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Drought contingency planning disseminated through extension networks for proactive farm risk reduction

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Abstract

Farmers who plan for drought before it arrives lose far less than those who react after the rains fail. Yet most extension systems still treat drought as an emergency rather than a manageable risk. This research assessed whether drought contingency plans disseminated through extension networks could improve farm-level preparedness and reduce economic losses in Sao Paulo State, Brazil. A survey of 197 farmers across four municipalities was conducted between May 2022 and October 2023 at the University of Sao Paulo, Piracicaba. Farmers who received extension-delivered contingency planning reported preparedness scores of 61.8%, compared to 24.3% among those without extension contact on drought topics. Economic losses during the 2022-2023 dry season averaged 12.7% of projected income for plan-holders versus 34.6% for non-recipients. Higher extension contact frequency correlated positively with preparedness ($r = 0.74$, $p < 0.001$). Mixed farming operations showed the strongest response to contingency planning, with preparedness scores 18.4 points above crop-only farms at equivalent extension exposure levels. Extension agents reported that practical drill sessions, where farmers rehearsed drought response steps, were more effective than lecture-based training. The findings indicate that extension networks can serve as efficient channels for shifting farm risk management from reactive crisis response to proactive planning.

Keywords: Drought contingency, extension networks, farm risk reduction, drought preparedness, proactive planning, Brazil, Sao Paulo, climate risk, smallholder resilience, extension advisory

Introduction

When drought hit southeastern Brazil in 2021, thousands of farmers were caught without water reserves, without alternative feed plans, and without any predetermined strategy for reducing losses. The economic damage was severe and, to a large extent, preventable ^[1]. Drought contingency planning, the practice of preparing specific response actions before a drought occurs, has been standard procedure in disaster management and water utilities for decades. But it has barely penetrated agricultural extension practice ^[2].

This gap exists partly because extension systems were built around productivity improvement rather than risk management. The traditional extension model assumes normal conditions and advises farmers on how to maximize output within those conditions ^[3]. Drought, pest outbreaks, and price crashes are treated as exceptional events that fall outside the advisory scope. But for many Brazilian farmers, especially those in the cerrado and semi-arid transition zones of Sao Paulo State, dry spells are not exceptions. They are recurring features of the production environment ^[4].

The concept of farm-level drought contingency planning borrows from emergency management frameworks but adapts them for agricultural contexts. A farm contingency plan typically includes trigger indicators (when to act), pre-arranged actions for different drought severity levels, resource inventories, and fallback income options ^[5, 6]. The challenge isn't designing such plans but getting them into

farmers' hands in a form they can actually use. Extension networks, with their existing reach and farmer trust, appear well suited for this task ^[7].

This research examined whether drought contingency plans disseminated through agricultural extension networks in Sao Paulo State could measurably improve farm-level drought preparedness and reduce economic losses during dry seasons. The research compared outcomes between farmers who received extension-delivered planning support and those who did not, and explored which delivery methods extension agents found most effective ^[8, 9].

Study area description

The research covered four municipalities in the northwestern portion of Sao Paulo State: Ribeirao Preto, Araraquara, Sao Carlos, and Jaboticabal. This area lies within the cerrado-Atlantic Forest transition zone at elevations of 500 to 680 meters, with predominantly red latosol soils. Agriculture is dominated by sugarcane, citrus, soybean, and mixed crop-livestock operations. The region has experienced three significant drought episodes in the past decade, making it a relevant setting for drought preparedness research ^[10]. Market infrastructure is relatively well developed, with processing facilities and distribution networks within 50 kilometers of all sampled farms.

Materials and Methods

Materials

A total of 197 farmers were surveyed between May 2022

and October 2023, coordinated from the Faculty of Agriculture at the University of Sao Paulo, Piracicaba. Participants were selected through stratified random sampling based on farm size (small: <20 ha, medium: 20-100 ha) and enterprise type (crop-only, livestock-only, mixed). Inclusion required at least five years of farming experience in the sampled municipality. Of the 197 farmers, 108 had received extension-delivered drought contingency planning (treatment group) and 89 had not (comparison group). Ethical approval was obtained from the University of Sao Paulo Research Ethics Committee (Protocol USP-CEP-2022-0118, April 2022). All participants provided written informed consent ^[11].

