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Risk Management of Rainfed Lowland Rice Farming Production in Jeneponto Regency, Indonesia

Noer Ibrah Ibrahim[1]*, Ratnawati Tahir[2], Irma Sribianti[3], Akhmad[4], Sri Mardiyati[5]

[1]Students in the Agribusiness Doctoral Program, Universitas Muhammadiyah Makassar
[2,3,4]Doctoral Program in Agribusiness, Universitas Muhammadiyah Makassar
[5]Master of Agribusiness Study Program, Universitas Muhammadiyah Makassar

*Correspondent Author: noeribrah.ibrahims3@gmail.com

Abstract

Rainfed lowland rice production in semi-arid tropical environments is increasingly vulnerable to extreme climate variability, severe droughts, and shifting rainfall patterns. This study aims to analyze a multi-stage production risk management framework—including risk identification, assessment, control, transfer, mitigation, and adaptation—among rainfed lowland rice farmers in Binamu District, Jeneponto Regency, South Sulawesi, Indonesia. A quantitative survey was conducted among 150 rainfed lowland rice farmers selected through simple random sampling from a population of 4,059 farmers. Primary data were analyzed using descriptive statistics and risk framework modeling. The results indicate that climate change (96.67%) and prolonged drought (96.00%) were identified as the primary drivers of severe rice production losses, with 84.00% of farmers experiencing a reduction in rice production exceeding 50% during adverse climate events. Risk transfer through government agricultural insurance (AUTP) has collapsed, with 92.67% not adopted due to institutional budget suspensions post-2021. In response, farmers relied on autonomous production control, including adherence to agricultural extension guidelines (96.67%) and emergency cash reserves (58.00%). Key mitigation strategies centered on planting drought-tolerant and short-duration rice varieties (57.33%, Inpari 42) and adopting pest-resistant crop varieties (100.00%). When faced with severe climate shocks, 40.67% of farmers adapted by switching crops to hybrid maize.

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Keywords: **risk management, climate change, rice production, rice farming, rainfed rice fields.**

INTRODUCTION

Rice (Oryza sativa L.) serves as a major staple food for more than half the global population, yet its production remains highly sensitive to temporal water availability and microclimate fluctuations (Chandio et al., 2020; Pramanik et al., 2022). In Southeast Asia, rainfed lowland rice systems cover millions of hectares and are a vital source of rural livelihoods, but they inherently suffer from high yield volatility driven by unpredictable monsoons, erratic rainfall distribution, and recurrent droughts (Babel et al., 2021; Simelton et al., 2021). Agricultural risks and uncertainties under climate change present major operational constraints that hamper agricultural productivity, distort supply chains, and exacerbate rural poverty (Quiggin, 2019; Reardon et al., 2019).

In Indonesia, where rice production is central to national food security and rural economic stability, production shocks from climate change are particularly severe in the eastern region, which is characterized by a semi-arid climate (Susilowati & Suhaeti, 2021; Wadu et al., 2019). Jeneponto Regency, located in South Sulawesi Province, is an agricultural area severely hampered by seasonal water scarcity and prolonged dry seasons (BPS Jeneponto, 2025; Susilowati & Suhaeti, 2021). According to the latest agricultural census data, of the 25,996 hectares of rice fields in Jeneponto Regency, 11,371 hectares—representing 43.74% of the total arable area—are entirely dependent on rainfed systems without permanent irrigation infrastructure (BPS Jeneponto, 2025). Binamu District is the area with the largest concentration of rain-fed rice farming in the regency, covering 2,434 hectares of rain-fed rice fields out of a total of 2,932 hectares (83.01%), followed by other vulnerable areas such as West Bangkala (2,271 hectares) and Kelara (1,460 hectares) (BPS Jeneponto, 2025).

Historical production records in Jeneponto Regency indicate severe crop failures (puso) due to climate anomalies (BPS Jeneponto, 2025). Between 2019 and 2024, total harvested area and annual rice production fluctuated dramatically; For example, extreme weather events caused total crop failure in 2019 and 2022, resulting in a drop in total district production to 100,536 tons in 2019 compared to 181,580 tons in 2024 (BPS Jeneponto, 2025). Rain-fed rice farmers in sub-districts like Binamu operate under constant production risks, with the unpredictable onset of the rainy season, prolonged droughts due to El Niño, and repeated surges in pest and disease outbreaks causing

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severe economic losses and threatening household survival (Lawolo & Waruwu, 2022; Mubarokah et al., 2017).

