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Comparing Climate Change Adaptation Strategies Between Urban and Rural Residents in France

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Abstract

French people are reluctant to pay carbon taxes due to perceived unfairness between urban and rural residents. However, they are committed to adapting to extreme weather and its consequences. This study aimed to analyze the incidence and impacts, and to compare adaptation strategies in urban and rural areas in France, using data from the EIB 2024-2025 survey and employing t-tests and stepwise multiple regression analyses. The results showed that urban areas experience more extreme temperatures and tend to employ infrastructure improvement strategies, while rural areas experience more storms and hail and employ ecosystem-based strategies. Both areas use education, awareness-raising, and relocation as adaptation strategies. Furthermore, those who have not experienced or been affected by extreme events are less likely to adapt. This study emphasizes the need to design adaptation strategies that account for differences between urban and rural areas, as spatial context is a key determinant of adaptation outcomes. New findings indicate that relocation strategies are a more important response for both groups than other strategies, suggesting a stronger response to severe disasters. However, they have distinctly different motivations for migration. Urban residents are more likely to migrate in response to fires and droughts, while rural residents are more likely to migrate when their health and quality of life are affected.

Keywords: Comparing; Climate Change; Adaptation Strategies; Urban Residents; Rural Residents; France.

1. Introduction

Although 66% of French citizens oppose paying taxes to address environmental change on the grounds of unfairness, this does not mean they reject climate action altogether. Rather, they demand more equitable government policies, such as taxing high-polluting corporations, providing green alternatives for low-income households, and enabling broader public participation in decision-making [1-3].

In 2018, the French government under President Emmanuel Macron attempted to increase diesel fuel taxes to reduce carbon emissions. This triggered mass protests by the Gilets Jaunes (Yellow Vests) movement, which began among rural working-class communities. These groups felt disproportionately burdened because they lacked viable alternatives, such as efficient public transportation systems, unlike urban residents who could rely on trains or electric bicycles. Ewald et al. [4], Mehleb et al. [5], Levain et al. [6], and Douenne & Fabre [7] argued that this sense of unfairness fueled

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widespread opposition, as low- and middle-income groups faced higher fuel costs while those with higher incomes remained less affected.

French people also expressed concerns about their personal economic well-being, perceiving that environmental taxes often increase daily expenses for energy, gas, and electricity. During the rising cost of living following the COVID-19 pandemic and the war in Ukraine, many perceived their economic burden as being exacerbated by the government's carbon tax. Douenne & Fabre [1] and Caillavet et al. [8] found that many French felt disengaged even before the government implemented the tax policy. Furthermore, Ali & Kirikkaleli [9] and van der Meer & van Erkel [10] agreed that the government failed to effectively communicate the long-term economic benefits of carbon taxes, thereby eroding public trust. Some people believe environmental taxes are simply a government excuse to generate revenue. Rakangthong et al. [3] commented that they want fair climate action, including policies that help the poor and vulnerable transition to a carbon-neutral society.

The French do not reject the concept of climate change. They support the goal of mitigating it but disagree with methods that affect their livelihoods [1-3]. At the same time, they are adapting to climate change in various ways to ensure their survival. For example, Guibert et al. [11], Pascal et al. [12], and Mascolo et al. [13] found that France is experiencing more frequent and severe heat waves, particularly the 2003 heat wave, which killed tens of thousands of people. The temperature increase necessitates adaptations in health, housing, and infrastructure, such as designing buildings to cool the air better and providing health services during summer. Duquesne & Carozza [14] also note that they are experiencing more frequent and severe natural disasters, including floods, droughts, storms, and wildfires, which damage property, infrastructure, and agricultural areas. Adaptation requires new urban planning, infrastructure reinforcement, and the use of natural disaster forecasting and prevention technologies.

France is one of Europe's major agricultural producers. Climate change, particularly altered rainfall patterns, affects crop yields of wine, wheat, and dairy products. Koenig & Brunette [15] noted that it forces farmers to adapt their cultivation methods, select new crop varieties, and adjust harvest times. Hotter, drier summers are depleting freshwater sources, impacting water use for electricity generation, such as cooling in nuclear power plants, agriculture, and public consumption; therefore, efficient water management is essential. Furthermore, Tramblay et al. [16] found that France has diverse ecosystems, both domestically and overseas. Climate change poses a significant threat to many species that cannot adapt quickly, including mountain animals, endemic plants, and marine organisms, which are declining at a dramatic rate [15, 16].

France has established itself as a global leader in climate change policy and international environmental cooperation. As a signatory to the Paris Agreement and a driving force within the European Union, France played a pivotal role by hosting the COP21 conference [17], which led to the landmark Paris Agreement. The French government has set ambitious targets, including achieving net zero emissions by 2050 [18], reflecting its commitment to reducing greenhouse gas emissions. However, despite high public knowledge and environmental awareness, implementing climate policies has faced significant challenges [19]. Some measures, such as carbon taxes, have proven socially unacceptable, revealing a fundamental tension between policy objectives and public acceptance. This conflict highlights the complexity of translating progressive environmental policies into practical action, even in a country with strong climate leadership.

France has diverse terrain and experiences different types of disasters across its regions, including coastal areas, mountains, forests, cities, and rural areas. The impacts of climate change vary; accordingly, for example, the South is prone to drought while the North faces heavy rains and floods. This has led to various adaptation methods, known as place-based adaptation, as noted in the research by Bettencourt et al. [20] and Smith et al. [21]. Paniagua [22] and Vigna [23] found that significant income gaps and opportunity inequalities exist between urban and rural populations. Diallo et al. [24] pointed out that people must adapt to climate change to protect their lives, maintain economic stability, preserve the environment, and ensure their long-term quality of life. Adaptation is not just a matter of solving immediate problems but a long-term planning process that requires cooperation from various parties and must be adapted to the context of each area [24].

France comprises urban areas with relatively complete infrastructure and public services and rural areas that rely primarily on natural resources, agriculture, and local communities. These differences in spatial characteristics create feelings of inequality or unfairness between urban and rural French people, according to studies by Ewald et al. [4], Caillavet et al. [8], Koenig & Brunette [15], Paniagua [22], Vigna [23], and Diallo et al. [24]. As a result, they require adaptation strategies to cope with climate change and its impacts, particularly extreme weather events. Studying these differences is therefore important, as effective adaptation strategies need to be tailored to the specific context of each area.

Urban and rural areas differ significantly in their social, economic, environmental, and infrastructure resilience, which shapes their responses to climate change. Research in France demonstrates these differences across multiple dimensions. Michau et al. [25] found that heatwaves in France will become more frequent, longer-lasting, and more intense in both urban and rural areas. Cities continue to warm due to urban heat islands (UHIs), but some rural areas are warming faster. The results emphasize the need for cities to take additional measures to address future risks. Raupach et al. [26] suggested that a warmer climate may be more conducive to the development of more intense hailstorms due to increased low-level humidity, higher convective instability, and increased melt layer height, which may lead to larger hailstones and subsequent danger to people, homes, and crops, especially in rural areas.

In terms of adaptation strategies, the literature shows that different contexts call for distinct approaches. Krigel et al. [27] emphasized that rural populations need to integrate adaptation into municipal policies and plans through local participation and context-specific implementation. For large cities, Büyüközkan et al. [28] and Jaiswal et al. [29] identified the importance of strengthening physical infrastructure, economic stability, communication networks, and socio-technological systems, with measures tailored to each city and region.

Although research on climate change impacts and adaptation strategies has grown, significant gaps remain. Existing studies predominantly examine specific disasters and adaptation strategies separately, and they lack investigation into how exposure severity influences adaptation choices. Studies analyzing both settings focus on physical impacts rather than comparing population adaptation across spatial contexts. For instance, Michau et al. [25] analyzed heatwave patterns, and Raupach et al. [26] examined hailstorm risks without comparing adaptation responses between contexts. Adaptation strategy studies remain context-specific, Krigel et al. [27] for rural and Büyüközkan et al. [28] and Jaiswal et al. [29] for urban, without cross-comparison.

More critically, limited comparative research examines how urban and rural populations differ in their adaptation responses, a gap that is particularly relevant given France's geographic diversity and substantial socioeconomic inequalities. Current research lacks an integrated framework examining both populations within a single study, limiting understanding of context-dependent adaptation processes. Most work focuses on single disaster types, heat waves by Michau et al. [25], hailstorms by Raupach et al. [26], or floods by Duquesne & Carozza [14], in isolation, with no systematic examination of how event severity influences adaptation strategies across settings. While social, economic, and political data clearly indicate urban-rural inequalities in France, including carbon tax fairness perceptions from Ewald et al. [4]; Mehleb et al. [5]; Levain et al. [6]; Douenne & Fabre [7]; Rakangthong et al. [3], income and infrastructure differences as Paniagua [22]; Vigna [23], and regional disparities in public service quality as Diallo et al. [24], climate adaptation research has yet to address these inequalities as a framework for explaining adaptation behaviors.

Consequently, there is a lack of comparative research that simultaneously examines how urban and rural residents in France experience extreme weather, how they are affected, and how they adopt different adaptation strategies depending on contextual factors, an increasingly important gap in the context of environmental inequality and injustice. This study aims to fill this gap by developing an integrated comparative analytical framework that covers space, events, climate, impacts, and population adaptation across France, a leading country in addressing climate change.

The researchers asked the research questions: (1) How do urban and rural French residents experience extreme weather events differently? (2) How do urban and rural French residents differ in the impacts they experience from extreme weather events? (3) What adaptation strategies do urban and rural French people employ to respond to extreme weather events and their consequences? The aim is to propose guidelines for individuals to adapt to climate change in various regions of France.

To conduct an in-depth comparison of urban and rural adaptation in France under extreme weather events, the study established the following objectives: (1) to compare the severity of extreme weather events experienced by urban and rural French residents; (2) to compare the impacts or consequences of extreme weather events on urban and rural French residents; and (3) to explore the adaptation strategies used by urban and rural populations in response to extreme weather events and their impacts.

In summary, France is characterized by substantial socioeconomic inequalities between urban and rural populations, with rural areas lacking the infrastructure and resources available in cities. Despite growing research on climate adaptation, comparative studies examining urban-rural differences remain limited. This study addresses this critical gap by providing an integrated comparative framework to examine how urban and rural populations experience extreme weather events, their impacts, and their adaptation strategies differently, in response to the urgent need for equitable, place-based climate policies.

Following the introduction, the study conducts a literature review covering theoretical frameworks and research on France, then presents the research design and methodology. The study presents results on the three objectives: comparing the severity of extreme weather events, examining subsequent impacts, and exploring adaptation strategies in urban and rural areas. The study discusses and interprets the findings for each objective, then concludes with recommendations for both contexts.

