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Farmers' perceptions of climate change and natural disaster risks and their adaptation responses in the upper Arpa River Basin, Chhattisgarh

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Abstract

Climate change poses one of the most serious and complex challenges to agricultural systems in developing countries, particularly in rain-fed regions of central India. The Upper Arpa River Basin in Bilaspur district, Chhattisgarh, is a predominantly agrarian zone where smallholder farmers depend heavily on seasonal monsoon rains and river water for their livelihoods. This study was conducted to assess farmers' perceptions of climate change impacts, their level of awareness about natural disaster risks, and the adaptation strategies they employ to sustain agricultural productivity. A structured interview schedule was administered to 200 farmers selected from 10 villages in the Kota block using simple random sampling. Data were analyzed using frequency and percentage statistics. Results revealed that the majority of respondents perceived rising agricultural costs, declining yields, and degraded soil fertility as the most significant effects of climate change. Awareness about natural disasters such as floods, irregular rainfall, and drought was predominantly at a medium level. Judicious use of pesticides and fertilizers, crop rotation, and adoption of horticultural crops as alternative ventures were the most widely practiced adaptation strategies, while income diversification and greenhouse farming remained largely absent. The findings underscore the urgent need for targeted extension services, climate-smart agricultural training, and institutional support to enhance adaptive capacity among farming communities in the region.

Keywords: Climate change perceptions, adaptation strategies, natural disasters, smallholder farmers, Chhattisgarh, Upper Arpa River Basin

1. Introduction

Climate change is increasingly recognized as a fundamental threat to global food security and rural livelihoods, particularly in tropical and subtropical agricultural zones of South Asia (IPCC, 2022) ^[10]. India, with more than 55% of its population dependent on agriculture, is among the countries most exposed to the adverse impacts of shifting climatic conditions, including erratic rainfall, rising temperatures, and greater frequency of extreme weather events (Ministry of Agriculture and Farmers Welfare [MAFW], 2021). These changes disrupt crop calendars, alter water availability, reduce soil productivity, and amplify the spread of pests and diseases, with disproportionate consequences for subsistence and small-scale farmers who possess limited financial, technological, and institutional resources to cope (BIRTHAL *et al.*, 2015) ^[4].

The state of Chhattisgarh, often referred to as the 'rice bowl of central India,' has a large agricultural population that relies on monsoon-fed farming systems and is directly exposed to climatic variability (Government of Chhattisgarh, 2022) ^[9]. The Arpa River, one of the major water bodies originating in the Maikal Hills and flowing through the Bilaspur district, supports a significant area of irrigated and rain-fed agriculture in its upper basin. Farmers in this region have historically cultivated paddy, pulses, and oilseeds, but evidence suggests that changing precipitation patterns, rising temperatures, and irregular seasons are progressively undermining agricultural productivity and household food security (Singh & Patel, 2019) ^[24].

Understanding farmers' perceptions of climate change is a critical prerequisite for designing effective, locally appropriate adaptation policies (Deressa *et al.*, 2011) [6]. Perception drives behavior; if farmers perceive climate change as real and consequential, they are more likely to adopt adaptive practices (Maddison, 2007) [15]. However, the nature, extent, and accuracy of farmers' perceptions vary considerably with socioeconomic status, access to information, years of farming experience, and proximity to extension services (Mabe *et al.*, 2014) [14]. In many rural communities of central India, farmers' climate perceptions are shaped primarily by long-term observation of local environmental changes rather than formal scientific data, making it essential to study grassroots-level awareness (Banerjee, 2010) [3].

Natural disasters, including floods, droughts, storms, and pest outbreaks, constitute a growing dimension of climatic risk for Indian farmers (National Disaster Management Authority [NDMA], 2020) [17]. The Upper Arpa Basin has experienced recurrent episodes of irregular rainfall and drought over the past two decades, resulting in crop failures and economic distress among farming households (Sahu & Verma, 2020) [23]. Despite governmental disaster risk reduction programmes, studies indicate that awareness and preparedness at the farm level remain insufficient, particularly in tribal and remote village clusters (Tripathi & Bhattacharya, 2017) [25]. A deeper understanding of how farmers perceive, evaluate, and respond to these disaster risks is therefore necessary to bridge the gap between policy intent and field-level outcomes.