Production risks in agribusiness encompass the variability and uncertainty of agricultural yields resulting from uncontrolled biological, physical, and atmospheric hazards (Darmawi, 2016; van der Vorst et al., 2019). Effectively managing production risks requires a comprehensive and multi-step operational framework comprising risk identification, quantitative risk assessment, risk control and transfer, and risk mitigation or adaptation (Kristiana et al., 2022; Suroso et al., 2020). While the existing literature has extensively examined general risk perceptions and isolated agronomic techniques—such as variety selection or fertilizer adjustments—few empirical studies have evaluated the entire multi-step risk management chain among smallholder farmers in drought-prone rainfed areas (Adnan et al., 2020; Mukasa, 2018). Furthermore, although the Indonesian government has initiated the Rice Farming Insurance Program (AUTP) to protect smallholder farmers from significant losses, formal risk transfer mechanisms face significant institutional and operational barriers in dryland areas (Pasaribu, 2020; Siregar & Suryana, 2021).

To address these empirical and policy gaps, this study investigates how small-scale rainfed rice farmers cope with production risks under climate variability in Binamu District, Jeneponto Regency (BPS Jeneponto, 2025; Wadu et al., 2019). The specific objectives of this study are to: (1) identify and quantify key drivers of production risks, yield losses, and price realization under climate stress; (2) assess the effectiveness and institutional constraints of formal and informal risk control and transfer mechanisms; and (3) evaluate autonomous mitigation, climate-smart agronomic adaptation, and crop switching options adopted by smallholder farmers to ensure agricultural sustainability..

RESEARCH METHODS

Research Location

This study employed a quantitative survey-based research design supplemented by structured interviews with farmers, field observations, and secondary institutional data collection (Asrulla et al., 2023; Sekaran & Bougie, 2016). The study was conducted in Binamu District, Jeneponto Regency, South Sulawesi Province, Indonesia (BPS Jeneponto, 2025). Binamu was purposefully selected because it has the largest rain-fed rice fields in Jeneponto Regency (2,434 hectares), a high concentration of smallholder farmers, and historical yield volatility indicating exposure to severe production risks (BPS Jeneponto, 2025; Wadu et al., 2019).

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Population and Sampling

The target population consisted of all 4,059 active rainfed rice farmers registered in 13 sub-districts/villages in Binamu District (BPS Jeneponto, 2025). To ensure statistical representation while taking into account population homogeneity in the agricultural system, probability sampling through simple random sampling was conducted (Asrulla et al., 2023; Sekaran & Bougie, 2016). Sample size calculation was performed using Slovin's formula with an acceptable margin of error (e) of 8% (Yamane, 1967):

$$n = \frac{N}{1 + N(e)^2} = \frac{4059}{1 + 4059(0.08)^2} = \frac{4059}{1 + 4059(0.0064)} \approx 150$$

Consequently, a total sample of 150 smallholder rainfed rice farmers was selected across Binamu Sub-district.

Data Collection and Operationalization

Primary data collection was conducted through direct interviews with farmers, using a pre-tested structured questionnaire to gather detailed empirical metrics on:

1. Socio-demographic profile: Farmer age, education, farming experience, land area, and household income.
2. Production and price dynamics: Historical yields (kg/ha) and farm-gate prices (IDR/kg) across normal, loss, and expected production seasons over the past five years.
3. Risk management stages: Risk identification, risk measurement/severity, risk control, formal insurance participation (AUTP), frequency of extension contacts, emergency reserve funds, and autonomous climate mitigation/adaptation practices.

Secondary data, covering land use, seasonal rainfall, and crop failure statistics, were obtained from the Jeneponto Regency Statistics Agency (BPS), the Jeneponto Regency Agriculture Office, and the local village office..