2. Literature Review

2.1. Related Theories

Climate change adaptation encompasses multiple dimensions, including social, economic, and political aspects, all interconnected with the Sustainable Development Goals. The Intergovernmental Panel on Climate Change (IPCC) [30] has categorized climate change adaptation into four main approaches: (1) structural and physical adaptation, which emphasizes the construction and enhancement of infrastructure and technological systems, such as dams, irrigation networks, and heat-resilient urban, designs to minimize disaster risks while modifying the physical environment to sustain local livelihoods [31]; (2) social and behavioral adaptation, which involves transforming human lifestyles, knowledge systems, attitudes, and daily practices, including initiatives to promote efficient water resource management and strengthen environmental education programs that cultivate awareness and foster enduring adaptive behaviors; (3) policy and institutional adaptation, wherein governmental bodies and organizations formulate policies, legislation, and management frameworks that facilitate adaptation efforts, such as implementing land-use regulations to prevent development in hazardous zones, harmonizing environmental policies with economic development strategies, and creating financial mechanisms to support community-level adaptation, these interventions enable systematic and sustained adaptation [32]; and (4) ecosystem-based adaptation, which harnesses natural ecosystem functions to address climate change impacts, exemplified by mangrove restoration projects that mitigate wave energy and cover crop cultivation that prevents soil erosion, while simultaneously preserving biodiversity and strengthening environmental sustainability [33].

Understanding how populations adapt to climate change necessitates collaboration among diverse stakeholders. It draws upon various conceptual and theoretical frameworks, as outlined below:

1. Socio-Ecological Systems Theory posits, according to Berkes et al. [34], that human societies and natural ecosystems are fundamentally interconnected and mutually dependent entities. Climate change adaptation must therefore transcend isolated ecological or social perspectives and embrace an integrated analytical approach. Both societal structures and ecological systems require resilience, the capacity to recover from disturbances and adapt to novel configurations when existing conditions prove untenable. This reciprocal adaptation enables both human communities and natural environments to persist and flourish despite climate-related hazards and uncertainties. Research by Colding & Barthel [35] revealed that Socio-Ecological Systems Theory became the predominant framework for developing national climate management policies between 2000 and 2019. Jozaei et al. [36] illustrated that when populations confront rapid environmental transformations, the resilience of coupled social-ecological systems, encompassing both adaptation and transformation capacities, becomes paramount, particularly through coastal ecosystem governance and strategic use of social media platforms to engage affected communities. Strengthening the adaptive capacity of these interconnected systems has thus become indispensable for sustaining resilience amid mounting environmental pressures.

2. Vulnerability Theory, as conceptualized by Cutter [37], frames vulnerability through three interconnected elements: exposure, sensitivity, and adaptive capacity. Climate researchers have extensively utilized this framework to evaluate natural disaster risks across diverse geographical contexts, including flooding, extreme heat events, and prolonged droughts. Tabasi et al. [38] documented how the convergence of climate change and accelerated urbanization has intensified flood frequency and severity, causing substantial damage across physical, economic, social, political, environmental, and infrastructural domains. The constituent elements of flood risk, including hazard characteristics, vulnerability levels, disaster susceptibility, fragility, and sensitivity, can be mitigated through enhanced resilience, which encompasses both coping mechanisms and adaptive capabilities, achieved by quantifying risks within specific study areas and leveraging available data to inform risk-reduction strategies [38]. Smallholder farmers in economically disadvantaged nations depend heavily on seasonal precipitation patterns and fluctuating temperature regimes. These rural agriculturalists are building resilient communities by understanding how climate change affects their livelihoods. Researchers have developed a climate change vulnerability assessment framework (CCVAF) that uses information and communication technology (ICT) within a GIS-based web platform to evaluate climate vulnerability at both household and community scales. This technological tool functions as a knowledge repository for assessing climate risks and formulating adaptation strategies to address identified vulnerabilities [38, 39]. Moreover, certain vulnerable demographic groups, including racial minorities, women, and individuals with limited educational attainment, exhibited heightened willingness to engage in stormwater management initiatives compared to white populations, men, and those with advanced education. Their participation was significantly influenced by concerns regarding local stormwater hazards, indicating that direct physical exposure and elevated vulnerability to disaster threats may shape both individual concerns and willingness to participate in localized hazard management efforts [39]. The practical application of vulnerability theory encompasses risk and sensitivity assessment, resilience development to minimize losses and enhance adaptive capacity, promotion of community engagement through interdisciplinary approaches, and integration of technological tools (ICT, GIS) to achieve more precise vulnerability evaluations [38-40].

3. Risk Management Theory, originating from the work of Knight [41], a prominent twentieth-century economist and financial theorist, provided the foundation for the Intergovernmental Panel on Climate Change (IPCC) [42] to establish a comprehensive framework for climate adaptation centered on risk assessment, mitigation strategies, and preparedness planning. This theoretical approach acknowledges that contemporary climate change is generating increasingly frequent, protracted, and intense natural disasters, producing intricate and cascading risks that pose growing threats to human populations and systems, both now and in the future. Consequently, developing a thorough understanding of risk landscapes becomes essential to enabling decision-makers, practitioners, and stakeholders to reduce disaster exposure and advance climate adaptation by understanding complex risk dynamics and formulating responsive policies and strategies. Risk Management Theory applies across academic research, business operations, and policy development, emphasizing the recognition and systematic management of comprehensive uncertainties to guide strategic decision-making informed by past impacts and significant events [41]. For example, the United Nations Office for Disaster Risk Reduction (UNDRR), partnering with the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) [43], has established an extensive framework for climate risk assessment and strategic planning. This methodological approach addresses the complex, non-linear characteristics of climate-related risks, necessitating enhanced risk governance structures that can be customized to accommodate national and local requirements. Private-sector entities, such as the Brookings Institution [44], have similarly proposed strategic management responses to climate change through a risk-management lens. Acknowledging the distinctive nature of climate change and its unprecedented challenges for corporations and executive leadership, this management paradigm focuses on how organizations can enhance operational performance and reduce volatility in future financial returns by identifying climate-related risks, evaluating their impacts on strategic objectives, incorporating risk assessment findings into strategic planning processes, and implementing measures to mitigate risks while capitalizing on emerging opportunities.

4. Consequence Theory emerged from B.F. Skinner's Operant Conditioning Theory [45, 46], synthesized with Risk Management principles and Safety Science, evolves into an analytical framework for examining the outcomes of discrete events. This theory is predominantly employed in risk assessment contexts to analyze potential consequences of hazards, including impacts on economic, social, and environmental systems, should specific events materialize. The fundamental components of Consequence Theory include: (1) the initiating event or hazard, such as heat waves, flood events, and severe storm systems; (2) exposure of human populations, animal species, and physical assets located within at-risk zones, including residential communities, agricultural operations, vineyards, and educational facilities; (3) vulnerability determinants, or coping capacity factors, such as limited economic resources and absence of early warning systems and resilient infrastructure; and (4) consequences, encompassing direct impacts such as immediate harm to life and property (including structural failures, electrical grid disruptions, and fatalities), indirect effects such as economic disruption, population displacement, psychological stress, and mental health deterioration, and protracted consequences including alterations in community demographics, agricultural land degradation, and permanent population migration. Studies by Hughes et al. [47] and Swenson & Daley [48] have established that climate change adversely affects human health, leading to elevated rates of cardiovascular and respiratory conditions and demonstrating substantial impacts on the health and well-being of affected populations. Research by Dianati Tilaki et al. [49] and Gogoi et al. [50] further confirmed that climate change exerts considerable effects on human health, including heat-related illnesses and respiratory ailments stemming from air pollution. Additionally, extreme meteorological events, such as flooding, drought conditions, and wildfire incidents, aggravate cardiovascular and respiratory diseases while contributing to malnutrition and psychological health challenges [51]. Populations characterized by heightened vulnerability, particularly children, elderly individuals, and those experiencing poverty, face disproportionate exposure to climate change hazards [52]. Environmental consequences are precipitating biodiversity loss and subsequent ecosystem deterioration. Intensifying extreme weather phenomena and rising temperatures substantially impact agricultural crop production and livestock systems [51, 53]. Alterations in temperature and precipitation regimes affect crop developmental cycles, resulting in diminished yields and modified growing seasons [54]. Soil quality and water resource availability are increasingly compromised, undermining the overall sustainability of agricultural production systems [55].

5. Behavioral Adaptation Theory, developed by Stern [56], presents a conceptual framework for understanding environmental behavior by analyzing determinants that shape individual adaptive responses, including threat perception, self-efficacy beliefs, and both intrinsic and extrinsic motivational factors. This framework elucidates why certain populations adapt successfully to climate challenges while others remain largely unresponsive, as individual and collective behaviors fundamentally underpin climate change mitigation and adaptation efforts within societies. Brown et al. [57] documented that farmer behavioral patterns vary substantially across contexts, with economic considerations exerting the greatest influence on decision-making. At the same time, communication channels, social interaction, predictive capabilities, and learning mechanisms remain inadequately addressed. Consequently, there exists a critical need to advance knowledge regarding behavioral

modification and psychological responses to climate change. Understanding human behavioral patterns and how individuals adapt to climate challenges through educational interventions can facilitate collaborative problem-solving approaches. Behavioral Adaptation Theory suggests that effective climate change management requires a multifaceted approach incorporating risk knowledge, self-efficacy perceptions, social normative influences, environmental awareness, and community engagement. Research conducted across agricultural, fisheries, and forestry sectors has validated that these theoretical models can successfully predict and encourage adaptation behaviors; however, they must be contextualized to align with target population characteristics and regional behavioral patterns [57].

6. Social Learning Theory, articulated by Bandura & Walters [58], proposes that humans acquire behaviors through observation and modeling of others, without necessarily requiring direct trial-and-error experiences. Through attentional processes and observation, learners must first notice demonstrated behaviors, subsequently retain the observed information, and then practice or replicate them. They can ultimately exhibit learned behaviors and develop motivation through this process. This motivation requires reinforcement through behavioral imitation, such as through reward mechanisms or the observation of favorable outcomes. This theoretical construct has been applied to natural resource management frameworks, particularly through the work of Pahl-Wostl [59], who identified social learning as fundamental to developing community understanding of climate risks and collaboratively designing participatory adaptation strategies. This learning progression advances from single-loop learning models to double-loop learning configurations, and ultimately to triple-loop learning frameworks. Furthermore, the establishment of informal network structures proves essential to this learning process. Buist et al. [60] similarly propose that cultivating relationships among stakeholders and implementing incremental steps in the learning process can facilitate the development of innovative strategies. Moreover, the successful implementation of these strategies could substantially diminish the adverse impacts of climate change. These six theoretical frameworks provide a comprehensive foundation for understanding adaptation, encompassing structural interventions, ecosystem approaches, vulnerability assessments, human behavioral dimensions, and the holistic impacts of climate change, thereby offering robust applicability to this research. Socio-ecological systems theory and vulnerability theory facilitate contextual analysis of regional conditions and risk profiles. Risk management theory enables practical analysis and informed decision-making processes. Consequence theory elucidates the multifaceted impacts of climate events. Behavioral and social learning theories illuminate human behavioral patterns and societal transformation processes.