Adaptation to climate change in the agricultural sector encompasses a wide range of practices, from crop diversification and the adoption of improved varieties to water management, agroforestry, and livelihood diversification (Lobell *et al.*, 2011) [13]. Studies conducted across Indian states have documented varying levels of adaptation practice adoption, influenced by factors such as land holding size, access to credit, availability of improved seed varieties, and the reach of agricultural extension (Kumar & Sharma, 2018; Jain *et al.*, 2015) [12, 11]. In Chhattisgarh specifically, limited studies have examined the full spectrum of adaptation strategies employed by farmers in the face of both slow-onset climatic changes and sudden natural disaster events. There remains a notable gap in the literature regarding the intersection of climate perception, disaster risk awareness, and adaptation behavior among farmers in the Upper Arpa River Basin.

Climate-smart agriculture (CSA) has emerged as a globally recognized framework for guiding agricultural development in the context of climate change (Food and Agriculture Organization [FAO], 2013) [7]. CSA promotes practices that simultaneously increase productivity, enhance resilience, and reduce greenhouse gas emissions. In the Indian context, government programmes such as the National Adaptation Fund for Climate Change (NAFCC) and the Pradhan Mantri Krishi Sinchayee Yojana (PMKSY) have been operationalized to support climate adaptation in agriculture, though their uptake at the field level remains uneven

(Planning Commission of India, 2014) [20]. Agricultural extension systems play a pivotal role in translating policy-level climate adaptation goals into farm-level practices by building farmers' knowledge and capacity (Anderson, 2007) [2]. However, the effectiveness of extension outreach depends substantially on prior understanding of local perceptions and existing adaptive behaviors.

Empirical evidence from studies in comparable agro-climatic regions highlights the complexity of climate adaptation at the farm level. Gbetibouo (2009) [8] found that South African farmers who perceived increased temperatures and reduced rainfall were significantly more likely to alter crop choices and adjust planting dates. Similarly, Nhemachena and Hassan (2007) [18] demonstrated that in sub-Saharan Africa, access to climate information and extension services were the strongest predictors of adaptation decision-making. Closer to the present study's context, research in Madhya Pradesh and Odisha has shown that while farmers broadly acknowledge climate variability, gaps in technical knowledge and market access continue to constrain meaningful adaptive action (Chauhan *et al.*, 2016; Panda *et al.*, 2013) [5, 19]. These findings reinforce the importance of grounding adaptation programming in locally validated perceptions and needs assessments.

The biological and physical dimensions of climate change are inseparable from their social consequences. Reduced agricultural output diminishes household incomes, increases debt burdens, and forces labor migration, eroding the social fabric of rural communities (Adger *et al.*, 2003) [1]. In Chhattisgarh, the connection between agricultural distress and rural poverty is especially acute, as many farming households operate at or near subsistence levels with minimal safety nets (Rao & Bhanja, 2019) [22]. Women and marginalized caste groups face amplified vulnerabilities, often bearing a disproportionate burden of labor intensification and food insecurity when harvests fail (Rao, 2005) [21]. A comprehensive understanding of farmers' perceptions and adaptive responses must therefore incorporate these social dimensions to be truly relevant for policy and program design.

Within this broader context, the present study was undertaken with the specific objectives of: (a) assessing farmers' perceptions of the impacts of climate change on agriculture in the Upper Arpa River Basin; (b) evaluating the level of awareness among farmers regarding different types of natural disasters; and (c) documenting the adaptation strategies currently practiced by farmers to respond to climate change and associated risks. By addressing these three interrelated dimensions — perception, awareness, and action — the study aims to provide an integrated empirical foundation for strengthening climate adaptation extension programs in the Bilaspur district and comparable agrarian regions of central India. The findings are expected to be of direct relevance to agricultural extension workers, district-level planners, state agricultural departments, and researchers working at the interface of climate science and rural development.

