assets and borrowing from formal and informal sources, to meet their consumption and cultivation needs. Adjustments made on the farm itself carry the least weight in their immediate response. The second position of institutional adaptation suggests that institutional support, such as crop insurance, employment under the Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA), relief measures and compensation for crop losses, forms the principal external buffer available to these households. Livelihood adaptation ranked third, closely behind institutional adaptation. This finding indicates that households also cope by diversifying their sources of income beyond crop cultivation, mainly through livestock rearing, off-farm employment, agricultural land leasing, and seasonal migration (Table 3). However, its lower weight than financial coping implies that such diversification is a secondary rather than a primary response to distress**.**

Table 2 Priority weights of the coping domains of farm households in the Cauvery basin (n = 400)

Coping domain	Priority weight	Rank	λmax	CI	CR
Farm-level adaptation	0.21	IV	4.03	0.009	0.010
Institutional adaptation	0.25	II			
Livelihood adaptation	0.23	III			
Financial coping	0.31	I			
Total	1.00				

λ_{max}, principal eigenvalue of the aggregated 4 × 4 domain comparison matrix; CI, consistency index = $(\lambda_{max} - n)/(n - 1)$; CR, consistency ratio = CI/RI, with random index (RI) = 0.90 for n = 4. CR < 0.10 indicates an acceptable level of consistency in the pairwise judgments. Ranks are assigned in descending order of priority weight (I = highest).

3.2 Priority weights of the distress coping strategies under different domains

Several coping and adaptation strategies were identified within each domain. The data in Table 3 present the local priority of each strategy within its domain, its overall priority, and the resulting overall rank, and Fig. 4a arranges the 20 strategies in descending order of overall priority. The consistency ratios of the four strategy matrices ranged from 0.005–0.013, well within the acceptable limit. The strategies are discussed domainwise in the following sections.

Table 3 Priority weights and overall ranks of the distress-coping strategies of farm households in the Cauvery basin (n = 400)

Coping domain	Scaling factor (SF)	CR	Coping strategy	Priority within domain (LP)	Overall priority (OP)	Overall rank
Farm level adaptation	0.21	0.005	Reduction in input use	0.28	0.06	III
			Seasonal abandonment of cultivation	0.25	0.05	IV
			Adjustment of sowing/planting time	0.19	0.04	V
			Adoption of drought- and salinity-tolerant varieties	0.15	0.03	VI
			Crop diversification	0.14	0.03	VI

Institutional adaptation	0.25	0.012	Crop insurance	0.29	0.07	II
			Participation in MGNREGA	0.25	0.06	III
			Compensation for crop losses	0.24	0.06	III
			Government relief measures	0.17	0.04	V
			Benefited by health scheme	0.05	0.01	VIII
Livelihood adaptation	0.23	0.013	Livestock as supplementary income	0.29	0.07	II
			Off-farm employment	0.23	0.05	IV
			Leasing out agricultural land	0.22	0.05	IV
			Seasonal migration for employment	0.17	0.04	V
			Women's entry into wage work	0.08	0.02	VII
Financial coping	0.31	0.005	Asset selling	0.27	0.08	I
			Informal borrowing	0.26	0.08	I
			Credit or loan (formal)	0.23	0.07	II
			Reduced household expenditure	0.20	0.06	III
			Using personal savings	0.04	0.01	VIII

SF, scaling factor, i.e., the priority weight of the domain (Table 2); LP, local priority of the strategy within its domain; OP, overall priority = SF × LP. CR, consistency ratio of the 5 × 5 strategy comparison matrix of each domain, with a random index (RI) = 1.12 for $n = 5$; CR < 0.10 indicates acceptable consistency. Overall ranks (I = highest) are assigned on overall priorities rounded to two decimal places; strategies with equal overall priority share a rank. Local priorities within a domain may not sum exactly to 1.00 owing to rounding. MGNREGA, Mahatma Gandhi National Rural Employment Guarantee Act.