2.2. Related Research on France

The French population has demonstrated active engagement in climate change adaptation through diverse strategies spanning policymaking, public awareness campaigns, healthcare system responses, coastal zone management, and industrial sector adaptation. To address and adapt to the unavoidable consequences of climate change, France has enacted policies to reduce greenhouse gas emissions while preparing for its impacts. The government has integrated all economic sectors into its climate adaptation strategy, establishing ambitious targets to achieve carbon neutrality by 2050 and to increase renewable energy's contribution to the national energy portfolio from 25.5% in 2020 to at least 40% by 2030. National survey data indicate rising public awareness of climate change impacts, particularly floods and heat waves, which are shaping the development of adaptation strategies. Research by Babutsidze et al. [61] and Bradley et al. [62] found that French citizens express significant concern about both economic ramifications and health consequences, underscoring the critical importance of effective communication about climate adaptation measures. These findings align with Roussel's [63] research, which found that French citizens show heightened concern about climate change's health impacts, particularly following extreme weather events. This heightened concern has prompted calls to integrate health and climate policy frameworks. In response to climate challenges, Le Cozannet & Cazenave [64] noted that France is developing integrated coastal management strategies to address sea-level rise and coastal flooding, representing an ongoing adaptation effort to reduce chronic flooding and erosion risks.

The private sector, exemplified by the French wine industry, has implemented various adaptation strategies, including technological innovations and modifications to agricultural practices, to address climate variability and enhance resilience through improved vineyard management approaches with consumer engagement, as evidenced in research by Ollat et al. [65] and van Leeuwen et al. [66].

In metropolitan regions such as Paris, Viguié et al. [67] and Azmeer et al. [68] documented that urban residents are implementing diverse strategies to mitigate the impacts of heat waves. These initiatives include urban greening programs and building insulation improvements, which can reduce ambient temperatures and decrease reliance on air conditioning, thereby lowering energy consumption during heat waves by as much as 50% throughout the summer months. This comprehensive approach also encompasses modifications to transportation behaviors to reduce energy consumption and air pollution. Tayyebi [69] observed that urban areas are also adopting innovative building design strategies that involve citizen participation to address climate change impacts.

Rural populations, particularly those in southwestern France, are adapting to global warming through traditional forest management practices and land-use modifications. Blanco et al. [70] documented that community members and local government authorities are collaborating to restore wetland ecosystems and riverine forests, to absorb excess water and adapt to environmental transformations caused by climate change, which has increased flooding frequency due to intensified rainfall events. In the Bordeaux and Languedoc regions, where heat waves and drought conditions are becoming more prevalent and altering wine flavor characteristics, agricultural producers are cultivating heat-tolerant grape varieties, including Riekötter & Hassler [71] and Holzinger et al. [72], while implementing agroforestry practices to provide vineyard shading. These interventions mitigate damage from elevated temperatures, maintain wine quality standards, and restore local ecological equilibrium.

In conclusion, France's approach to climate change adaptation reflects a comprehensive undertaking that encompasses public policy development, public awareness enhancement, health system protection, coastal zone management, urban adaptation measures, and industrial and agricultural sector transformation. Both urban and rural French populations are employing diverse strategies to build resilience appropriate to their local contexts, not only to address current climate change impacts but also to prepare for future climate challenges.

3. Research Design

The study was designed according to the following flowchart and corresponding details (Figure 1):

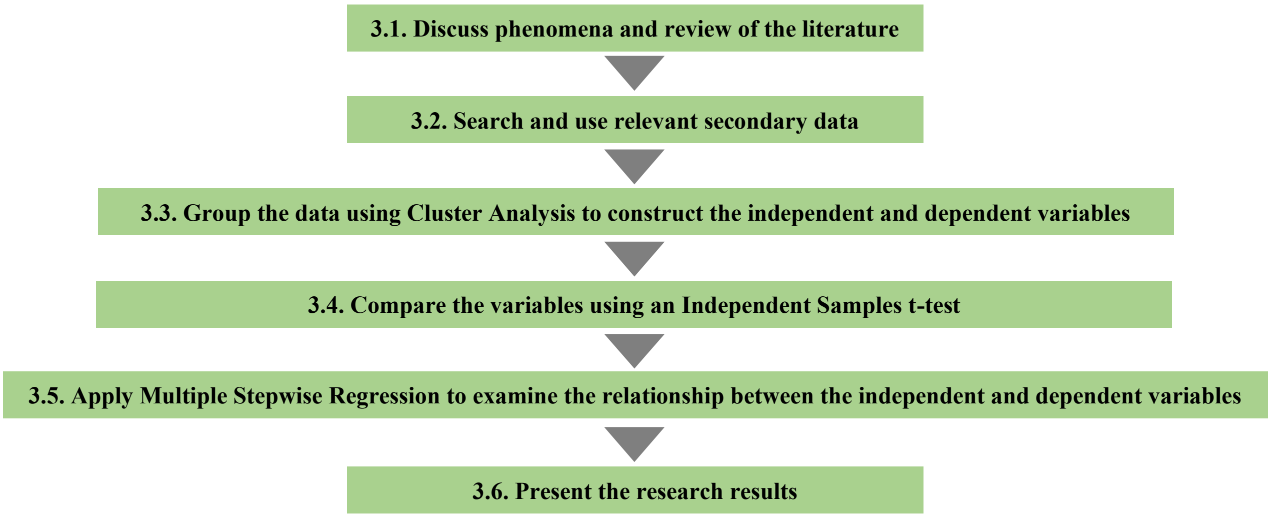


Figure 1. Research workflow

3.1. Discuss Phenomena and Review of Literature

A collaborative review and discussion of the literature on climate change adaptation in France indicated that different regions experience impacts in distinct ways. Based on this insight, the study set out to investigate: (1) how urban and rural French populations differ in their experiences of extreme weather events; (2) how urban and rural French populations differ in their vulnerability to the impacts of extreme weather events; and (3) what strategies urban and rural French populations employ to adapt to extreme weather and its impacts. The ultimate aim was to propose guidelines to help citizens across France adapt effectively to climate change.

3.2. Search and Use of Relevant Secondary Data

The data were obtained from the EIB Climate Survey 2024–2025: Adaptation to Climate Change, conducted by the European Investment Bank [73]. The survey collected responses from 596 French citizens, including 276 urban residents and 320 rural residents. The BVA Group consulting firm administered the online survey, which was completed via computers, tablets, or mobile devices, between August 6 and August 23, 2024.

The EIB Climate Survey 2024–2025 data were determined to be contextually appropriate for this study, both in terms of content and objectives. The dataset contains variables directly relevant to the research questions, including experiences with extreme weather events, climate change impacts, and adaptation behaviors. Because the EIB collected data from a nationally representative sample of the French population, reliable comparisons between urban and rural populations were possible. The dataset, collected during 2024–2025, reflects the current state of climate change. The factual and experience-based questions required respondents to report actual experiences rather than rely on interpretation or personal opinions, enabling the use of reliable and up-to-date data that accurately represent the current French context. Therefore, the dataset was considered methodologically and thematically suitable for the study.

In addition, the European Investment Bank is recognized as a highly credible European Union organization that conducted the data collection and tested the reliability of the survey instrument using Cronbach's alpha. The analysis produced a reliability value of 0.76. This value meets the acceptable threshold recommended by Nunnally & Bernstein [74] and Hair et al. [75], who advised that reliability coefficients should exceed 0.70. Based on this, the EIB Climate Survey 2024–2025 data were considered sufficiently reliable for statistical analysis.

The researchers classified respondents by their area of residence following the approaches used by Rizzo et al. [76] and Robert et al. [77]. Urban Residents: A total of 276 respondents lived in major French cities, defined as areas with populations exceeding 10,000 and characterized by dense urban environments with diverse economic, educational, and administrative activities. These cities include Paris, Lyon, Marseille, Strasbourg, and Bordeaux. They are characterized by heavy traffic and intensive land use for residential, commercial, and industrial purposes, as illustrated in Figure 2.

Figure 2. Map of major cities in France

The researchers used 320 rural residents in France, focusing on individuals living in areas with populations of fewer than 2,000. These areas are characterized by low population density, where buildings are spaced more than 200 meters apart, and consist primarily of agricultural or natural landscapes, including forestry and animal husbandry [77], as illustrated in Figure 3.

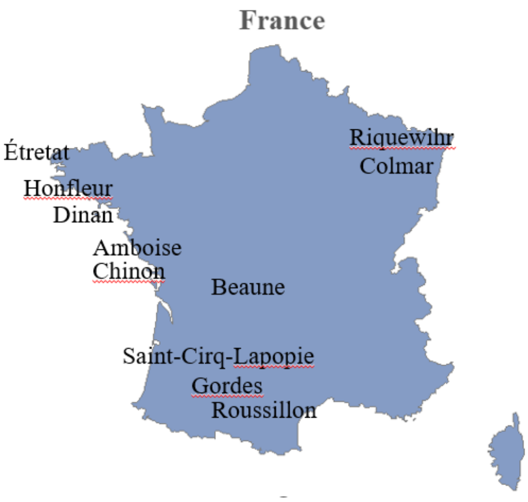


Figure 3. Map of rural areas in France

3.3. Group the Data Using Cluster Analysis to Construct the Independent and Dependent Variables

3.3.1. Independent Variable 1: Extreme Weather Events

The researchers used the variable from Question 5 of the EIB Climate Survey 2024–2025, which asks: "Within the past five years, which of the following extreme weather events has had a direct negative impact on your everyday life?" [73]. They applied cluster analysis, a method that groups data with similar characteristics into clusters based on similarity or proximity, to organize the datasets into meaningful categories for further statistical analysis.

Hierarchical cluster analysis was first performed without pre-specifying the number of clusters. The coefficients at each stage were examined, and a dendrogram was used to determine the optimal number of clusters. Subsequently, K-means clustering was conducted to reanalyze the data using a predetermined number of clusters, in order to test whether the selected number was appropriate and feasible. The original dataset included nine variables representing extreme weather events. Hierarchical clustering indicated that these variables could be grouped into seven categories. K-means clustering was then applied to classify the variables into five groups, as shown in Table 1.

Table 1. Grouping of extreme weather events

Extreme weather events	Clusters				
	1	**2**	**3**	**4**	**5**
1. Wildfire **(Group 1)**	0	0	1	0	0
2. Heatwaves **(Group 2)**	0	1	0	0	0
3. Cold spikes **(Group 2)**	0	1	0	0	0
4. Drought **(Group 1)**	0	0	1	0	0
5. Storm & hail **(Group 3)**	0	0	0	1	0
6. Landslides **(Group 4)**	0	0	0	0	1
7. Coastal flood **(Group 4)**	0	0	0	0	1
8. Inland flood **(Group 4)**	0	0	0	0	1
9. Non-experience **(Group 5)**	1	0	0	0	0

From Table 1, extreme weather events were grouped as independent variables as follows:

Group 1: Fire and drought related to drought and natural fire risk, including wildfires and droughts.

Group 2: Temperature extremes that directly impact health, physiology, and daily activities, including heat waves and cold spikes.