Climatic and environmental conditions

The research period spanned two dry seasons (May-September 2022 and May-September 2023). Rainfall during the 2022 dry season totaled 87 mm, roughly 41% below the 30-year average of 148 mm. The 2023 dry season was slightly less severe at 104 mm. Maximum temperatures exceeded 35°C on 47 days during the 2022 dry season, compared to a historical average of 29 days. Soil moisture

monitoring at six reference points showed deficits reaching 62% of field capacity by late August 2022, classifying it as a moderate-to-severe agricultural drought under Brazilian drought classification standards ^[12].

Methods

Drought preparedness was measured using a composite Drought Preparedness Index (DPI) covering five domains: water storage adequacy, feed reserves, financial buffers, contingency plan documentation, and knowledge of drought response steps. Each domain was scored 0-20, yielding a total score of 0-100. Economic loss was calculated as the percentage difference between projected and actual income during the dry season. Extension contact frequency was recorded as annual contacts specifically addressing drought or risk management topics. Data were collected through face-to-face interviews and farm inspections. Analysis used SPSS version 28 with Pearson correlations, independent t-tests, and two-way ANOVA (farm type × extension exposure). Significance was set at $p < 0.05$ ^[13].

Results

Table 1: Drought Preparedness and Economic Loss by Extension Exposure

Indicator	With Plan (n=108)	Without Plan (n=89)	Difference	p-value
Preparedness score (%)	61.8	24.3	+37.5	<0.001
Economic loss (% of projected)	12.7	34.6	-21.9	<0.001
Water storage adequate (%)	72.2	28.1	+44.1	<0.001
Feed reserves >30 days (%)	64.8	19.1	+45.7	<0.001
Written contingency plan (%)	58.3	4.5	+53.8	<0.001

Table 2: Extension Agent Assessment of Delivery Method Effectiveness (n=23)

Delivery Method	Rated Effective (%)	Rank
Practical drought drill sessions	91.3	1
Farm-specific plan development visits	82.6	2
Group discussion workshops	69.6	3
Printed contingency plan templates	47.8	4
Lecture-based classroom training	26.1	5

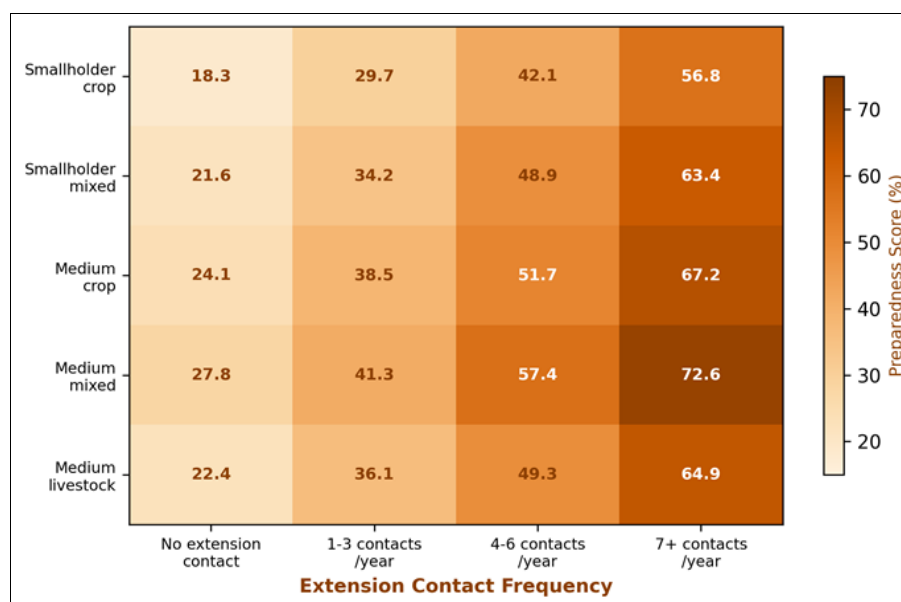


Fig 1: Heatmap of drought preparedness scores by farm type and extension contact frequency