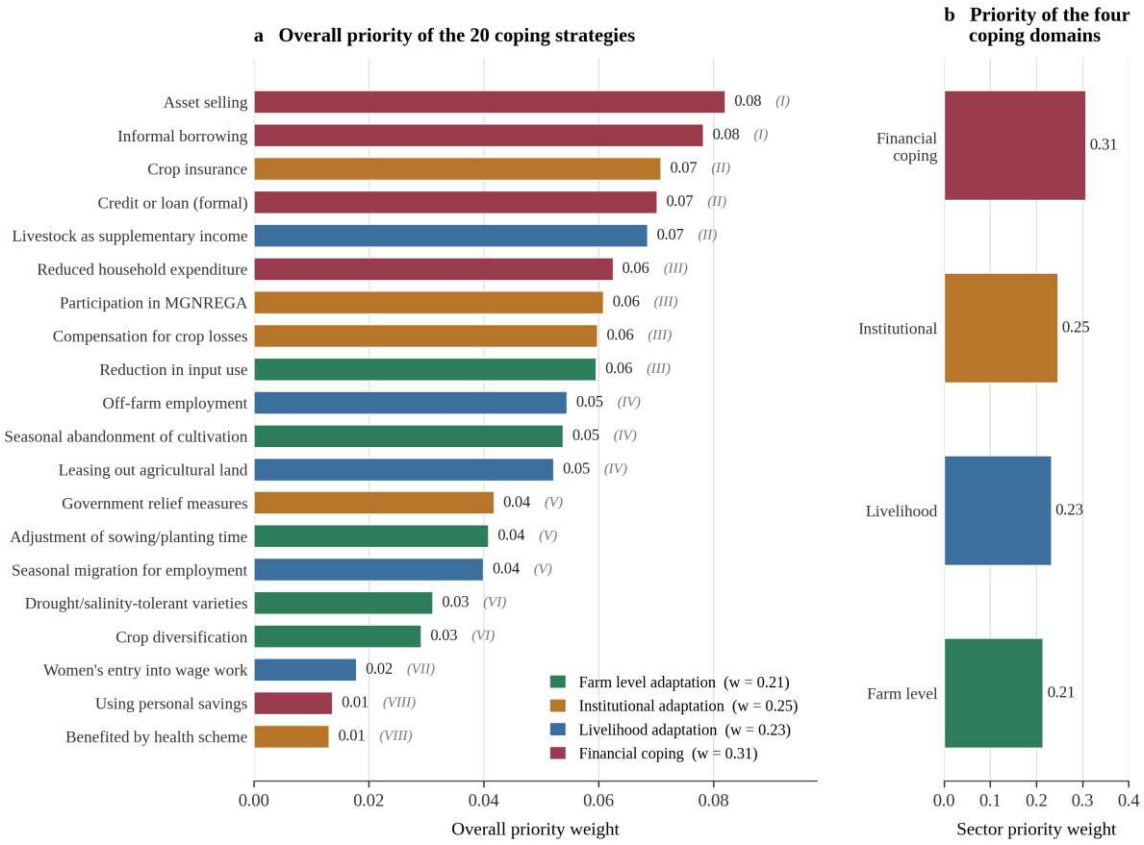


Fig. 4 Priority weights of the distress-coping strategies of farm households in the Cauvery basin. (a) Overall priority of the 20 coping strategies, arranged in descending order and coloured by domain; Roman numerals in parentheses denote the overall rank. (b) Priority weights of the four coping domains. Weights were derived through AHP from the pairwise judgments of 400 farm households in the Mysuru and Mandya (Karnataka) districts and the Tiruvarur and Nagapattinam (Tamil Nadu) districts; CR < 0.10 for every comparison matrix

3.2.1 Major coping strategies in the financial domain

Financial coping was not only the highest-weighted domain (SF = 0.31) but also contributed four of the ten highest-ranked strategies in the overall hierarchy (Table 3; Fig. 4a); the strategy matrix for this domain returned a CR of 0.005. Among all 20 strategies, asset selling (local priority 0.27; overall priority 0.08) and informal borrowing (0.26; 0.08) were ranked first. The respondents described asset disposal as a graded response: gold and jewellery are pledged or sold first, followed by livestock, while farm machinery such as tractors and, ultimately, parcels of land are sold only when other options are exhausted. Pledging jewellery was preferred because it is quick, requires no documentation, and leaves open the possibility of redemption, whereas the sale of land and machinery was described as irreversible. Similar liquidation of productive assets to service debt has been

reported among suicide-affected households in Karnataka (Deshpande 2002) and among farm households in coastal Odisha after disasters (Padhan and Madheswaran 2023). Such responses typify what Warner and van der Geest (2013) term erosive coping: they relieve immediate pressure but deplete the asset base on which the household's future income and resilience depend.

The high priority given to informal borrowing reflects the continued dependence of the sample households on moneylenders, input dealers, commission agents and relatives. Loans from moneylenders and traders were reported to carry interest rates far above institutional rates and were frequently tied to the sale of produce, whereas loans from relatives carried little or no interest but were limited in size and duration. Informal lenders were nevertheless preferred for their timeliness, the absence of collateral and their willingness to lend for consumption, medical needs and ceremonial needs that formal institutions do not finance. Nationally, noninstitutional sources still account for approximately 30% of the outstanding debt of agricultural households, and professional moneylenders alone account for approximately one-fifth (National Statistics Office 2021). The link between high-cost informal debt and farmer suicides is well established: indebted cash-crop farmers with marginal holdings explain much of the interstate variation in suicide rates (Kennedy and King 2014), and the humiliation associated with default to moneylenders is a recurrent theme in accounts of suicide-affected households (Mohanty 2005; Kumar 2020).