Group 3: Storm and hail cause damage to homes, property, and transportation, including severe storms and hail.

Group 4: Flood and landslide involving flooding from both rainfall and seawater, including landslides, coastal floods, and inland floods.

Group 5: Non-experience cases where respondents have not experienced any extreme events due to climate change, indicated by the response "None of the above."

3.3.2. Independent Variable 2: Consequences of Extreme Weather Variables

The researchers used the variable from Question 6 of the EIB Climate Survey 2024–2025, which asks: "Over the past five years, have you experienced any of the following consequences due to extreme weather events?" [73]. They first applied hierarchical cluster analysis without specifying the number of groups in advance. The researchers examined the coefficients at each stage and used a dendrogram to identify six potential clusters.

Next, they conducted K-means clustering to reanalyze the data, defining five prespecified groups to test whether this number of clusters was appropriate and feasible. Hierarchical cluster analysis initially examined 11 variables and found that they could be grouped into 9 clusters based on the consequences of extreme weather events. The researchers then used K-means clustering to group the variables into five clusters, as shown in Table 2.

Table 2. Grouping of the following consequences

The following consequences	Clusters				
	1	**2**	**3**	**4**	**5**
1. Power cut **(Group 1)**	0	0	1	1	0
2. Drinking water **(Group 1)**	0	0	1	0	0
3. Property damage **(Group 2)**	0	1	0	0	0
4. Destruction of forests **(Group 3)**	0	0	0	1	0
5. Health issues **(Group 4)**	0	0	0	0	1
6. Transportation disruptions **(Group 1)**	0	0	1	0	0
7. Food supply **(Group 4)**	0	0	0	0	1
8. Public services **(Group 1)**	0	0	1	0	0
9. Excess insurance **(Group 2)**	0	1	0	0	0
10. Loss of home **(Group 2)**	0	1	0	0	0
11. No effect **(Group 5)**	1	0	0	0	0

From Table 2, the consequence variables were classified into five categories:

Group 1: Infrastructure and public services impact encompass (1) power supply disruptions, including outages and insufficient energy provision; (2) drinking water shortages or related problems; (3) transportation disruptions such as road closures, bridge collapses, and delays in mobility; and (4) interruptions to public services, including school closures and delays in waste collection.

Group 2: Property and housing impact comprises (1) property damage (e.g., roof damage, flooding, landslides, and soil erosion) (2) depreciation in home value; and (3) increased insurance premiums.

Group 3: Environmental impact refers to the destruction or degradation of forests and natural spaces in proximity to residential areas.

Group 4: Health and livelihood impact means adverse health outcomes, such as heatstroke and respiratory illnesses, as well as disruptions in food supply chains that result in shortages of specific products.

Group 5: No effect indicates the absence of reported impacts from climate change-induced extreme weather events.

3.3.3. Dependent Variable: Adaptation Strategies

Two variables from the EIB Climate Survey 2024–2025 were used: Question 10, which asks, "Do you think you will have to take the following actions in the future because of the impacts of climate change?", and Question 12, which asks, "What do you think should be prioritized to adapt to climate change in your local area?" [73]. Hierarchical cluster analysis was first applied without specifying the number of groups in advance. The coefficients at each stage were examined, and a dendrogram was used to identify seven potential clusters.

Subsequently, they performed K-means clustering to reanalyze the data, defining five clusters in advance to test whether this number was appropriate and feasible. The original dataset contained 11 variables. Hierarchical clustering revealed that these variables could be grouped into nine distinct clusters. The researchers then applied K-means clustering to classify the variables into five clusters, as shown in Table 3.

Table 3. Grouping of strategies for adaptation

Strategies for adaptation	Clusters				
	1	2	3	4	5
1. Public warning **(Group 1)**	0	0	0	1	0
2. Educating the public **(Group 1)**	0	0	0	1	0
3. Cooling cities **(Group 2)**	0	1	0	0	0
4. Improve homes & buildings **(Group 2)**	0	1	0	0	0
5. Planting vegetation **(Group 3)**	0	0	0	0	1
6. Improving water **(Group 2)**	0	1	0	0	0
7. Improving infrastructure **(Group 2)**	0	1	0	0	0
8. Move to Cooler **(Group 4)**	0	0	1	2	2
9. Move to Less Risk **(Group 4)**	0	0	1	2	3
10. Not Adapt **(Group 5)**	1	0	0	0	0

From Table 3, five dependent variables representing adaptation strategies were grouped as follows:

Group 1: Education and awareness are strategies to help the public acquire the knowledge and behaviors needed to mitigate the impacts of extreme weather events. This includes improving public warning systems before extreme weather events and educating the public to adopt preventive and preparatory behaviors.

Group 2: Physical and infrastructure adaptation strategies enhance buildings, utilities, and urban spaces to mitigate the impact of extreme weather events. This includes: (1) cooling cities, such as creating tree-lined streets and green spaces; (2) improving the insulation of homes and public buildings; (3) improving water management systems; and (4) improving infrastructure, such as drainage systems, flood barriers, storm shelters, and power grids.

Group 3: Ecosystem-Based Adaptation is also known as environmental and natural systems management strategies. This refers to the care, restoration, and utilization of nature to support adaptation and mitigate the impacts of climate change. This includes planting vegetation that is more resilient to climate change.

Group 4: Relocation combines the variables "Move to a cooler region or country" and "Move to a less risky location, even locally, to avoid floods, forest fires, or other extreme weather events".

Group 5: Non-adaptation represents no intention to adopt adaptation strategies.

3.4. Compare the Variables Using an Independent Samples T-Test

Independent-samples t-tests were used to compare the mean values of extreme weather events and their consequences between urban and rural areas in France. Prior to the analysis, Levene's Test for Equality of Variances was conducted. When the test indicated a statistically significant difference in means ($p < 0.05$), it was concluded that the two areas differed significantly on those variables. This approach made it possible to address the following questions: (1) How do urban and rural French residents differ in their experiences of extreme weather events? and (2) How do urban and rural French residents differ in the impacts they experience from these events?

3.5. Apply Multiple Stepwise Regression to Examine the Relationship Between Independent and Dependent Variables

Multiple stepwise regression analyses were applied to examine how extreme weather events and their consequences predict adaptation strategies to climate change in each area. This analysis explored how extreme weather events and their impacts influenced the adaptation strategies of French citizens in both urban and rural contexts. Stepwise regression systematically selects predictor variables by determining which variables have a statistically significant influence on the outcome and eliminating those that do not meaningfully contribute to the model. As a result, the final model contains only the most influential predictors, ensuring that the retained independent variables genuinely explain variations in the dependent variable. This analytical approach addressed Question 3: What adaptation strategies do urban and rural French populations employ to respond to extreme weather events and their consequences?

In addition, multicollinearity diagnostics were conducted to further reinforce the robustness of the regression models. These diagnostics, including variance inflation factors (VIFs) and tolerance values, help verify that the independent variables do not exhibit excessive multicollinearity. Low multicollinearity ensures that each predictor provides unique explanatory power, strengthens the accuracy of coefficient estimates, and enhances confidence in the interpretation of the regression results.

3.6. Present the Research Results

The findings are presented through charts, tables, and explanatory narratives, and are analyzed alongside relevant theories and previous research. Data drawn from the French context are used to enrich and contextualize the discussion. The presentation addresses three stated objectives: (1) to compare the severity of extreme weather events experienced by urban and rural French residents; (2) to compare the impacts or consequences of extreme weather events on urban and rural French residents; and (3) to explore the adaptation strategies employed by urban and rural French populations in response to extreme weather events and their impacts.

In summary, secondary data from the EIB Climate Survey 2024–2025 were used, collected online from 596 French citizens (276 urban and 320 rural residents). Differences in extreme weather events, their impacts, and adaptation strategies were analyzed by categorizing residential areas according to established research criteria. Relevant survey questions were grouped using hierarchical clustering, and the suitability of these groupings was verified through K-means clustering to construct independent and dependent variables. Independent-samples t-tests were conducted to compare differences between urban and rural groups, and multiple stepwise regression was used to predict adaptation strategies based on extreme weather events and their impacts. The results are presented using tables, charts, and theoretical discussion, integrating insights from related studies to provide a comprehensive understanding. Following the literature review and study design, the conceptual framework illustrated in Figure 4 was developed.

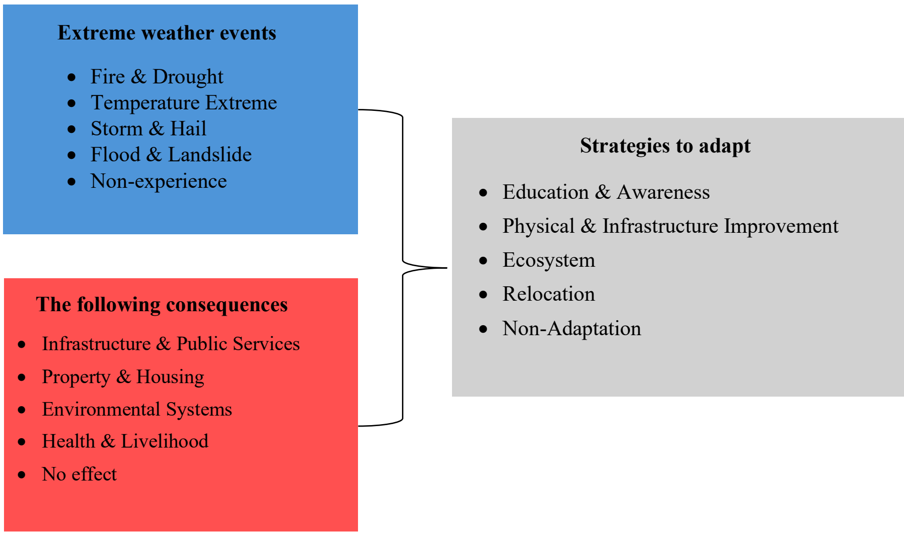
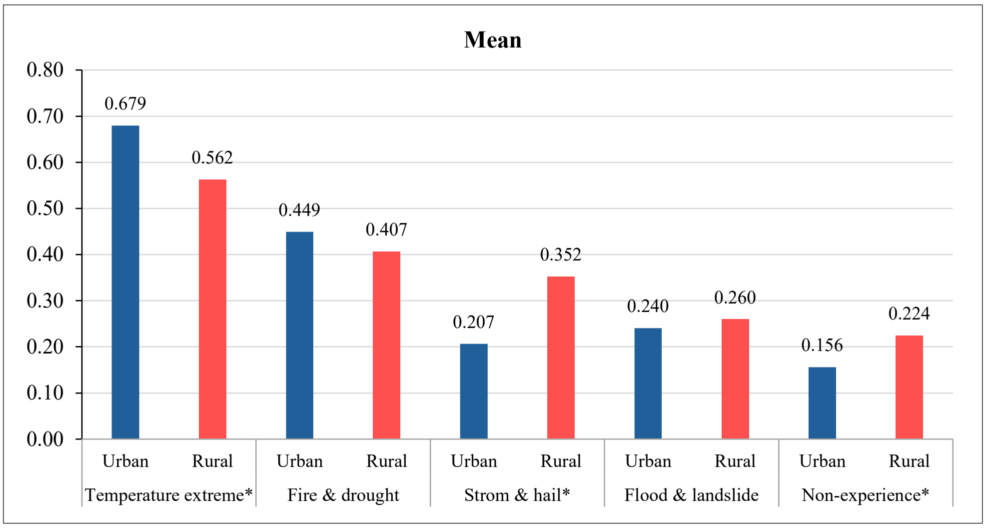


Figure 4. Research framework

The conceptual framework of this study aims to examine the relationships between extreme weather events and their consequences on adaptation strategies. The objective is to identify the characteristics of extreme weather events affecting the French population and their consequences on the adaptation strategies adopted by urban and rural residents.