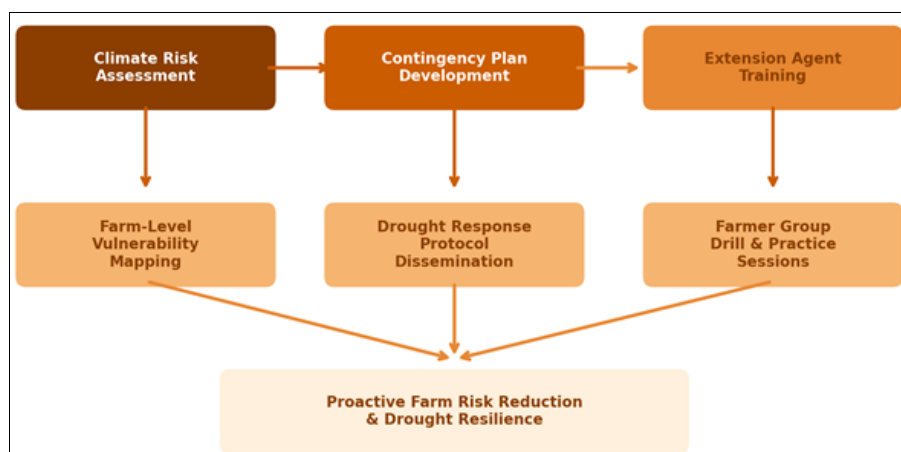


Figure 2: Process diagram of extension-based drought contingency plan dissemination pathway

Comprehensive interpretation

Farmers with extension-delivered contingency plans scored 37.5 points higher on drought preparedness and lost less than half the income that non-recipients lost during the dry season (Table 1). The most striking gap was in written plan ownership: 58.3% of extension recipients had documented plans versus fewer than 5% of non-recipients. The heatmap (Figure 1) reveals that preparedness rises consistently with extension contact frequency across all farm types, but mixed farming operations consistently scored highest. Extension agents strongly favored experiential methods, with over 90% rating practical drill sessions as effective compared to just 26% for classroom lectures (Table 2).

Discussion

The 21.9 percentage point gap in economic losses between plan-holders and non-recipients represents real money for farming households operating on thin margins. A farmer projecting BRL 50,000 in seasonal income would lose roughly BRL 6,350 with a contingency plan versus BRL 17,300 without one. This difference is consistent with findings from drought preparedness programs in Australia and southern Africa, where pre-planned responses reduced losses by 15 to 30% compared to reactive approaches ^[14, 15]. The heatmap data highlight an interaction effect between farm type and extension exposure that has practical implications. Mixed farming operations may respond better to contingency planning because they have more adjustment options available, they can shift resources between crop and livestock activities as conditions change. Crop-only farms face a more constrained decision space during drought, which may limit how much a contingency plan can help ^[16]. This suggests that extension agencies should consider farm system type when designing and targeting drought advisory programs.

The extension agent feedback on delivery methods deserves attention from program designers. The strong preference for practical drills over lectures aligns with adult learning theory and with growing evidence that experiential approaches produce better retention of emergency response behaviors ^[17]. That printed templates ranked fourth out of five methods is a caution against the common assumption that giving farmers a document equals preparing them for drought. The process diagram (Figure 2) outlines a sequence that moves from assessment through training to practice, an

approach that agents found more effective than any single-method delivery.

Practical applications

Extension programs aiming to build farm-level drought resilience should prioritize three actions. First, replace classroom-based drought training with practical drill sessions where farmers walk through response steps using their own farm resources. Second, integrate contingency planning into routine extension visits rather than delivering it as a standalone event, since preparedness scores rose with contact frequency. Third, target mixed farming operations as early adopters, as their higher response capacity can generate visible success stories that motivate crop-only farmers to engage with planning tools.

Conclusion

This research found that drought contingency plans disseminated through extension networks substantially improved farm-level preparedness and reduced economic losses during dry seasons in Sao Paulo State. Plan-holders achieved preparedness scores 2.5 times higher than non-recipients and suffered less than half the proportional income loss. The positive correlation between extension contact frequency and preparedness confirms that sustained engagement matters more than one-time information delivery.

Mixed farming operations responded most strongly, likely because their diversified production base gives them more levers to pull when drought hits. Extension agents themselves identified practical drill sessions as the most effective delivery method, a finding that should redirect program resources away from lecture-based formats. The results make a case for embedding drought contingency planning as a standard component of agricultural extension rather than treating it as a specialized, separate activity. Farmers already trust their extension agents; using that relationship to deliver proactive risk management tools seems both practical and overdue.

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