Credit from formal sources (0.23; 0.07; rank II) comprised crop loans from primary agricultural cooperative credit societies, the Kisan Credit Card (KCC) limits from commercial banks and, in the perception of the respondents, the Pradhan Mantri Kisan Samman Nidhi (PM-KISAN) income transfer, which they treated as part of the same institutional financial cushion. Access to a KCC has been shown to reduce dependence on moneylenders by approximately one quarter (Kumar et al. 2023), and PM-KISAN eases the liquidity constraint of farmers with poor access to credit at the time of sowing (Varshney et al. 2020). Formal credit is nevertheless ranked below informal borrowing because loan limits are tied to the scale of finance rather than to actual needs, disbursement is often delayed beyond the sowing window, households with overdue loans are ineligible for fresh credit, and tenant cultivators, who are numerous in the delta, are excluded altogether.

Reduced household expenditure (0.20; 0.06; rank III) took three main forms: withdrawing children from fee-charging private schools and enrolling them in government schools; postponing medical treatment and elective health expenditure; and curtailing spending on food quality, clothing and social ceremonies. These adjustments protect the household's cash flow but transfer the cost of the shock to its human capital. Rural Indian households are known to reduce children's schooling in response to unanticipated income shocks (Jacoby and Skoufias 1997), and deferred treatment frequently culminates in hospitalisation financed through borrowing or the sale of assets (Kastor and Mohanty 2018). Using personal savings recorded the lowest priority in the domain (0.04; 0.01; rank VIII).

Rather than indicating an aversion to drawing on savings, this reflects their absence: successive crop losses exhausted whatever reserves the households possessed, and with an average monthly income of approximately ₹10,000 per agricultural household in the country (National Statistics Office 2021), the margin available for saving was minimal. The order of preference within the financial domain therefore describes a descending ladder of liquidity in which savings are consumed first, followed by borrowing and, finally, the disposal of assets.

3.2.2 Major adaptation strategies in the farm-level domain

Farm-level adaptation received the lowest domain weight (SF = 0.21; CR = 0.005), and none of its strategies ranked above third overall (Table 3). Within the domain, the reduction in input use held the highest local priority (0.28; overall priority 0.06; rank III). Households reported cutting the number of fertiliser applications and the quantity applied per hectare, reducing plant protection sprays and substituting family labour for hired labour. The immediate driver was the rising cost of cultivation, particularly of fertilisers, relative to stagnant output prices. The squeeze is well documented: the cost of cultivation data show that the real profitability of most crops in India has declined as input costs have risen faster than farm-harvest prices (Narayanamoorthy 2013), and the profitability of the principal crops of the Cauvery basin of Karnataka has been found to be marginal or negative once imputed costs are included (Ashwini 2018). Reducing inputs lowers cash outlay in the short run but depresses yield and may accelerate the depletion of soil nutrients, so it is also a form of erosive coping rather than adaptation.

Seasonal abandonment of cultivation (0.25; 0.05; rank IV) was the most visible farm-level response in the basin. In the delta, the kuruvai (June–September) paddy crop depends on the release of water from the Mettur Reservoir, which in turn depends on inflows from Karnataka and on the southwest monsoon; when the release is delayed or inadequate, farmers leave the land fallow and wait for the samba season, which is fed by the northeast monsoon. In the upper basin, farmers at the tail ends of the canal commands similarly forgo a season when supply is curtailed by untimely or inadequate releases (Venkataramana et al. 2020). Reduced canal flows, resulting in fallowing and a shift to groundwater, have been documented across the delta (Nair et al. 2024; Prayag et al. 2023). Abandoning a season avoids the loss of inputs on a crop that cannot be irrigated to maturity, but it also removes an entire season's income for the household and employment for agricultural labourers.

The sowing and planting times (0.19; 0.04; rank V) were adjusted by staggering nursery raising and transplanting to coincide with the onset of rainfall, the announced date of canal release and the expected behaviour of the monsoon; some households reported switching from transplanting to direct seeding to shorten the crop duration once water became available. Farmers in the delta have been shown to modify sowing practices and cropping calendars in response to water stress and market signals (Nair et al. 2024), and the timing of monsoon onset is a principal determinant of such

decisions elsewhere in India (Jain et al. 2015). The adoption of drought- and salinity-tolerant varieties (0.15; 0.03; rank VI) ranked lower despite widespread awareness of such varieties. The respondents explained that the grains of tolerant varieties fetch a lower price than do the fine-grained varieties preferred by traders and consumers and are less readily procured; thus, the agronomic advantage under stress is offset by a market penalty in normal years. The marketability of specific paddy varieties, given inadequate public procurement, has been identified as a decisive influence on variety choice in the delta (Nair et al. 2024), and the demand for stress-tolerant rice varieties has been found to be highly price-elastic and constrained by information about their traits (Varkey et al. 2023).

Crop diversification recorded the lowest priority in the domain (0.14; 0.03; rank VI). In the delta, heavy clay soils, waterlogging during the northeast monsoon, salinity in coastal tracts and the absence of assured procurement for alternative crops confine farmers to paddies; in the upper basin, the assured cane price and factory linkages have comparable lock-in effects on sugarcane. Diversification also requires planning, new skills and working capital that distressed households lack, which is why coping responses predominate over adaptation in such settings (Daze et al. 2009; Van der Geest and Warner 2015). The ordering within the farm-level domain thus confirms that households curtail expenditure on the existing crop and adjust its timing long before they restructure the cropping pattern.