4. Research Results

The research results are presented in relation to the three study objectives. The first objective was to compare the frequency of extreme climate change events experienced by urban and rural residents in France over the past five years. The sample included 276 urban residents and 320 rural residents. Independent-samples *t*-tests were used to compare the mean values between the two groups. The findings are illustrated in charts and tables, as shown in Figure 5.



Variables	F	Sig.	t	df	Sig. (2-tailed)
Temperature extreme	3.21	0.074	2.77	595	0.006*
Fire & drought	2.262	0.133	0.964	595	0.335
Storm & hail	66.253	0	-4.022	594.887	0.000**
Flood & landslide	0.123	0.726	-0.452	595	0.651
Non-experience	18.632	0	-2.143	594.92	0.033*

*p < 0.05, **p < 0.001

Figure 5. Comparing the results of extreme weather events experienced by urban and rural French residents

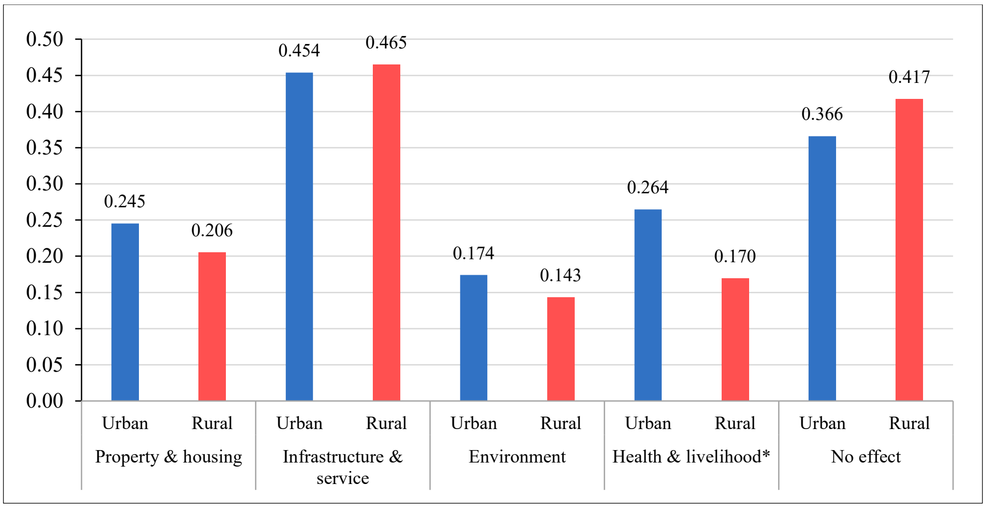
Figure 5 compares the average frequency of extreme weather events experienced by urban and rural populations. Preliminary findings indicate that urban residents reported slightly higher average levels of extreme weather events than rural residents, while both groups maintained similar variances. Based on this observation, the researchers applied independent-samples t-tests to compare the two groups across five variables: temperature extremes, fire and drought, storms and hail, floods and landslides, and non-experience. The results indicate that both groups experienced temperature extremes more frequently than other event types, and the tests detected statistically significant differences in several categories ($p < 0.05$).

When examining temperature extremes, such as heat waves, urban respondents reported higher mean scores (Mean = 0.679) than rural respondents (Mean = 0.562). The t-test revealed a significant difference ($p < 0.05$), indicating that individuals in urban areas experienced more extreme temperature events than those in rural communities. In the case of fire and drought events, urban residents reported slightly higher mean scores (Mean = 0.449) than rural residents (Mean = 0.407). However, the t-test showed no significant difference ($p = 0.335$), suggesting that both groups experienced these events at comparable levels.

Regarding storms and hail, rural respondents reported a higher mean (Mean = 0.352) than urban respondents (Mean = 0.207). The t-test indicated a significant difference ($p < 0.05$), demonstrating that rural residents experienced more storms and hail than those in urban areas. For floods and landslides, the means remained similar between urban and rural residents (Mean = 0.24 and Mean = 0.26, respectively). The t-test confirmed no significant difference ($p = 0.651$). Regarding non-experience, defined as never having encountered a severe climate change event or disaster, rural respondents reported a higher mean (Mean = 0.224) than urban respondents (Mean = 0.156). The t-test also revealed a significant difference ($p < 0.05$), suggesting that rural residents were more likely to report no prior experience of such events.

Overall, the graphical and statistical analyses demonstrate distinct differences in exposure to extreme weather events between urban and rural residents in France. Temperature extremes are substantially more prevalent in urban areas, whereas storms and hail occur more frequently in rural regions, reflecting the differing environmental conditions and infrastructural characteristics of these settings. A notable finding is the higher likelihood of non-experience among rural residents, indicating that a significant proportion of individuals in rural areas have not previously encountered severe climate-related events. In contrast, the frequencies of fires, droughts, floods, and landslides do not differ significantly between the two groups, suggesting that these hazards occur at relatively similar levels across the country.

The second objective was to analyze the consequences of extreme weather events caused by climate change for French citizens living in urban and rural areas, using independent-samples t-tests. The comparative results are presented in the charts and tables shown in Figure 6.



Variables	F	Sig.	t	df	Sig. (2-tailed)
Property & housing	6.686	0.01	1.048	595	0.295
Infrastructure & service	0.613	0.434	-0.193	595	0.847
Environment	4.179	0.041	1.023	595	0.307
Health & livelihood	21.521	0	2.666	541.998	0.008**
No impact	6.53	0.011	-1.286	585.373	0.199

**p < 0.01

Figure 6. Comparing the following consequences of extreme weather events between urban and rural French residents

Figure 6 presents the comparative results of the mean impacts of extreme weather events across five variables: property and housing, infrastructure and service, environment, health and livelihood, and no impact for urban and rural residents in France. The data indicate that both groups experienced comparable levels of impact across most categories, though notable differences emerged in certain areas. Preliminary analysis further showed that, although the mean impacts reported by urban residents were generally higher than those of rural residents for several variables, the variances between the two groups were comparable, supporting the use of independent-samples t-tests to examine these differences.

When examining property and housing, urban respondents reported a higher mean score (Mean = 0.245) than rural respondents (Mean = 0.206). However, the t-test result (p = 0.295) indicated no statistically significant difference between the two groups.

For infrastructure and service, the means were nearly identical for both groups (Urban Mean = 0.454; Rural Mean = 0.465), and the t-test confirmed no significant difference (p = 0.847). This suggests that both urban and rural populations experienced comparable disruptions in infrastructure and public services. Regarding the environment, urban respondents reported a slightly higher mean score (Mean = 0.174) than rural respondents (Mean = 0.143). The t-test (p = 0.307) showed no significant difference, indicating that environmental impacts were similar across both areas.

A statistically significant difference emerged for health and livelihood, where urban respondents reported higher mean impacts (Mean = 0.264) than rural respondents (Mean = 0.17), with the t-test showing (p = 0.008). This finding suggests that extreme weather events had a stronger negative effect on health and livelihood in urban areas than in rural areas. For the No Impact variable, rural respondents reported a higher mean (Mean = 0.417) compared to urban respondents (Mean = 0.366); however, this difference was not statistically significant (p = 0.199).

In summary, the study found that while the impacts of extreme weather events on several dimensions, such as property, environment, and infrastructure, did not differ significantly between urban and rural areas, the health and livelihood impacts were significantly more severe in urban areas. Indicating that these events occurred at similar levels nationwide and were not limited to any specific area.

The third objective involved examining the adaptive strategies of the French population, both in major cities and rural areas, in response to extreme weather events and their consequences. Stepwise multiple regression analysis was employed to examine the relationships between independent and dependent variables. This statistical approach enables the simultaneous consideration of multiple independent variables to assess their individual and collective impacts on a single dependent variable, which in this study is defined as adaptive strategies. The results illustrate the extent to which each independent variable influences the adaptive strategies of French citizens. The findings are presented in Tables 4 and 5.

Table 4. Adaptive strategies to extreme weather events and the following consequences for urban French residents

Independent Variables	B	S.E.	Beta	t	Sig. (p-value)	Collinearity Statistics	
						Tolerance	VIF
Education & Awareness							
(Constant)	0.318	0.052		12.056	0.000		
No effect	-0.144	0.056	-0.156	-2.594	0.010	0.96	1.042
Temperature extreme	0.108	0.053	0.124	2.057	0.041	0.96	1.042
R = 0.218, R² = 0.048, Adjusted R² = 0.041, F = 6.824, p < 0.001							
Infrastructure							
(Constant)	0.576	0.064		9.059	0.000		
Temperature extreme	0.235	0.075	0.189	3.146	0.002	0.951	1.052
Infrastructure & service	0.113	0.056	0.122	2.033	0.043	0.951	1.052
R = 0.247, R² = 0.061, Adjusted R² = 0.054, F = 8.874, p < 0.000							
Relocation							
(Constant)	3.548	0.114		31.002	0.000		
Not effect	-0.691	0.151	-0.268	-4.581	0.000	0.938	1.066
Fire & drought	0.388	0.131	0.173	2.956	0.003	0.938	1.066
R = 0.353, R² = 0.125, Adjusted R² = 0.118, F = 19.447, p < 0.000							

As shown in Table 4, urban French residents employed three primary strategies to cope with extreme weather events and their consequences: education and awareness, infrastructure improvement, and relocation. The regression analysis shows that the models' explanatory power varies across strategies, with some independent variables exerting stronger effects than others.

For education and awareness, the findings indicate that no effect had a significant negative influence (B = -0.144, p = 0.010), suggesting that individuals who had not been affected by adverse climate-related events were less likely to engage in learning or awareness-raising activities. In contrast, exposure to temperature extremes was positively associated with this strategy (B = 0.108, p = 0.041), suggesting that exposure to extreme temperatures increased the likelihood of educational engagement and awareness-building. Overall, this model explained 4.8% of the variance (R^2 = 0.048).

For infrastructure improvement, both temperature extremes (B = 0.235, p = 0.002) and impacts on infrastructure and services (B = 0.113, p = 0.043) showed significant positive associations. This result suggests that urban residents who experienced extreme heat events and disruptions to public infrastructure were more likely to support or adopt infrastructural adjustments to mitigate climate risks. The model accounted for 6.1% of the variance (R^2 = 0.061).