Data Analysis

The collected data were coded, tabulated, and analyzed using descriptive statistics and agricultural risk framework modeling. Percentage distributions, range values, and quantitative frequency metrics were evaluated to interpret farmer behavior across four sequential risk management domains: (1) hazard driver identification, (2) loss severity assessment, (3) control and transfer mechanism evaluation, and (4) climate adaptation strategy classification (Hafids et al., 2021; Kristiana et al., 2022; Mubarokah et al., 2017).

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RESULTS

Production Loss Dynamics and Risk Identification

Empirical evidence collected from 150 rain-fed lowland rice farmers in Binamu District indicates significant variation in crop productivity and realized prices depending on climatic conditions. Under normal weather conditions, rain-fed lowland rice productivity ranges from a minimum of 1,972.16 kg/ha (1.97 tons/ha) to a maximum of 3,588.58 kg/ha (3.59 tons/ha) per planting season, with the selling price of dry paddy (Harvested Dry Paddy - GKP) fluctuating between Rp 3,946.43/kg and Rp 5,749.33/kg.

However, during adverse risk events, yields dropped sharply, ranging from 1,027.51 kg/ha (1.03 tons/ha) to 3,416.86 kg/ha (3.42 tons/ha), accompanied by depressed realized prices ranging from IDR 3,819.33/kg to IDR 5,016.00/kg. When evaluating farmers' expectations for the future, the minimum expected yield under severe losses was 1,537.68 kg/ha, while the optimistic yield target under ideal conditions reached 6,355.33 kg/ha, with expected prices ranging between IDR 4,022.00/kg and IDR 6,355.33/kg. Farmers identified low rainfall, extreme drought, pest and disease attacks (Plant Pest Organisms - OPT), and the El Niño climate anomaly as the main drivers of severe production losses.

Table 1. Risk Identification Perception Among Rainfed Lowland Rice Farmers

No	Risk Identification Statement	Response Options	Percentage (%)
1.	Climate change is the main factor causing production loss risks	Yes / No	96.67 / 3.33
2.	Pest and disease attacks cause significant production drop	Yes / No	38.00 / 62.00
3.	Drought is the highest risk causing low yield productivity	Yes / No	96.00 / 4.00
4.	Risk of crop failure occurs almost every planting season	Yes / No	40.00 / 60.00
5.	Farmers are fully prepared to face harvest failure risks	Yes / No	91.33 / 8.67

Source: Primary Data Processed, 2025.

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Table 1 details the structure of risk perceptions among respondents. A total of 96.67% of farmers confirmed that climate change is the primary driver of production loss risk, and 96.00% explicitly identified prolonged drought as the highest risk contributing to low yields. Pest and disease attacks were cited as the primary driver of yield decline by 38.00% of farmers. While 40.00% of respondents reported that crop failures occur almost every planting season, 91.33% stated that farmers actively prepare themselves mentally and operationally to face the risk of crop failure.

Risk Measurement and Financial Impact Assessment

The risk assessment results presented in Table 2 indicate widespread yield instability and severe financial exposure among smallholder farmers dependent on rainfall. A total of 87.33% of farmers reported that rice production has been highly unstable in recent years, compared to only 12.67% who reported stable yields. When droughts hit, 66.67% of farmers experienced yield losses exceeding 30%, while 21.33% suffered losses between 21% and 30%. In contrast, yield losses caused by pests and diseases generally ranged from 0–10% for 96.00% of respondents.

Table 2. Risk Severity Measurement and Household Financial Status

No	Risk Assessment Indicators	Categories	Percentage (%)
1.	Paddy yield stability over recent years	Stable / Unstable	12.67 / 87.33
2.	**Severity of yield loss due to drought**	**0–10%** **11–20%** **21–30%** **> 30%**	**4.67** **7.33** **21.33** **66.67**
3.	Severity of yield loss due to pests/diseases	0–10% 11–20%	96.00 4.00
4.	**Magnitude of overall yield drop during severe shock**	**0–10%** **11–20%** **21–30%** **31–40%** **41–50%** **> 50%**	**0.67** **2.67** **3.33** **1.33** **8.00** **84.00**
5.	Income sufficiency for farm costs & household needs	Deficit Barely Sufficient	13.33 46.00

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No	Risk Assessment Indicators	Categories	Percentage (%)
		Surplus	40.67

Source: Primary Data Processed, 2025.