3.2.3 Major adaptation strategies in the livelihood domain

Livestock as a supplementary source of income (0.29; 0.07; rank II) was the most preferred strategy in the livelihood domain (SF = 0.23; CR = 0.013). Dairy animals, backyard poultry and small ruminants provide a regular cash flow from the sale of milk and eggs, absorb family labour during the fallow season and constitute a liquid asset that can be sold in an emergency. The stabilising role of milch animals in the incomes of farm households has long been recognised in peninsular India (Bhende and Venkataram 1994), and livestock diversification has been shown to increase the resilience of smallholders to drought (Kumar et al. 2020). Nationally, animal husbandry contributes approximately 15% of the income of agricultural households (National Statistics Office 2021).

Off-farm employment (0.23; 0.05; rank IV) took the form of petty trade, driving, construction work and casual wage employment in nearby towns and was undertaken by the household head or adult sons while the farm was retained. Nonfarm diversification is a well-established route out of poverty for rural households (Himanshu et al. 2013), and wage income now exceeds crop income in the average agricultural household in India (National Statistics Office 2021), a pattern that the sample households mirror. Leasing out agricultural land (0.22; 0.05; rank IV) was equally preferred. Households lease part or all of their holdings for fixed cash or kind rent because hired labour has become scarce and expensive, the household head is ageing, and sons are unwilling to cultivate. Leasing converts an uncertain crop income into an assured rent and releases family labour for other

work. The reluctance of educated rural youth to continue farming (Sharma and Bhaduri 2009; Nandi et al. 2022) and the consequent transfer of cultivation to lessees from labouring households (Mohanty and Lenka 2023) are increasingly reported across India, and the study area is no exception.

Seasonal migration for employment (0.17; 0.04; rank V) was directed mainly towards the knitwear and garment cluster of Tiruppur and the industrial belt around Coimbatore from the delta districts and towards Bengaluru and Mysuru city from Mandya and Mysuru districts. Young men migrate after the samba harvest and return for the next season, and their remittances are used to repay loans and finance cultivation. The Tiruppur cluster has long drawn on migrants from the agrarian districts of Tamil Nadu (De Neve 2003; Carswell and De Neve 2013), and seasonal migration is a characteristic coping strategy of poor and middle-income farm households after covariate shocks (Padhan and Madheswaran 2023). Women's entry into wage work (0.08; 0.02; rank VII) received the lowest priority in the domain. Women from distressed households took up agricultural wage labour, MGNREGA work and employment in nearby mills, but this was described as a late-stage response, adopted after the household's financial and institutional options had been drawn down. This finding is consistent with evidence that women's labour functions as insurance when male incomes fall (Bansal and Mahajan 2023) and that the increasing participation of women in agricultural work in India is largely a manifestation of agrarian distress rather than of empowerment (Abraham 2009; Pattnaik et al. 2018).

3.2.4 Major adaptation strategies in the institutional domain

Crop insurance (0.29; 0.07; rank II) was the most preferred strategy in the institutional domain (SF = 0.25; CR = 0.012). Coverage under the Pradhan Mantri Fasal Bima Yojana (PMFBY) is high among paddy growers in both states because enrolment is linked to crop loans, and respondents reported that the claims received after the 2016–17 drought and after Cyclone Gaja in 2018 (George et al. 2021) partly compensated for their losses. The scheme nonetheless attracted criticism for claims that were not triggered because losses were assessed over a unit area larger than the village and for settlements that arrived a year or more after the loss; these weaknesses are widely reported (Kaur et al. 2021; Tiwari et al. 2020), including among paddy farmers in Tamil Nadu (Paulraj and Easwaran 2020).

Participation in the MGNREGA (0.25; 0.06; rank III) and compensation for crop losses (0.24; 0.06; rank III) followed closely. The MGNREGA was valued because it provides assured wage employment close to the village during the lean season and because women members of the household can participate; respondents in the delta, in particular, described income as regular and dependable. Tamil Nadu is among the strongest implementers of the scheme, and it has functioned as a safety net that has raised rural wages and the bargaining power of labouring households (Carswell and De Neve 2014); more generally, the scheme has been shown to cushion rural households against rainfall shocks (Sarma 2022; Padhan and Madheswaran 2023). Compensation for crop losses refers to

454 the input subsidy and relief paid from the State and National Disaster Response Funds after floods and
455 cyclones, which respondents found helpful but small in relation to the loss and slow to arrive.
456 Government relief measures (0.17; 0.04; rank V), principally drought relief, interest waivers and
457 rescheduling of cooperative loans announced after the 2016–17 drought (Sabarisakthi 2019; Vignesh
458 Kumar and Karthikeyan 2017), ranked lower because they are episodic, depend on the formal
459 declaration of a calamity and reach households long after the distress has peaked.