The relocation strategy demonstrated the strongest explanatory power among all models, accounting for 12.5% of the variance (R^2 = 0.125). The results revealed that no effect had a strong negative influence (B = -0.691, p = 0.001), indicating that individuals not directly affected by severe climate events were less inclined to relocate. Conversely, fire and drought had a significant positive effect (B = 0.388, p = 0.003), suggesting that experiences with wildfires and droughts considerably increased the likelihood of migration as an adaptive measure.

The assessment of multicollinearity supported the robustness of the regression results. Tolerance values ranged from 0.938 to 0.960, while VIF values ranged from 1.042 to 1.066. These fell within acceptable thresholds (Tolerance > 0.2 and VIF < 5), confirming that the independent variables did not overlap excessively. The closeness of both measures to 1 further indicated that the predictors operated independently and that the regression coefficients remained stable and reliable.

Among the three models for urban residents, the relocation model explained the most variance (12.5%), followed by the infrastructure improvement model (6.1%) and the education and awareness model (4.8%). These results indicate that direct experience of extreme weather significantly influences strategies related to housing change. Although the explained variance (R^2) values for all three models ranged from 4.8% to 12.5%, the modest values, consistent with the multifactorial nature of human behavior and climate research, are sufficient for interpreting behavioral relationships in a French urban population. This is consistent with the work of Hair et al. [75], Cohen [78], Falk & Miller [79], and Tabachnick & Fidell [80], who consider human and social science research, typically yielding low to moderate R^2 values, as humans are exposed to multiple factors.

The adaptive strategies of rural French residents in response to extreme events and their subsequent impacts are presented in Table 5.

Table 5. Adaptive strategies to extreme weather events and the following consequences for rural French residents

Independent Variables	B	S.E.	Beta	t	Sig. (p-value)	Collinearity Statistics	
						Tolerance	VIF
Education & Awareness							
(Constant)	0.237	0.031		7.597	0.000		
Fire & drought	0.138	0.046	0.165	2.967	0.003	0.956	1.046
Property & housing	0.157	0.059	0.149	2.670	0.008	0.956	1.046
R = 0.244, R² = 0.06, Adjusted R² = 0.054, F = 10.072, p < 0.000							
Infrastructure Improvement							
(Constant)	0.892	0.039		22.654	0.000		
Non-experience	-0.248	0.083	-0.165	-2.985	0.003	1	1
R = 0.165, R² = 0.027, Adjusted R² = 0.024, F = 8.91, p < 0.003							
Ecosystem							
(Constant)	0.460	0.042		10.971	0.000		
Temperature extreme	0.171	0.055	0.171	3.106	0.002	1	1
R = 0.171, R² = 0.029, Adjusted R² = 0.026, F = 9.65, p < 0.002							
Relocation							
(Constant)	3.067	0.078		39.260	0.000		
Non-experience	-0.537	0.152	-0.194	-3.547	0.000	0.966	1.035
Health & livelihood	0.543	0.161	0.184	3.377	0.001	0.966	1.035
R = 0.291, R² = 0.085, Adjusted R² = 0.079, F = 14.388, p < 0.000							

As presented in Table 5, rural French residents employed four primary strategies to cope with extreme events and their aftermath: education and awareness, infrastructure improvement, ecosystem-based adaptation, and relocation. The regression results revealed distinctive patterns of adaptation that differed from those observed among urban populations.

For education and awareness, the analysis revealed significant positive associations with fire and drought ($B = 0.138$, $p = 0.003$) and property and housing impacts ($B = 0.157$, $p = 0.008$). This suggests that rural residents who experienced wildfires, droughts, or property damage were more likely to engage in educational activities and raise awareness about climate change. The model explained 6.0% of the variance ($R^2 = 0.06$). For infrastructure improvement, non-experience exerted a significant negative influence ($B = –0.248$, $p = 0.003$), meaning that rural residents without direct exposure to severe climate events were less inclined to make infrastructural adjustments. The explanatory power was modest, accounting for 2.7% of the variance ($R^2 = 0.027$).

Regarding ecosystem-based adaptation, a significant positive relationship was found between temperature extremes and the dependent variable ($B = 0.171$, $p = 0.002$). Thus, the experience of extreme weather conditions, such as severe heat or cold, motivated rural communities to adopt ecosystem-oriented protective measures. The model accounted for 2.9% of the variance ($R^2 = 0.029$).

The relocation strategy demonstrated relatively stronger explanatory power than the previous strategies, accounting for 8.5% of the variance ($R^2 = 0.085$). Non-experience was strongly and negatively related ($B = –0.537$, $p = 0.000$), indicating that those without direct exposure to extreme events were less likely to relocate. Conversely, health and livelihood impacts had a significant positive effect ($B = 0.543$, $p = 0.001$), indicating that concerns over health and quality of life strongly encouraged migration to other areas.

The multicollinearity diagnostics reinforced the robustness of the regression models. Tolerance values ranged from 0.956 to 1.000, and VIF values ranged from 1.000 to 1.046, which were well within accepted thresholds (Tolerance > 0.2, VIF < 5). These values, which were very close to 1, confirmed that the independent variables were independent of one another, ensuring stable and reliable regression coefficients.

Comparing the four models for rural residents, the relocation strategy demonstrated the highest explanatory power (8.5%), followed by education and awareness (6.0%), ecosystem-based adaptation (2.9%), and infrastructure improvement (2.7%). Hair et al. [75], Cohen [78], Falk & Miller [79], and Tabachnick & Fidell [80] suggested that, although the variance-explained (R^2) values ranged from 2.7% to 8.5%, modest but consistent with the multi-factorial nature of human behavioral and climate research, they appropriated for interpreting the adaptation characteristics of rural French populations.

The comparative analysis revealed distinct adaptation patterns between urban and rural French populations. Urban residents employed three strategies (education and awareness, infrastructure improvement, and relocation), while rural populations used four strategies, adding ecosystem-based adaptation to their portfolio. Relocation emerged as the most important strategy for both groups, but with different drivers: urban migration responded to direct threats from fires and droughts, while rural migration was motivated by health and livelihood impacts. Temperature extremes and infrastructure disruptions primarily influenced urban adaptation, whereas rural adaptation responded to broader factors, including property damage and quality of life concerns. Direct climate experience proved critical for both populations, with non-exposed individuals showing significantly lower engagement in adaptation across all strategies.

5. Discussion

The findings were discussed in relation to the *three* stated research objectives. The first objective—comparing extreme weather events between urban and rural residents in France—indicates that both populations have been affected by extreme events associated with climate change. This result aligns with socio-ecological systems (SES) theory proposed by Berkes et al. [34], Colding & Barthel [35], and Berkes [81], which emphasizes the interconnectedness of humans and nature. Citizens in both urban and rural areas of France reported experiencing climate-related hazards, including temperature extremes, wildfires, droughts, storms, hail, floods, and landslides.

The study also aligns with vulnerability theory developed by Cutter [37] and Wisner & Wisner [82], which posits that both urban and rural communities are vulnerable to climate risks, although their vulnerabilities differ in nature. Urban areas are characterized by higher population density and more complex infrastructure, while rural areas rely more heavily on natural resources and agriculture. Although both contexts face climate-related hazards, the patterns of impact differ.

Studies have demonstrated that urban areas are more vulnerable to the effects of extreme temperatures, particularly heat waves. For example, the summer heat wave of 2022 resulted in record-breaking temperatures across France, particularly in major cities such as Lyon, leading to elevated mortality from heat-related diseases [83]. This finding is consistent with research by Alari et al. [84], who reported that several major French cities, including Paris, Nancy, Lille, Marseille, and Rouen, experienced higher heat-related mortality rates. Although rural areas were also affected, Michau et al. [83] noted that urban areas are more severely impacted by the urban heat island (UHI) effect, which is exacerbated by high population density and extensive heat-absorbing surfaces.

The urban heat island phenomenon occurs because cities experience significantly higher ground and air temperatures than rural areas. This temperature differential results from several factors: urban infrastructure, such as concrete and asphalt surfaces, absorbs and retains more heat and releases it more slowly; high building density contributes to greater heat retention; cities have less green space, fewer trees, and fewer natural cooling surfaces than rural areas; and the greater concentration of vehicles, engines, air conditioners, and energy systems in cities releases additional heat into the atmosphere. Consequently, urban temperatures remain elevated both during the day and at night [83].

In contrast, rural areas are more vulnerable to storms and hail. Rural topography, including open areas, wind paths, and hillsides, facilitates the formation of hailstorms, causing substantial crop damage, particularly affecting grape yield and quality. Southern and mountainous areas, such as the Massif Central and the Alps, are highly vulnerable to hailstorms [85]. Such phenomena pose significant risks to agriculture, especially to vineyards, as hail can damage grape skins, leaves, and vines, resulting in reduced yields and diminished wine quality [86]. Severe hailstorms also increase production costs, as farmers must repair vineyards and cope with yield losses [87]. These findings align with research by Riekötter & Hassler [71] and Holzinger et al. [72], which identified hailstorms as a major threat to French agriculture, particularly to the vineyard and wine industry.

Furthermore, the study found that rural residents reported higher levels of non-exposure to extreme events than their urban counterparts. This finding aligns with resilience theory proposed by Berkes [81] and Holling [88], which posits that rural areas tend to exhibit greater ecological resilience. Diverse ecosystems such as forests, mixed agricultural landscapes, and wetlands act as natural buffers, mitigating climate shocks more effectively than urban areas dominated by built infrastructure and heat-retaining concrete. As a result, rural residents experience fewer extreme climate impacts than urban residents, consistent with Michau et al. [25] and Viguié et al. [67], who clearly indicate that France, particularly urban areas, will face more frequent, intense, and longer-lasting heatwaves within this century, with cities significantly more at risk than rural areas, as UHI exacerbates the impacts. As demonstrated in studies by Balzan et al. [89], rural areas possess natural landscapes that mitigate the intensity of extreme events more effectively than urban areas, resulting in lower exposure to extreme weather because natural ecosystems and landscapes dissipate heat and reduce the impact of extreme weather conditions.

Based on the first objective, the study found that urban residents in France experience greater exposure to climate extremes than rural residents. Heat waves are particularly severe in urban areas due to the urban heat island effect. Rural areas are more vulnerable to storms and hail, which can cause severe damage to crops and the agricultural industry. These findings are consistent with research by the European Environment Agency (EEA) [90] and Hincks et al. [91], which found that urban and rural areas in Europe exhibit distinct climate risks. Urban areas are more vulnerable to heat waves due to the urban heat island effect, population density, and heat-retaining infrastructure, with urban temperatures likely to exceed rural temperatures systematically in the future. Lakatos & Csabai [92] indicated that rural areas are more vulnerable to storms, hail, and drought, hazards that particularly affect agricultural production.