Regarding overall yield declines during severe climate shocks, 84.00% of respondents experienced drastic yield declines exceeding 50% of normal yields. Consequently, 46.00% of farmers stated that their farm income was barely sufficient to cover production costs and basic household living expenses, while 13.33% experienced chronic income deficits (insufficient).

Risk Control, Transfer, and Institutional Support

An evaluation of risk management and transfer mechanisms (Table 3) revealed significant institutional breakdowns in the adoption of formal risk transfer. A total of 92.67% of rainfed rice farmers did not utilize the government-subsidized Rice Agricultural Insurance Program (AUTP). Qualitative field verification confirmed that although farmers had previously participated in AUTP since 2017 and appreciated its financial safety net (subsidized premium: IDR 36,000/ha; compensation payment: IDR 6,000,000/ha for total crop failure), the program was discontinued in Jeneponto Regency after 2021 due to central budget reallocations and policy adjustments.

Table 3. Risk Control and Transfer Mechanisms

No	Risk Control / Transfer Strategy	Response Options	Percentage (%)
1.	Active participation in Crop Insurance (AUTP)	Yes / No	7.33 / 92.67
2.	Compliance with fertilizer & pest control extension recommendations	Yes / No	96.67 / 3.33
3.	Frequency of consultation with agricultural extension agents	1–2 times/year 3–5 times/year > 5 times/year	32.00 48.00 20.00
4	Active information seeking on farm risk management	Yes / No	62.67 / 37.33
5	Special emergency cash fund allocation for crop failure	Yes / No	58.00 / 42.00

Source: Primary Data Processed, 2025.

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Due to the lack of formal insurance, farmers rely heavily on agricultural extension services and independent cash reserves. A total of 96.67% of respondents strictly followed the fertilizer and pest control guidelines recommended by Agricultural Extension Officers (PPL). Farmers consult with agricultural extension officers frequently: 48.00% consult 3–5 times per year, 32.00% consult 1–2 times per year, and 20.00% consult more than 5 times per year. Furthermore, 62.67% actively seek risk management information, and 58.00% allocate emergency cash reserves specifically to anticipate crop failures.

Adaptation and Mitigation Strategies

To maintain economic viability under severe water stress, rainfed farmers implemented both immediate coping adaptation strategies and long-term mitigation practices (Table 4). The dominant coping adaptation when rice farming became unviable was switching to hybrid corn (40.67%), followed by switching to vegetables (24.67%), beans/legumes (18.67%), switching to off-farm employment (11.33%), and seeking external financial assistance (4.67%). Hybrid corn was widely chosen due to government seed assistance programs, established partnerships between feed mills and buyers, lower water requirements, and shorter cultivation cycles.

For pre-season production mitigation, 57.33% of farmers used drought-tolerant, short-duration, and early-maturing varieties such as Inpari 42 (matures in ~112 days). Additional mitigation measures include the implementation of the Legowo Planting System combined with OPT control (8.67%), accelerated planting combined with organic fertilization (8.00%), shallow boreholes and pumping (5.33%), construction of small agricultural ponds (embung) (2.00%), and proper soil processing (1.33%).

Table 4. Farmers' Adaptation and Mitigation Strategies in Rainfed Rice Farming

Category	Strategy / Response Option	Percentage (%)
Coping Adaptation	Crop switching to Hybrid Maize	40.67
	Crop switching to Vegetables	24.67
	Crop switching to Pulses/Legumes	18.67
	Shifting focus to Off-farm labor	11.33
	Seeking external financial aid	4.67
Production Mitigation	Cultivating drought-tolerant early-maturing varieties (Inpari 42)	57.33

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Category	Strategy / Response Option	Percentage (%)
	Jajar Legowo planting system & OPT control	8.67
	Accelerated planting & organic fertilizer application	8.00
	Shallow tube wells and pump irrigation	5.33
	Small farm pond construction (embung)	2.00
	Proper soil tillage and plant maintenance	1.33

Source: Primary Data Processed, 2025.