460 Benefiting from a health scheme (0.05; 0.01; rank VIII) recorded the lowest priority in the entire
461 hierarchy, together with personal savings, even though both states operate publicly funded health
462 insurance (the Chief Minister's Comprehensive Health Insurance Scheme, merged with the Pradhan
463 Mantri Jan Arogya Yojana (PM-JAY), in Tamil Nadu and Ayushman Bharat–Arogya Karnataka in
464 Karnataka). The respondents attributed low use to limited awareness of their entitlements, the
465 exclusion of outpatient care and medicines, which constitute the bulk of their health spending, and the
466 distance to empanelled hospitals. Awareness of PM-JAY is markedly lower among the poorest and
467 least educated households (Parisi et al. 2023), and hospitalisation continues to be financed largely
468 through borrowing and the sale of assets (Kastor and Mohanty 2018). Given that medical expenditure
469 was one of the reasons households cited for curtailing other spending and for borrowing, the
470 negligible weight of health protection points to a significant gap in the institutional safety net.

471 **3.3 Policy implications**

472 The prioritisation reveals a coping hierarchy in which the responses on which households rely most,
473 asset disposal, informal debt and expenditure cuts, are precisely those that erode their future capacity,
474 whereas the responses that build resilience, diversification and planned adaptation are the least
475 preferred. Policies should therefore aim to move households up this hierarchy, from erosive coping to
476 protective and adaptive responses. Several implications follow.

477 First, the dependence on asset sales and informal credit calls for a widening of timely institutional
478 credit. KCC coverage should be extended to tenant cultivators through joint liability groups and lease
479 certificates, a consumption component should be built into crop loans, and the loans of households in
480 a calamity-declared area should be restructured automatically rather than through ad hoc waivers.
481 Cooperative societies could offer gold-backed loans at concessional rates so that households pledge
482 jewellery within the formal system rather than with moneylenders.

483 Second, the institutional support that households already trust, such as crop insurance, MGNREGA
484 employment, relief measures and compensation for crop losses, needs to be delivered faster. Claims
485 under PMFBY should be settled within the season through village-level yield assessment supported
486 by remote sensing, and a trigger linked to the non-release of canal water would address the principal
487 source of loss in the delta. MGNREGA entitlements should be raised in drought-declared blocks, and
488 works should converge with on-farm activities such as farm ponds, drainage and field bunding.

Third, farm-level adaptation will remain the least preferred domain until water becomes available on time and in assured quantities, alternative crops become marketable and commercial crops such as sugarcane and tobacco fetch assured remunerative prices. A published schedule of reservoir releases, seasonal advisories tied to it and support for short-duration pulses or fodder crops on kuruvai fallows would reduce seasonal abandonment. In the upper basin, assured, remunerative and timely prices for sugarcane and tobacco, backed by transparent procurement and prompt payment, would reduce the price risk that drives borrowing for these commercial crops. Assured procurement of stress-tolerant paddy varieties at price parity with fine varieties and price support and market linkages for millets, pulses and maize would eliminate the market penalty that currently discourages tolerant varieties and diversification.

Fourth, the livelihood strategies that households already favour, livestock and off-farm work, deserve direct support: fodder banks, veterinary services and dairy cooperative coverage in distressed villages, backyard poultry units for women, and skill training that enables migrants to obtain better-paid and more secure work.

Fifth, the safety net must protect human capital. Automatic enrolment of distressed farm households in the state health insurance scheme, coverage of outpatient costs, and school fee support or scholarships for children of households in calamity-affected blocks prevent shocks from being transferred to health and education. Psychosocial support through farmer helplines and primary health centres is warranted in districts with a high incidence of farmer suicide. Finally, the growing incidence of leasing points to the need for a legal framework that records leases so that lessees can access credit, insurance and compensation, and for programmes that make farming a viable choice for rural youth.

4 Conclusion

This study prioritised the strategies through which farm households in the suicide-prone districts of the upper and lower Cauvery basin cope with agrarian distress. Households respond first through financial means, chiefly asset disposal and informal borrowing, rely on institutional support as their main external buffer, treat livelihood diversification as a secondary response and alter their farming practices only reluctantly, whereas resilience-building strategies such as crop diversification, savings and health protection rank lowest. Distress in the basin is therefore met largely through short-term, erosive coping rather than planned adaptation. To the authors' knowledge, this is the first study to quantify farmers' own preferences among distress-coping strategies in the basin; by applying a group AHP across both the upper and lower basin, it shifts attention from the drivers of distress to household responses and converts the conceptual distinction between coping and adaptation into a measurable ranking within a single framework.

Beyond the study area, the findings indicate that asset sales, mounting informal debt and the fallowing of land are sequential responses that can serve as early-warning indicators of distress, and that support programmes should be judged by whether they displace erosive coping rather than by coverage alone. They also show that, under compound stress, adaptation is constrained more by liquidity, market access and institutional reach than by awareness. The approach can be replicated in other distress-prone regions and repeated over time to assess whether interventions move households from coping towards adaptation, and future work could link coping priorities to landholding, tenancy and gender.