The second objective, comparing the consequences of extreme weather events, found that urban and rural populations experience similar overall effects. This finding is consistent with Skinner's Consequence Theory [45, 46], which posits that hazards generate both direct and indirect consequences. Direct consequences include immediate damage to health and property, while indirect consequences encompass disruptions to infrastructure, public services, and the environment [31].

Direct consequences identified in this study include health and livelihood impacts, such as heatstroke and respiratory problems, as well as property and housing impacts, including roof damage, floods, landslides, soil erosion, loss of housing value, and increased insurance costs. Indirect consequences include infrastructure and public service disruptions, such as power outages, drinking water shortages, road and bridge closures, delayed transportation, and interruptions to schools and waste collection services. Environmental impacts include the destruction of forests and natural areas surrounding communities [73].

However, the study found significant differences in health and livelihood impacts between urban and rural populations, with urban residents experiencing more severe effects. This disparity is primarily attributable to the severity of urban heat waves, which are exacerbated by heat-absorbing infrastructure and population density [93, 94]. Much urban infrastructure is not designed to withstand extreme conditions, thereby intensifying the impacts of flooding and heat waves [95]. Furthermore, high energy consumption and vehicle emissions increase urban carbon dioxide levels, exacerbating climate change-related health risks. These findings are consistent with research by François et al. [96] and Leroutier & Quirion [97], who found that cities possess infrastructure that increases heat and CO_2 pollution, thereby amplifying health effects for urban residents. In particular, commuting in Paris is a major source of emissions, leading to greater urban pollution and CO_2 accumulation compared to rural areas, thereby exacerbating health impacts.

Extreme heat in urban areas has been shown to significantly increase public health risks. Vulnerable groups, particularly older adults, are more susceptible to heat-related impacts than other demographic groups, making the consequences more severe in urban areas during heat waves. Studies by Roussel [63], Lemonsu et al. [98], and Grislain-Letremy et al. [99] demonstrate strong correlations between rising temperatures and mortality in Paris and other French cities. These findings underscore the pressing need for enhanced climate services and heat-risk mitigation policies in urban settings.

Supporting evidence from Sabri et al. [100] and Forceville et al. [101] further confirms that urban populations experience greater impacts on their well-being and health compared to rural populations. Heat stress in cities, especially at night, increases morbidity and mortality during widespread heat waves. Vulnerable groups, particularly the elderly, face heightened risks, with approximately 8,000 heat-related deaths reported in French cities between 2000 and 2017. These findings reinforce the conclusion that urban residents face greater health risks from climate change than rural populations, whose primary vulnerabilities lie in agriculture and natural resources [101].

In response to the second objective, the study found that urban and rural areas are similarly affected by extreme weather events across most impact dimensions. However, health and livelihood impacts are significantly more severe in urban areas due to urban heat stress exacerbated by heat-trapping infrastructure and population density. Vulnerable groups, particularly the elderly, face disproportionately high risks from heat wave effects in urban settings. Multiple studies conducted in France have confirmed that heat-related illness and mortality rates in cities are significantly higher than in rural areas.

The third objective, the adaptation strategies employed by urban and rural populations in France in response to extreme weather events and their consequences, is summarized in Table 6.

Table 6. Summarizes the adaptation strategies for extreme weather events and their consequences for urban and rural residents in France

Dependent variables	Education & Awareness		Physical & Infrastructure		Ecosystem-Based		Relocation		Not Adapt	
	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural
Extreme weather events										
• Fire & Drought		+					+			
• Temperature Extremes	+		+			+				
• Storm & Hail										
• Flood & Landslide										
• Non-experience				-						
The following consequences										
• Infrastructure & Services			+							
• Property & Housing		+								
• Environmental Impact										
• Health & livelihood								+		
• No effect	-						-			

Table 6 shows that urban and rural French populations employ distinct adaptation strategies in response to extreme weather events. Four of the five strategies, education and awareness, physical and infrastructure improvements, ecosystem-based adaptation, and relocation, were significantly used, while non-adaptive behaviors showed non-significant effects. Urban residents exposed to heat waves typically respond by increasing their knowledge, seeking information, and improving infrastructure to mitigate the impacts of heat on daily life and public services. They also consider relocating to less vulnerable areas when faced with wildfires or drought. Meanwhile, rural populations increase education and information-seeking during wildfire and drought risks, including property and home damage from disasters, adopt ecosystem-based strategies to address extreme temperatures, and relocate when extreme events threaten their health and well-being. Individuals without direct exposure often underestimate risks, thereby reducing their readiness for adaptation.

These findings support socio-ecological systems theory by Berkes [81] and Holling [88], which conceptualizes adaptation as an interaction between humans and ecosystems. Because climate change affects daily life in France, both urban and rural residents adapt, recover, and transform, whereas those who have not experienced or been directly affected by extreme events perceive no need for adaptation.

These results also align with vulnerability theories by Cutter [37], Wisner & Wisner [82], and Adger [102], which argue that an area's vulnerability shapes residents' adaptation choices. Major French cities are vulnerable to temperature extremes, prompting urban residents to adopt education, awareness, and relocation strategies during fire and drought events. This pattern reflects Knight's [41] risk management theory, which explains how individuals and communities perceive, assess, and interpret risks. However, such assessments vary according to personal factors, living environments, and individual experiences.

These patterns are further consistent with Stern's behavioral adaptation theory [56] and Bandura's social learning theory [58], which state that adaptation arises from risk perception and learning processes. Urban residents adapt by enhancing education and awareness and upgrading infrastructure, such as installing cooling or heat-protection systems, in response to temperature extremes. They show a stronger tendency to relocate during fire and drought events. Rural populations rely on ecosystem-based strategies during extreme temperatures and choose relocation when their health or livelihoods are significantly affected. Overall, the findings indicate that urban and rural residents differ in risk perception, learning, and behavioral adaptation. At the same time, those lacking direct experience with extreme events remain indifferent and fail to recognize the need for adaptation [103].

The following sections present detailed discussions of the four adaptation strategies identified in this study:

- **Education and Awareness Strategy**

This study found that during heat waves, French urban residents employ adaptation strategies that raise awareness and public consciousness, including public relations campaigns, exhibitions, billboards, online media, and the integration of climate change content into educational curricula. As Roussel [63] noted, the 2003 heat wave served as a turning point, prompting the French government to prioritize public health, prevention, and public information dissemination, particularly for vulnerable groups. Recent research by Lemonsu et al. [98], Sabri et al. [100], and Ribes et al. [104] demonstrated that urban residents in France are more severely affected by heat waves due to the urban heat island effect, highlighting the continued need for awareness raising, education, and communication of climate risks to the public. This aligns with Douenne & Fabre's [1] findings, which show that climate change information campaigns raise climate awareness and increase support for climate policy, especially when they deliver scientific information. Understanding climate change requires recognizing it as a complex issue that involves both social and scientific dimensions, marked by uncertain and context-specific knowledge.

French rural populations are adapting by increasing their education and seeking information and knowledge to address the risks of fire and drought, as well as the risks of home and property damage. For example, the 2021 Provence-Alpes-Côte d'Azur wildfires and the severe drought in several regions in 2022 highlighted the vulnerability of rural communities. In rural areas, education and awareness strategies focus on addressing drought, wildfires, and extreme weather events that affect property and housing. du Cunha et al. [105] mentioned France's national adaptation plan emphasizes providing information to rural communities, and Yanou et al. [106] suggested integrating local knowledge into education to promote resource conservation. Furthermore, O'Brien et al. [107] suggested that collaborative environmental learning and community discussions promote ownership and enhance adaptation effectiveness. The research by Šakić Trogrlić et al. [108] also indicated that property and housing damage increase the need for early warning systems and training workshops. Studies by Runde et al. [109] and the United Nations Office for Disaster Risk Reduction emphasize the importance of transferring technical knowledge, regulations, and technological systems to mitigate risk and enhance resilience to disasters.

Education and awareness strategies in France play crucial roles in both urban and rural areas, albeit with different emphases. Urban areas prioritize public communication and behavioral change, while rural areas focus on building knowledge and practical skills to cope with climate risks. Awareness of the severe impacts of climate change is a key factor that positively influences climate mitigation actions [110, 111].

- **Physical and Infrastructure Improvement Strategy**

Physical and infrastructure improvement strategies differ significantly between urban and rural France. French urban residents face substantial impacts from the urban heat island effect and extreme temperature events, necessitating adaptation through structural measures. These measures include the creation and expansion of green infrastructure, including parks, tree-lined streets, green roofs and walls, as well as improvements in cooling systems in public buildings and the creation of bicycle paths to reduce heat and pollution [112]. Prominent examples include the Jardin du Luxembourg and Parc de Sceaux, large parks in the capital and surrounding areas that serve both environmental and recreational functions. This approach is consistent with research by Técher et al. [112], who found that increasing green space, adopting open-city structures, and creating green corridors can significantly reduce the severity of urban heat islands.

Urban areas also face challenges related to direct impacts on infrastructure and public services. These impacts include reduced electricity generation due to drought affecting nuclear power plants, shortages of drinking water in southern cities such as Montpellier and Nice, flash floods that damage roads, bridges, and transportation systems, and disruptions to public services such as school closures and delayed waste collection during heat waves and heavy rainfall. Research by Portugal-Pereira et al. [113] confirmed that drought reduced electricity generation from nuclear power plants in France, necessitating infrastructure adaptations. Salvo et al. [114] noted that flooding damaged roads and bridges and disrupted urban transportation systems, with urban flooding capable of disrupting entire city systems. Schneider et al. [115] observed that climate disasters, such as heat waves, floods, and storms, often result in simultaneous failures of multiple public services. Therefore, most cities need to invest substantially in early warning systems and more resilient infrastructure connections.

In contrast, rural France does not exhibit the same infrastructure adaptation needs. Rural homes are often situated within agricultural, forested, and natural areas that already function as natural heat barriers. Therefore, rural areas do not require the same level of infrastructure investment to mitigate heat waves, reduce urban heat-island effects, and address challenges in energy, drinking water, transportation, and public services. This finding is consistent with research by Boinot et al. [116] and Dardonville et al. [117], who found that rural areas rely heavily on ecosystems, including forests, open fields, bocages, wetlands, agroforestry, and agroecology, all of which serve as natural heat barriers that mitigate the impacts of heat waves, droughts, and storms. This ecological foundation means rural areas do not need to invest as extensively in heat-reducing infrastructure as urban areas do.

Urban areas are particularly vulnerable to heat waves and the urban heat island effect, requiring significant investment in infrastructure such as green spaces, cooling systems for public buildings, and flood and drought-resistant infrastructure. In a different context, rural areas are naturally protected by ecosystems such as forests, farmlands, and wetlands, which mitigate heat and mitigate the impacts of extreme weather, and thus do not require as much investment in adaptation infrastructure as urban areas.

- **Ecosystem-Based Adaptation Strategy**

Rural French communities demonstrate a distinctive reliance on ecosystem-based adaptation strategies, using natural systems and local landscapes as primary mechanisms to address extreme temperature events, including heat waves and cold snaps. This approach centers on harnessing natural resources and implementing sustainable agricultural practices to mitigate the impacts of climate change [118].