Specific Management Practices Adopted

Table 5 outlines specific risk management practices routinely implemented by rainfed rice farmers in the field. Universal adoption (100.00%) was recorded for pest and disease resistant varieties and light tillage. High adoption rates were also observed for reducing chemical fertilizer use (86.00%), modifying harvest dates (82.00%), adjusting plant spacing (78.00%), adjusting planting dates based on weather forecasts (74.67%), using drought-resistant varieties (70.00%), seeking climate information (69.33%), using short-duration varieties (67.33%), and implementing water conservation technologies (58.00%).

Table 5. Specific Risk Management Practices Implemented by Farmers

No	Management Practice	Yes (%)	No (%)
1.	Seeking climate change information	69.33	30.67
2.	Adopting submergence/flood-tolerant varieties	44.67	55.33
3.	Adopting drought-tolerant varieties	70.00	30.00
4.	Adopting pest/disease-resistant varieties	100.00	0.00
5.	Adjusting planting dates according to rainfall	74.67	25.33
6.	Implementing recommended cropping patterns	34.67	65.33
7.	Regulating plant spacing (e.g., Jajar Legowo)	78.00	22.00
8.	Drainage and water flow management	42.00	58.00
9.	Applying organic fertilizer (compost/manure)	53.33	46.67
10.	Utilizing short-duration / early-maturing varieties	67.33	32.67
11.	Water management tech (macak-macak, wells, ponds)	58.00	42.00
12.	Performing light soil tillage	100.00	0.00

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No	Management Practice	Yes (%)	No (%)
13.	Reducing chemical fertilizer usage	86.00	14.00
14.	Reducing chemical pesticide application	47.33	52.67
15.	Applying organic/bio-pesticides	18.00	82.00
16.	Modifying/shifting harvest schedules	82.00	18.00

Source: Primary Data Processed, 2025.

DISCUSSION

Climatic Vulnerability and Yield Shock Perception

Empirical findings indicate that rain-fed lowland rice farming in semi-arid tropical regions like Jeneponto operates under extreme climate vulnerability. Over 96% of farmers explicitly recognized climate change and drought as the primary risk drivers leading to severe yield declines. This finding aligns closely with global literature in South Asia and Sub-Saharan Africa, which confirms that smallholder farmers in monsoon-dependent ecosystems bear the brunt of losses due to rainfall anomalies (Chandio et al., 2020; Simelton et al., 2021; Zizinga et al., 2022). The stark yield differences between normal seasons (1.97–3.59 tons/ha) and adverse seasons (1.03–3.42 tons/ha), coupled with 84% of farmers experiencing yield declines exceeding 50% during severe climate events, underscore the extremely fragile economic foundations of rain-fed rice farming (Lawolo & Waruwu, 2022). On the other hand, research by Mardiyati & Natsir (2026) shows that rain-fed rice farming in the Tanakeke Islands District, Takalar Regency, averages Rp 5,930.30 per hectare per planting season (once a year). The coefficient of variation (CV) for agricultural production is 0.1374, meaning the risk of rice production loss has so far only reached 13.74 percent.

Despite experiencing severe yield shocks, 91.33% of farmers reported strong psychological and operational preparedness to manage the risk of crop failure. This adaptive mindset is rooted in generations of experience in dryland farming, where climate uncertainty is normalized as an inherent part of farming life (Fahad & Wang, 2018). Smallholder farmers adapted by maintaining flexible planting schedules, building emergency cash reserves (58.00%), and seeking seasonal climate forecasts from agricultural extension officers (Aini et al., 2014; Ward et al., 2020).

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Failure of Formal Risk Transfer and Policy Implications

A key finding of this study is the near-collapse of formal agricultural risk transfer mechanisms, as evidenced by the failure of 92.67% of farmers to adopt the AUTP insurance scheme (Pasaribu, 2020; Siregar & Suryana, 2021). In theory, crop insurance provides the most effective market-based risk transfer mechanism to protect smallholder farmers from significant debt during extreme climate shocks (Adnan et al., 2020; Quiggin, 2019). Under Indonesia's AUTP program, farmers pay a heavily subsidized annual premium of IDR 36,000/ha to receive compensation payments of IDR 6,000,000/ha when crop damage exceeds 75% (Pasaribu, 2020; Siregar & Suryana, 2021).