References

Abraham V (2009) Employment growth in rural India: distress-driven? Econ Polit Wkly 44(16):97–104

Aczél J, Saaty TL (1983) Procedures for synthesizing ratio judgements. J Math Psychol 27:93–102. https://doi.org/10.1016/0022-2496(83)90028-7

Adityan S, Velusamy R, Balasubramaniam P, Devi MN, Anjugam M, Prabakaran K (2026) Economic vulnerability and farm-size inequality in the Cauvery Delta: a multidimensional quantitative assessment. Plant Sci Today 13(sp1). https://doi.org/10.14719/pst.13073

Ashwini BC (2018) Are crops still profitable in Cauvery River Basin of Karnataka? Econ Aff 63(4). https://doi.org/10.30954/0424-2513.4.2018.3

Balaselvakumar S, Hemavarthinii S (2026) Climate change impacts on coastal agriculture in Tamil Nadu, India: an assessment of sea-level rise and salinity intrusion. Int J Environ Clim Change 16:70–85

Bansal I, Mahajan K (2023) COVID-19, income shocks, and women's employment in India. Fem Econ 29:285–317. https://doi.org/10.1080/13545701.2023.2250797

Bhende MJ, Venkataram JV (1994) Impact of diversification on household income and risk: a whole-farm modelling approach. Agric Syst 44:301–312. https://doi.org/10.1016/0308-521X(94)90224-4

Bomble P, Lhungdim H (2020) Mental health status of farmers in Maharashtra, India: a study from farmer suicide prone area of Vidarbha region. Clin Epidemiol Glob Health 8:684–688. https://doi.org/10.1016/j.cegh.2020.01.002

Brema J, Trivedi S, Sherin M, Dhotrad DS, Raj KG, Samal D (2021) Urban growth impact on Cauvery river: a geospatial perspective. In: Geo-intelligence for sustainable development. Springer, pp 127–147. https://doi.org/10.1007/978-981-16-4768-0_9

Carswell G, De Neve G (2013) Labouring for global markets: conceptualising labour agency in global production networks. Geoforum 44:62–70. https://doi.org/10.1016/j.geoforum.2012.06.008

Carswell G, De Neve G (2014) MGNREGA in Tamil Nadu: a story of success and transformation? J Agrar Change 14:564–585. https://doi.org/10.1111/joac.12054

Census of India (2011) Primary census abstract. Office of the Registrar General and Census Commissioner, Ministry of Home Affairs, Government of India, New Delhi

559 Chidambaram S, Ramanathan A, Thilagavathi R, Ganesh N (2018) Cauvery River. In: The Indian
560 rivers: scientific and socioeconomic aspects. Springer, pp 353–366. https://doi.org/10.1007/978-981-
561 10-2984-4_28
562 Daze A, Ambrose K, Ehrhart C (2009) Climate vulnerability and capacity analysis handbook. CARE
563 International
564 De Neve G (2003) Expectations and rewards of modernity: commitment and mobility among rural
565 migrants in Tirupur, Tamil Nadu. Contrib Indian Sociol 37:251–280.
566 https://doi.org/10.1177/006996670303700111
567 Deshpande RS (2002) Suicide by farmers in Karnataka: agrarian distress and possible alleviatory
568 steps. Econ Polit Wkly 2601–2610
569 Forman E, Peniwati K (1998) Aggregating individual judgments and priorities with the analytic
570 hierarchy process. Eur J Oper Res 108:165–169. https://doi.org/10.1016/S0377-2217(97)00244-0
571 George SL, Balasubramani K, Shekhar S et al (2021) A comprehensive study on preparedness,
572 impacts, response and recovery from tropical severe cyclonic storm 'GAJA': lessons for the future. J
573 Coast Conserv 25:58. https://doi.org/10.1007/s11852-021-00842-3
574 Himanshu, Lanjouw P, Murgai R, Stern N (2013) Nonfarm diversification, poverty, economic
575 mobility, and income inequality: a case study in village India. Agric Econ 44:461–473.
576 https://doi.org/10.1111/agec.12029
577 India Meteorological Department (2023) Districtwise rainfall data, Cauvery River Basin. Ministry of
578 Earth Sciences, Government of India
579 Jacoby HG, Skoufias E (1997) Risk, financial markets, and human capital in a developing country.
580 Rev Econ Stud 64:311–335. https://doi.org/10.2307/2971716
581 Jain M, Naeem S, Orlove B, Modi V, DeFries RS (2015) Understanding the causes and consequences
582 of differential decision-making in adaptation research: adapting to a delayed monsoon onset in
583 Gujarat, India. Glob Environ Change 31:98–109. https://doi.org/10.1016/j.gloenvcha.2014.12.008
584 Kastor A, Mohanty SK (2018) Disease-specific out-of-pocket and catastrophic health expenditure on
585 hospitalization in India: do Indian households face distress health financing? PLoS One 13:e0196106.
586 https://doi.org/10.1371/journal.pone.0196106
587 Kaur M, Mehra A (2018) Regional patterns in farm suicides in India: a critical analysis. Contemp Soc
588 Sci 27:18–37. https://doi.org/10.29070/27/57461
589 Kaur S, Raj H, Singh H, Chattu VK (2021) Crop insurance policies in India: an empirical analysis of
590 Pradhan Mantri Fasal Bima Yojana. Risks 9:191. https://doi.org/10.3390/risks9110191
591 Kennedy J, King L (2014) The political economy of farmers' suicides in India: indebted cash-crop
592 farmers with marginal landholdings explain state-level variation in suicide rates. Glob Health 10:16.
593 https://doi.org/10.1186/1744-8603-10-16