2. Research Methodology

The study was conducted in the Upper Arpa River Basin located in the Kota block of Bilaspur district, Chhattisgarh, India. The Arpa River originates in the Maikal Hill range and the upper basin area is characterized by a mix of irrigated and rain-fed paddy cultivation, making it ecologically and agriculturally representative of the broader region.

A purposive sampling technique was used to select the Arpa River Basin as the study area due to its agrarian significance and documented exposure to climatic variability. From the Kota block, which forms the core of the upper basin, 10 villages were selected using simple random sampling. Subsequently, 20 respondents were selected from each village through simple random sampling, yielding a total sample of 200 farmers. Only cultivating farmers who had been engaged in farming for at least five years were included as respondents.

A pre-tested and structured interview schedule was used as the primary data collection instrument. The schedule covered three thematic areas: (i) perception of climate change impacts on agriculture, measured using a five-point Likert scale (Strongly Disagree to Strongly Agree) across 14 impact items; (ii) awareness of natural disaster risks, assessed using a four-category response format (Low, Medium, High, No Information) for eight disaster types; and (iii) current adaptation strategies in agriculture, documented through yes/no responses across 19 strategy items. The interview schedule was pilot-tested on a sub-sample of 20 farmers not included in the final study and refined for clarity and local relevance before formal data collection.

Data were collected through personal interviews with selected farmers conducted in the local dialect with the

assistance of trained field investigators. Collected data were tabulated, classified, and analyzed using descriptive statistics, specifically frequency counts and percentage distributions. All data analysis was performed using Microsoft Excel and the results are presented in tabular form.

3. Results and Discussion

3.1 Farmers' Perceptions of Climate Change Impacts

Table 1 presents the distribution of respondents based on their perceptions of the impacts of climate change. The results indicate that rising agricultural costs were perceived most strongly, with 52.00% of respondents strongly agreeing and 38.50% agreeing, giving a combined positive perception of 90.50%. This finding is consistent with Singh and Patel (2019), who reported that input cost escalation was the most cited climate-related agricultural challenge in central Indian farming communities. Declining yields were likewise strongly recognized, with 40.50% strongly agreeing and 49.00% agreeing, a combined rate of 89.50%. Changes in farming practices were acknowledged by 76.00% of respondents (65.00% agree + 11.00% strongly agree), while degraded soil fertility was recognized by 67.00% (52.00% agree + 15.00% strongly agree). These perceptions reflect ground-level observations of long-term soil health deterioration associated with changing rainfall patterns and over-reliance on chemical inputs (Kumar & Sharma, 2018) ^[12]. Decreased soil productivity was perceived positively by 63.50% of respondents (51.50% agree + 12.00% strongly agree), suggesting that farmers are sensitive to soil quality changes even without formal scientific measurement.

Table 1: Distribution of respondents based on perception of climate change impacts

S. N.	Impacts of Climate Change	Strongly Disagree F	%	Disagree F	%	No Opinion F	%	Agree F	%	Strongly Agree F	%
1	Changes in crop cycles	6	3.00	37	18.50	55	27.50	83	41.50	19	9.50
2	Emergence of new pests and diseases	25	12.50	89	44.50	10	5.00	63	31.50	13	6.50
3	Frequent floods	24	12.00	142	71.00	30	15.00	4	2.00	0	0.00
4	Frequent droughts	18	9.00	88	44.00	56	28.00	38	19.00	0	0.00
5	Degraded soil fertility	0	0.00	2	1.00	64	32.00	104	52.00	30	15.00
6	Decreased soil productivity	17	8.50	14	7.00	42	21.00	103	51.50	24	12.00
7	Reduced livestock production	0	0.00	35	17.50	54	27.00	86	43.00	25	12.50
8	Changes in crop patterns	0	0.00	0	0.00	73	36.50	105	52.50	22	11.00
9	Flowering/fruiting times changed	0	0.00	20	10.00	118	59.00	60	30.00	2	1.00
10	Insects, weeds, diseases proliferating	0	0.00	9	4.50	105	52.50	61	30.50	25	12.50
11	Agricultural costs are rising	0	0.00	0	0.00	19	9.50	77	38.50	104	52.00
12	Yields are declining	0	0.00	0	0.00	21	10.50	98	49.00	81	40.50
13	Seasonal changes	0	0.00	12	6.00	75	37.50	51	25.50	62	31.00
14	Farming practices are changing	0	0.00	15	7.50	33	16.50	130	65.00	22	11.00