The integration of trees and natural landscapes through agroforestry systems has proven effective in enhancing resilience against extreme weather by mitigating heat, drought, and soil erosion, as documented by Boinot et al. [116], Dardonville et al. [117], and Raj et al. [119]. Vignola et al. [120] further demonstrate that ecosystem-based adaptation empowers smallholder farmers to manage drought and temperature extremes by strategically leveraging ecosystems and indigenous knowledge. This pattern corresponds directly with observed adaptation behaviors in rural French settings.

Throughout rural France, initiatives focus on wetland and green space restoration, the implementation of agroecological management, and collaborative landscape-scale restoration projects designed to strengthen climate resilience. The Conseil National des Villes et Villages Fleuris exemplifies this systematic framework, a national quality of life certification program established by the French government in 1959 to advance environmental stewardship, greening initiatives, and the enhancement of local quality of life. More than 4,500 towns and villages have received the "Ville/Village Fleuri" designation through comprehensive evaluation criteria encompassing green space quality, resource conservation (energy and water), community engagement, and contributions to quality of life and tourism. This program functions as a significant motivator for communities to embrace sustainable ecosystem management practices.

Collaborative efforts between community members and local governments to restore wetland and riverine forest ecosystems, enabling the absorption of excess water and adaptation to climate-induced environmental shifts, are supported by Blanco et al. [70]. These restoration initiatives illustrate how ecosystem-based approaches can address multiple climate threats simultaneously while safeguarding traditional landscape management knowledge. In vineyard management, research by Ollat et al. [65] and van Leeuwen et al. [66] reveals that agroforestry systems provide substantial resilience against heat waves, prompting agricultural producers to integrate heat-tolerant grape varieties and implement farming practices that generate shade for vineyards. Riekötter & Hassler [71] and Holzinger et al. [72] further report that agroforestry methods successfully minimize crop damage from elevated temperatures while maintaining crop quality standards and restoring local ecological equilibrium.

Notably, ecosystem-based adaptation strategies appear exclusively among rural French populations, who depend on ecosystems, particularly agroforestry and natural landscape management, to build resilience against heat waves, drought, and other extreme weather phenomena. This adaptation strategy showed no significant correlations with urban French residents.

- **Relocation Strategy**

Relocation is the most important strategy, and it is observed in both urban and rural France, driven by distinct contextual factors. Urban migration in France is primarily linked to wildfires and droughts, which directly threaten residences and infrastructure. For example, the Gironde wildfires in 2022 displaced over 37,000 people, leading many households to relocate permanently from high-risk areas [121, 122]. Research by Spencer & Strobl [123] confirmed that extreme weather events, particularly high-intensity wildfires, significantly influence the migration decisions of urban households. Droughts tend to trigger temporary rather than permanent migration unless they are prolonged beyond individuals' adaptive capacity.

In rural areas, migration is associated with significant health and livelihood impacts, including heatstroke, respiratory problems, stress, and declines in agricultural production and income. For example, vineyards and olive groves in the Aude and Provence regions were damaged by wildfires and drought, leading many families to transition to non-agricultural employment or relocate to cities with greater public services and economic opportunities. There has also been migration to cooler, more climatically stable regions, such as Brittany and Hauts-de-France. Previous studies indicate that resource scarcity, particularly water and arable land, constitutes a significant driver of migration, both within and across countries, particularly among poor and vulnerable rural populations [73, 124].

This finding is consistent with research by Hermans & McLeman [122], who found that prolonged drought, land degradation, and food insecurity resulting from climate change are primary drivers of migration, particularly in rural areas, and that migration should be viewed as an important adaptation strategy for vulnerable households. Zickgraf [125] points out that chronic drought and land degradation are structural drivers of migration, and that migration serves as an adaptation strategy for rural communities. Furthermore, Hoffmann et al. [126] provided global evidence that drought and chronic drought are among the most important drivers of internal migration, particularly in agricultural areas, which is consistent with the migration patterns observed among rural residents in France in this study. Moreover, Falco et al. [127], Benveniste et al. [128], and Schwerdtle et al. [129] demonstrated that migration due to climate change has multidimensional health impacts, including physical, mental, and social consequences, particularly for those displaced by wildfires, droughts, or floods. This evidence supports the findings of this study, which identified health and livelihood impacts as key drivers of rural migration in France.

Relocation strategies represent adaptations to climate change risks that occur in both urban and rural areas, but with distinct characteristics. Urban migration often results from direct exposure to wildfires and droughts, whereas rural migration typically aims to mitigate health and livelihood impacts. Thus, migration serves both as a safety-seeking and a livelihood-preservation strategy for French citizens.

- **Non-Adaptive Behavior**

This study found no significant relationships with deliberate non-adaptive strategies. However, the research found that individuals who have not experienced extreme events, particularly rural residents who have not experienced extreme weather, do not perceive a need to restructure infrastructure. Similarly, urban French residents who have not been affected by extreme events do not perceive the need for adaptation and demonstrate no motivation to pursue education, raise awareness, and relocate. Because they have not experienced these events and are not directly affected, they exhibit significantly lower adaptation readiness.

Several theoretical frameworks can explain this pattern. According to the risk perception theory of Slovic [130, 131], when individuals have not directly experienced a threat, their perception of risk remains low, leading to insufficient motivation to adapt. For example, in urban areas where infrastructure and technology already exist, residents often feel secure and do not perceive the need for behavioral changes. Furthermore, social learning theory by Bandura & Walters [58] suggested that imitation of social models influences behavior; if the surrounding community does not adapt, individual adaptation is unlikely. For example, communities in the Massif Central that are infrequently affected by disasters may not perceive the need for change. Meanwhile, the hazard-response model from Kates & White [132] explains that if hazard perception is low, adaptive response will be limited.

These findings are consistent with research by Ettinger et al. [103] and Sisco [133], who found that individuals who have not experienced extreme events tend not to develop adaptive learning, leading them to maintain existing behaviors. However, direct experience with extreme events may significantly increase their willingness to support climate policies.

Research by Howe [134] and Sambrook et al. [135] supported this pattern, finding that exposure to floods or other disasters reinforces climate change beliefs and motivates individuals to take more preventative measures. Meanwhile, those who have not experienced disasters tend to have lower risk perceptions and place less emphasis on adaptation. Furthermore, Bergquist et al. [136] emphasized that disaster learning often occurs when people experience disasters themselves rather than receiving indirect information, leading those with direct experience to be more likely to adapt their behaviors.

In short, individuals who have not experienced disasters or been directly affected are more likely to remain unaware of the need for adaptation, to demonstrate lower support for climate strategies, and to be less likely to change their behaviors.

The study addressing the third objective found that urban and rural residents in France employ different adaptation strategies to extreme weather depending on their contextual vulnerabilities and experiences. Of five potential strategies examined, four were actively employed: education and awareness, infrastructure development, ecosystem-based adaptation, and relocation. The results of this research are synthesized in Figure 7.

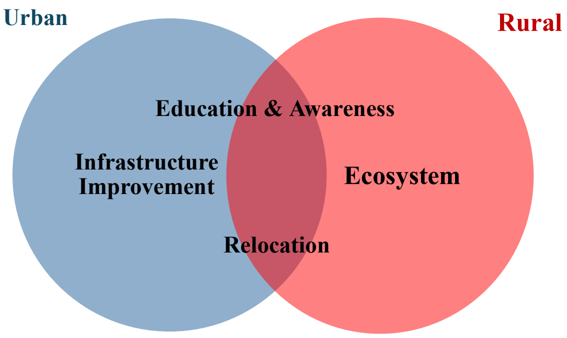


Figure 7. Comparison of adaptation strategies of French urban and rural residents

Figure 7 illustrates the climate change adaptation strategies adopted by urban and rural populations in France. Urban residents focus on infrastructure development and improvement, while rural residents take a more ecological approach. However, both groups prioritize education, awareness raising, and promoting sustainable mobility. This pattern reflects how area context influences climate change adaptation approaches in France. Importantly, while spatial context determines the primary adaptation patterns, some strategies, particularly education and awareness raising, as well as relocation, can be effectively applied in both urban and rural areas.

6. Conclusions

This study found that urban residents experience greater exposure to heat waves due to the urban heat island effect, leading to more severe health and livelihood impacts. Rural residents experience more storms and hailstorms but report less prior experience with extreme weather.

Adaptation strategies differ notably; urban residents prioritize relocation (driven by fires and droughts), infrastructure improvements, and education, while rural residents focus on ecosystem-based approaches, education, and relocation motivated by health and livelihood concerns. Critically, individuals lacking direct experience with extreme weather show significantly lower engagement in adaptation, indicating that personal experience is essential for translating awareness into action.

This study examined the experiences, impacts, and adaptation strategies of urban and rural populations in France in response to extreme weather events driven by climate change. The results revealed significant differences between the two groups.

Based on the study's findings, the following recommendations can be made to enhance adaptive capacity:

- First, context-specific policies: urban areas need heat-mitigation strategies, resilient infrastructure, and supported relocation programs (€5,000-€15,000 assistance) to safer regions. Rural areas require ecosystem restoration, climate-smart agriculture, expanded health services, and diversified economic opportunities.
- Second, proactive education: since direct experience drives action, implement indirect learning through climate simulations, case studies, community drills, and provide scientific knowledge to create urgency without requiring personal disaster exposure.
- Third, ecosystem-based adaptation: develop green infrastructure, urban forests, wetlands, and agroforestry systems that provide multiple benefits such as temperature regulation, stormwater management, and biodiversity conservation.
- Finally, Integrated coordination: establish a Climate Migration Support Agency and National Climate Migration Fund; designate climate-safe zones to enact protection legislation and ensure cross-sectoral collaboration linking health, infrastructure, environmental, and social policies. Community participation in planning is essential for creating resilient, equitable communities across France's diverse landscape.

7. Declarations

7.1. Author Contributions

Conceptualization, J.R., M.R., and S.K.; methodology, J.R., M.R., and S.K.; software, J.R. and M.R.; validation, J.R., M.R., and S.K.; formal analysis, J.R.; investigation, S.K.; writing—original draft preparation, M.R. and S.K.; writing—review and editing, J.R. and M.R.; supervision, J.R.; project administration, J.R. and S.K.; funding acquisition, S.K. All authors have read and agreed to the published version of the manuscript.

7.2. Data Availability Statement

Data available in a publicly accessible repository that does not issue DOIs: Publicly available datasets were analyzed in this study. This data can be found here: eib-individual-data-2024-2025.xlsx and https://www.eib.org/en/press/all/2024-415-80-of-french-respondents-say-they-will-have-to-adapt-their-lifestyle-due-to-climate-change-eib-survey-finds.

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7.5. Institutional Review Board Statement

Not applicable.

7.6. Informed Consent Statement

Not applicable.

7.7. Declaration of Competing Interest

The authors declare that there are no conflicts of interest concerning the publication of this manuscript. Furthermore, all ethical considerations, including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancies have been completely observed by the authors.

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