Kumar A, Sonkar VK, Srinivasa AK (2023) Assessing the impact of lending through Kisan Credit Cards in rural India: evidence from eastern India. Eur J Dev Res 35:602–622. https://doi.org/10.1057/s41287-022-00522-4

Kumar S (2020) Agrarian crisis and farmers issues in India: from indebtedness to suicide. Best Publishing House

Kumar S, Mishra AK, Pramanik S, Mamidanna S, Whitbread A (2020) Climate risk, vulnerability and resilience: supporting livelihood of smallholders in semiarid India. Land Use Policy 97:104729. https://doi.org/10.1016/j.landusepol.2020.104729

Merriott D (2016) Factors associated with the farmer suicide crisis in India. J Epidemiol Glob Health 6:217–227. https://doi.org/10.1016/j.jegh.2016.03.003

Ministry of Finance (2022-23) Economic survey. Department of Economic Affairs, Government of India, New Delhi

Mohanty BB (2005) 'We are like the living dead': farmer suicides in Maharashtra, western India. J Peasant Stud 32:243–276. https://doi.org/10.1080/03066150500094485

Mohanty BB, Lenka PK (2023) 'For them farming may be the last resort, but for us it is a new hope': ageing, youth and farming in India. J Agrar Change 23:771–791. https://doi.org/10.1111/joac.12538

Nair J, Thomas BK, Bahinipati CS (2024) Cropping decisions under water stress: evidence from Cauvery Delta Region, India. World Water Policy 10:711–729. https://doi.org/10.1002/wwp2.12177

Nandi R, Pratheepa CM, Nedumaran S, Rao N, Rengalakshmi R (2022) Farm parent and youth aspirations on the generational succession of farming: evidence from South India. Front Sustain Food Syst 5:804581. https://doi.org/10.3389/fsufs.2021.804581

Narayanamoorthy A (2013) Profitability in crops cultivation in India: some evidence from cost of cultivation survey data. Indian J Agric Econ 68:105–121. https://doi.org/10.22004/ag.econ.206325

National Statistics Office (2021) Situation assessment of agricultural households and land and livestock holdings of households in rural India, 2019 (NSS 77th round, January–December 2019). Ministry of Statistics and Programme Implementation, Government of India, New Delhi

National Statistics Office (2025) Press note on provisional estimates of annual gross domestic product for 2024-25. Ministry of Statistics and Programme Implementation, Government of India

NCRB (2025) Accidental deaths & suicides in India 2023. National Crime Records Bureau, Ministry of Home Affairs, Government of India, New Delhi. https://www.ncrb.gov.in

Padhan N, Madheswaran S (2023) Effectiveness of post-disaster coping strategies among the farming households in the coastal districts of Odisha, India. Nat Hazards Res 3:66–75. https://doi.org/10.1016/j.nhres.2022.12.006

Parisi D, Srivastava S, Parmar D et al (2023) Awareness of India's national health insurance scheme (PM-JAY): a cross-sectional study across six states. Health Policy Plan 38:289–300. https://doi.org/10.1093/heapol/czac106

Pattnaik I, Lahiri-Dutt K, Lockie S, Pritchard B (2018) The feminization of agriculture or the feminization of agrarian distress? Tracking the trajectory of women in agriculture in India. J Asia Pac Econ 23:138–155. https://doi.org/10.1080/13547860.2017.1394569

Paulraj AP, Easwaran N (2020) Evaluation of 'revamped' crop insurance Pradhan Mantri Fasal Bima Yojana (PMFBY) among paddy farmers in Tamil Nadu, India. Curr J Appl Sci Technol 39:66–77. https://doi.org/10.9734/cjast/2020/v39i3431037

Pouchepparadjou A, Umamageswari M, Varadan RJ et al (2025) Distress proneness of farmers in agriculturally developed Cauvery Delta zone of India. Agric Res 15:564–578. https://doi.org/10.1007/s40003-025-00864-5

Prayag AG, Zhou Y, Srinivasan V, Stigter T, Verzijl A (2023) Assessing the impact of groundwater abstractions on aquifer depletion in the Cauvery Delta, India. Agric Water Manag 279:108191. https://doi.org/10.1016/j.agwat.2023.108191

Reddy AA, Bhattacharya A, Reddy SV, Ricart S (2021) Farmers' distress index: an approach for an action plan to reduce vulnerability in the drylands of India. Land 10:1236. https://doi.org/10.3390/land10111236

Saaty TL (1980) The analytic hierarchy process: planning, priority setting, resource allocation. McGraw-Hill, New York