Interestingly, a majority of respondents (71.00%) disagreed that frequent floods were a major impact, and 44.00% disagreed about frequent droughts. This may reflect that the upper basin area is not primarily flood-prone, and multi-year drought conditions have not consistently manifested in recent years. However, the emergence of new pests and diseases showed a more divided perception, with 44.50%

disagreeing and 38.00% agreeing, possibly reflecting variation in farm types and crop systems across sampled villages. The findings broadly corroborate Chauhan *et al.* (2016) ^[5], who found that Indian farmers with longer agricultural experience exhibit stronger recognition of gradual productivity-related climate impacts compared to episodic event-based changes.

3.2 Awareness of Natural Disaster Risks

Table 2 presents the distribution of respondents based on their awareness of different types of natural disasters. The findings reveal that awareness of floods was predominantly medium, with 78.00% of respondents in this category and 15.00% at a low level. Irregular rainfall awareness was

similarly concentrated at the medium level (72.50%), followed by drought (61.00% medium). These findings suggest that while farmers are broadly aware of hydro-meteorological hazards, their awareness is not at a high level that would typically translate into proactive risk mitigation behavior (Tripathi & Bhattacharya, 2017) [25].

Table 2: Distribution of respondents based on awareness of natural disasters

S. N.	Types of Natural Disasters (n=200)	Low F	%	Medium F	%	High F	%	No Info F	%
1	Floods	30	15.00	156	78.00	14	7.00	0	0.00
2	Irregular rainfall	45	22.50	145	72.50	10	5.00	0	0.00
3	Drought	60	30.00	122	61.00	18	9.00	0	0.00
4	Storms	80	40.00	120	60.00	0	0.00	0	0.00
5	Epidemics	63	31.50	90	45.00	0	0.00	47	23.50
6	Grazing	75	37.50	125	62.50	0	0.00	0	0.00
7	Environmental pollution	50	25.00	135	67.50	15	7.50	0	0.00
8	Disease & pest infestations	68	34.00	112	56.00	20	10.00	0	0.00

Awareness of storms was distributed between medium (60.00%) and low (40.00%) levels, with no respondents reporting high awareness or absence of information. This pattern is notable because storms can cause severe crop damage, and the absence of high-level awareness may indicate limited exposure to early warning systems or storm risk communication. Epidemic awareness was particularly low, with 23.50% of respondents reporting no information available at all, reflecting the limited integration of public health risk communication into agricultural extension programming in the study area.

Grazing as a land use risk was known at medium levels by 62.50% of respondents, pointing to farmers' recognition of uncontrolled grazing as a form of agricultural disruption,

particularly during seasonal crop rotation periods. Environmental pollution awareness was medium for 67.50%, with 7.50% reporting high awareness. Disease and pest infestation awareness was reported at medium levels by 56.00% and high by 10.00%, reflecting farmers' practical engagement with crop protection challenges in day-to-day farming (NDMA, 2020) [17]. Overall, the results suggest that while general awareness exists, significant gaps remain in translating awareness into high-level risk preparedness, a finding consistent with Banerjee (2010) [3] and Panda *et al.* (2013) [19].

3.3 Adaptation Strategies

Table 3: Distribution of respondents based on adaptation strategies in agriculture

S. N.	Adaptation Strategies	Frequency	Percentage
1	Do you rotate crops?	131	65.50
2	Do you use disease-resistant varieties?	55	27.50
3	Do you use drought-tolerant varieties?	54	27.00
4	Do you practice crop diversification?	23	11.50
5	Do you practice organic farming?	18	9.00
6	Do you practice agroforestry?	56	28.00
7	Do you manage irrigation water?	98	49.00
8	Do you use renewable energy?	12	6.00
9	Do you use fertilizers judiciously?	194	97.00
10	Do you use pesticides judiciously?	198	99.00
11	Do you adopt alternative ventures like horticulture?	134	67.00
12	Have you adopted other income-generating activities?	0	0.00
13	Do you process crops to reduce post-harvest losses?	47	23.50
14	Do you use crop sheds or greenhouses?	0	0.00
15	Do you construct and restore farm ponds?	25	12.50
16	Do you grow fodder crops?	4	2.00
17	Do you breed new breeds of cattle?	23	11.50
18	Do you change cropping systems?	19	9.50
19	Do you discuss climate-smart agriculture with other farmers?	0	0.00