However, field evidence suggests that non-participation in Jeneponto stems from supply-side institutional failures rather than farmer reluctance (Siregar & Suryana, 2021). Although farmers registered in previous years (2017–2021) and understood the compensation benefits, the program was suspended in the study area due to national budget reallocations and administrative reprioritization (Siregar & Suryana, 2021). Furthermore, traditional compensation-based crop insurance in rainfed areas faces high transaction costs, complex loss verification, and concerns about moral hazard (Li et al., 2023; Mukasa, 2018). The absence of formal crop insurance forces rainfall-dependent smallholder farmers to absorb crop shocks personally through emergency cash reserves (58.00%) or the sale of distressed assets, severely limiting long-term household wealth accumulation (Di Falco & Veronesi, 2018; Saqib et al., 2018).

Autonomous Agronomic Adaptation and Climate-Smart Agriculture

To manage water stress and biological hazards, smallholder farmers employ a combination of climate-smart agronomic practices and input adjustments (Imran et al., 2019; Pramanik et al., 2022). Cultivation of drought-tolerant and short-duration varieties (57.33%), Inpari 42, is a highly effective stand-alone mitigation strategy (Susilowati & Suhaeti, 2021). Inpari 42 matures in approximately 112 days and exhibits high tolerance to vegetative water deficits, allowing farmers to complete the crop cycle before the end-of-season drought occurs (Susilowati & Suhaeti, 2021).

The universal application of pest-resistant varieties (100.00%) and light tillage (100.00%) reflect deliberate efforts to minimize operational costs and maintain soil moisture (Tadesse et al., 2021). Light tillage maintains soil structure and organic matter, reducing soil evaporation in drylands (Babel et al., 2021; Yazar & Ali, 2021). Furthermore, 86.00% of farmers reduced chemical fertilizer use, driven by rising commercial fertilizer prices and agronomic understanding that excessive chemical nitrogen under severe

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water stress increases crop susceptibility to drought damage and pest attacks (Nguyen-Van et al., 2021).

Crop Switching as a Value Chain Climate Hedge

When severe drought made rice cultivation unviable, 40.67% of farmers adapted by switching to hybrid corn (Adnan et al., 2020; BPS Jeneponto, 2025; Reardon et al., 2019). Hybrid corn serves as an effective socio-economic climate response because it requires significantly less water than rice, tolerates higher temperatures, and offers a shorter growing cycle (Adnan et al., 2020; Masud et al., 2017).

This crop-switching transition was made possible by favorable institutional and agribusiness market conditions in Jeneponto Regency (Suroso et al., 2020). A government seed distribution program combined with private livestock feed purchase contracts provided guaranteed market access, input credit, and price stability for smallholder farmers (Reardon et al., 2019). This structural diversification highlights the need for flexible, market-oriented agricultural policies that support seasonal multi-crop transitions rather than imposing rigid single-crop rice mandates in water-stressed dryland ecosystems (Adnan et al., 2020; World Bank, 2023).

CONCLUSION

This study provides strong empirical evidence on the multi-stage production risk management framework used by smallholder rainfed rice farmers in semi-arid regions of Indonesia. Climate change and severe, prolonged drought were identified as key production risk drivers, causing yield losses exceeding 50% for 84.00% of respondents during adverse climate events. Formal risk transfer through crop insurance (AUTP) has largely collapsed due to the suspension of institutional funding post-2021, leaving 92.67% of farmers uninsured and relying on personal emergency savings (58.00%) and extension service guidance (96.67%). To reduce crop losses, farmers widely adopted climate-smart agronomic practices, particularly drought-tolerant and short-duration rice varieties (57.33%, Inpari 42), light tillage (100.00%), pest-resistant seeds (100.00%), and fertilizer rationalization (86.00%). In addition, crop switching to hybrid corn (40.67%) served as a major market-supported coping strategy during severe water deficits.

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