Saaty TL (2008) Decision making with the analytic hierarchy process. Int J Serv Sci 1:83–98. https://doi.org/10.1504/IJSSCI.2008.017590

Sabarisakthi M (2019) An exploration on farm crisis and suicides in the Cauvery Delta districts of Tamil Nadu. Shanlax Int J Econ 7:84–90. https://doi.org/10.34293/economics.v7i4.646

Sarma N (2022) Domestic violence and workfare: an evaluation of India's MGNREGS. World Dev 149:105688. https://doi.org/10.1016/j.worlddev.2021.105688

Sawant S, Mohite J, Sakkan M, Pappula S (2019) Near real time crop loss estimation using remote sensing observations. In: 2019 8th International Conference on Agro-Geoinformatics (Agro-Geoinformatics). IEEE, pp 1–5. https://doi.org/10.1109/Agro-Geoinformatics.2019.8820217

Shagun (2025) Farmer suicides in India: what 28 years of data shows. Down To Earth, 31 December 2025. https://www.downtoearth.org.in/agriculture/farmer-suicides-in-india-what-28-years-of-data-shows. Accessed 21 October 2026

Sharma A, Bhaduri A (2009) The 'tipping point' in Indian agriculture: understanding the withdrawal of the Indian rural youth. Asian J Agric Dev 6:83–97. https://doi.org/10.37801/ajad2009.6.1.5

Sharma M, Lone AM, Nautiyal JP et al (2024) An atlas of riverscape: Cauvery River Basin

Tiwari R, Chand K, Anjum B (2020) Crop insurance in India: a review of Pradhan Mantri Fasal Bima Yojana (PMFBY). FIIB Bus Rev 9:249–255. https://doi.org/10.1177/2319714520966084

Van der Geest K, Warner K (2015) Vulnerability, coping and loss and damage from climate events. In: Hazards, risks, and disasters in society. Elsevier, pp 121–144. https://doi.org/10.1016/B978-0-12-396451-9.00008-1

Varkey LM, Veettil PC, Patil V (2023) Do farmers pay for climate-resilient technology? Evidence from bidding experiments in eastern India. Environ Chall 11:100724. https://doi.org/10.1016/j.envc.2023.100724

Varshney D, Joshi PK, Roy D, Kumar A (2020) Pradhan Mantri Kisan Samman Nidhi (PM-KISAN) and the adoption of modern agricultural technologies in Uttar Pradesh, India. IFPRI Discussion Paper 1907. International Food Policy Research Institute, Washington, DC. https://doi.org/10.2499/p15738coll2.133592

Venkataramana M, Muralidhar L, Ranganatha A, Gururaj B (2020) The relative economic benefits of conjunctive use of water over surface and ground water in the Cauvery command area. Curr J Appl Sci Technol 39:45–51. https://doi.org/10.9734/cjast/2020/v39i4431150

Vignesh Kumar S, Karthikeyan C (2017) Farmers' distress in Cauvery Delta region of Tamil Nadu – an analysis. Madras Agric J 104:381–385. https://doi.org/10.29321/maj.2017.000083

Warner K, van der Geest K (2013) Loss and damage from climate change: local-level evidence from nine vulnerable countries. Int J Glob Warm 5:367–386. https://doi.org/10.1504/IJGW.2013.057289

Willows R, Reynard N, Meadowcroft I, Connell R (2003) Climate adaptation: risk, uncertainty and decision-making. UKCIP Technical Report. UK Climate Impacts Programme

Statements and Declarations

Clinical trial number: not applicable.

Funding

The authors declare that no funds, grants, or other support were received during the preparation of this manuscript.

Competing interests

The authors have no relevant financial or non-financial interests to disclose.

Ethics approval and consent to participate

The study protocol was reviewed and approved by the Ethics Committee of the Division of Agricultural Extension, ICAR-Indian Agricultural Research Institute (ICAR-IARI), New Delhi, India, the institution at which the study was conducted and to which the corresponding author is affiliated. The ethics clearance certificate (Approval No. Ag EXT/497) was issued by the Head, Division of Agricultural Extension, ICAR-IARI, New Delhi, on 30 October 2026. All procedures involving human participants were performed in accordance with the ethical principles of the Declaration of Helsinki and its later amendments, the institutional research ethics guidelines of ICAR-IARI, and the protocol approved by the Ethics Committee of the Division of Agricultural Extension, ICAR-Indian Agricultural Research Institute (ICAR-IARI), New Delhi, India. The study was non-interventional, was conducted solely for academic purposes, and involved no invasive procedures. Freely given,

informed consent was obtained from all individual participants prior to data collection. Participants were informed of the purpose of the study, that participation was entirely voluntary, and that they could withdraw at any stage without any consequences. Confidentiality and anonymity were ensured by using coded data and restricting access to research records.

Authors Contribution

All authors contributed to the study conception and design. Material preparation, data collection, and analysis were performed by M.Bharath. The first draft of the manuscript was written by M. Bharath, and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

Data availability

The datasets generated and analysed during the current study are available from the corresponding author on reasonable request.