Table 3 presents the adaptation strategies adopted by respondents. The most universally practiced strategy was judicious use of pesticides, reported by 198 respondents (99.00%), followed closely by judicious fertilizer use at

97.00% (194 respondents). These high adoption rates likely reflect the practical necessity of input management under increasingly unpredictable conditions, as well as government advisory campaigns on responsible

agrochemical use (MAFW, 2021) ^[16].

Adoption of horticultural crops as an alternative venture alongside the main crop was practiced by 134 respondents (67.00%), indicating awareness of income diversification within the agricultural sector. Crop rotation was practiced by 131 respondents (65.50%), a strategy with well-documented benefits for soil health maintenance and pest management under variable rainfall (Lobell *et al.*, 2011) ^[13]. Irrigation water management was practiced by 98 respondents (49.00%), suggesting moderate but incomplete uptake of water conservation strategies despite the region's dependence on seasonal rainfall.

Agroforestry was practiced by 56 respondents (28.00%), and disease-resistant varieties were used by 55 (27.50%), while drought-tolerant varieties were adopted by 54 respondents (27.00%). These levels of uptake are consistent with findings by Jain *et al.* (2015) ^[11], who identified limited access to certified seeds and inadequate extension support as major barriers to variety adoption in central Indian states. Farm pond construction and restoration was practiced by only 25 respondents (12.50%), and crop diversification by 23 (11.50%), indicating significant room for expansion of water harvesting and diversification strategies.

Notably, several critical adaptation strategies showed zero uptake: no respondent reported adoption of other income-generating activities such as fisheries or cottage industries; no respondent used crop sheds or greenhouses; and none engaged in community-level discussions on climate-smart agriculture. The complete absence of greenhouse farming and livelihood diversification beyond agriculture points to structural gaps in access to capital, training, and market linkages. The absence of climate-smart agriculture (CSA) dialogue among farmers is particularly concerning, as peer-to-peer knowledge sharing has been identified as a low-cost, high-impact pathway for adaptation diffusion in similar agrarian communities (FAO, 2013; Anderson, 2007) ^[7, 2].

4. Conclusion

This study provides field-level evidence on the perceptions, disaster risk awareness, and adaptation behaviors of 200 farmers in the Upper Arpa River Basin, Chhattisgarh. The findings demonstrate that farmers strongly perceive the economic and productivity-related consequences of climate change, particularly rising agricultural input costs, declining crop yields, changes in farming practices, and degraded soil fertility. However, awareness of natural disasters, including floods, droughts, storms, and epidemics, is predominantly at a medium level, suggesting that existing extension and disaster risk communication efforts have not yet achieved a high-level preparedness outcome.

In terms of adaptation, while certain input management practices, such as judicious use of pesticides and fertilizers, and crop rotation, are widely adopted, more advanced strategies such as income diversification, greenhouse cultivation, and community-based climate-smart agriculture engagement are virtually absent. This gap between what is necessary for building robust adaptive capacity and what is currently practiced reflects constraints in knowledge access,

institutional support, financial resources, and market connectivity.

The study recommends that agricultural extension systems in Chhattisgarh prioritize climate literacy programs that move farmers from medium to high-level disaster risk awareness, facilitate the introduction and dissemination of drought-tolerant and disease-resistant crop varieties, and promote income diversification strategies beyond crop farming. Village-level climate-smart agriculture groups, supported by Krishi Vigyan Kendras (KVKs) and the state agricultural department, could serve as effective platforms for peer learning and technology dissemination. Investments in farm pond infrastructure, crop insurance schemes, and rural credit access would further strengthen the adaptive capacity of smallholder farming households in the region. Future research should explore the role of gender, land holding size, and access to information in shaping adaptation decisions in this and similar agro-climatic zones.

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