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Mechanism of the impact of AI climate risk early warning on adaptive behavior of farmers

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1 Introduction

Research on the impact of AI (artificial intelligence) climate risk early warning on farmer adaptive behavior has not yet examined its psychological cognitive mechanisms[1]. This gap not only makes it difficult to explain the lag in farmer adaptive behavior in response to AI climate early warning, but also constrains the development of intervention strategies tailored to its cognitive characteristics[2]. Therefore, this study takes AI climate risk early warning as the research object, focuses on its comprehensive perceived value, and investigates the mechanism by which it affects farmer adaptive behavior, with the aim of promoting its application.

2 Theoretical basis, core concepts, and research hypotheses

This study drew on protection motivation theory, source credibility theory, and the theory of planned behavior as its theoretical foundations. The core concepts were AI climate risk early warning, farmer adaptive behavior, climate information credibility, and comprehensive perceived value of AI climate early warning. With the latter referring to farmer comprehensive subjective evaluation of AI climate early warning, encompassing utilitarian, emotional, social, and cost value.

The research hypotheses were: H1, AI climate risk early warning has a significant positive impact on the willingness of farmers to adopt climate adaptation behaviors; H2, comprehensive perceived value mediates the relationship between farmers' use of AI climate risk early warning tools and their willingness to adopt climate adaptation behaviors; and H3, the higher the credibility of AI early warning, the stronger the adaptive behavior of farmers.

3 Research methods, scales, sample, and variables

This study used moderated mediation and bootstrap methods. The scale was developed based on the IPCC climate change vulnerability theoretical framework, reviewed by agricultural economics experts and grassroots agricultural technicians, and finalized after a pre-survey. A stratified random sampling approach was adopted to select participants, and data were collected through the Questionnaire Star platform and household surveys.

A total of 290 valid questionnaires were obtained. The surveyed farmers were mostly aged 40–61 (55%) with educational backgrounds at the high school/vocational school and junior

college levels (63%); most operated farms of 0.3–3.3 ha (61%), and over 90% had more than 10 years of agricultural production experience. The dependent variable was farmer adaptive behavior (designated as ICB), referring to the immediate, short-term adjustments in farming activities that farmers make based on early warning information[3]. The independent variable (designated as AIU) is farmer use of AI climate risk early warning information[4]. The mediating variable was the comprehensive perceived value (PV) of that information[1]. The moderating variable is farmer-perceived credibility of the early warning information (designated as IC)[3,4]. Control variables included age, education level, farm size, household economic status, and local climatic conditions during AI-assisted production practices[5–7].

4 Empirical results

The study implemented ex ante procedural controls for potential common method bias. Following necessary statistical tests, the research hypotheses were examined (Table 1). The use of AI climate risk early warning tools had a significant and direct positive effect on farmer willingness to adopt climate adaptation behaviors (β = 0.317, p < 0.01). Therefore, H1 is supported. The use of AI climate risk early warning had a significant positive impact on perceived value (β = 0.327, p < 0.01) and perceived value, in turn, significantly and positively influenced behavioral intention (β = 0.389, p < 0.01). The mediating pathway (AIU → PV → ICB) was also significant (indirect effect: β = 0.327, p < 0.01). Hence, H2 is supported.

The interaction between AI climate risk early warning use and information credibility had a significant positive effect on comprehensive perceived value (β = 0.214, p < 0.01). When information credibility was high, the positive effect of AI climate risk early warning use on perceived value was stronger; conversely, when information credibility was low, this positive effect was attenuated. Thus, H3 is supported.

5 Conclusions and practical implications

First, the use of AI climate risk early warning was found to have a significant positive impact on farmer willingness to adopt climate adaptation behaviors. Second, AI early warning appears to promote farmer intention to adopt adaptive behavior by enhancing their comprehensive perceived value. Finally, highly credible early warning information could potentially strengthen the positive effect of AI climate risk early warning on farmer-perceived value.

The study found that trust in early warning information is a key prerequisite for the effectiveness of early warning but it does not support the assumption that technology can directly change farmer production behavior. Accordingly, the following practical implications are proposed. Grassroots agricultural technology extension workers should not only promote AI climate risk early warning technologies, but also build a solid foundation of information trust, enhance multidimensional farmer-perceived value, and conduct localized and crop-specific adaptations to facilitate the practical adoption of the technology. Policymakers should establish a full-chain

Table 1 Hypothesis testing results of the mechanism of the impact of AI climate risk early warning on adaptive behavior of farmers

Path	Coefficient	SE	p
Direct effects			
AI → ICB	0.317	0.061	0.000***
AI → PV	0.327	0.06	0.000***
PV → ICB	0.389	0.056	0.000***
Mediating effect			
AI → PV → ICB	0.327	0.058	0.000***
Moderating effect			
AI × IC → PV	0.214	0.06	0.000***

Note: *** Indicates p < 0.001.

monitoring, evaluation, and empirical feedback system following the path of information reception → perception → action → outcome, and continuously optimizing public agricultural technology services such as climate early warning.

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Compliance with ethics guidelines

Donghui Yang, Yihang Guo, Suping Shen, Gong Chen, and Wanbao Yuan declare that they have no conflicts of interest or financial conflicts to disclose. This article does not contain any studies with human or animal subjects performed by any of the authors.

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