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Citizen Participation and Ecosystem-Based Territorial Adaptation to Climate Change in Morocco: A Case Study from Settât

Amine Hmid ¹ , Azzeddine Rakhimi ² , Redouane Kaiss ^{3*} , Bouchra Serroukh ⁴ , Abdelghafour Achy ⁵,
Yahya Fikri ⁶ , Hicham el Moussaoui ²

¹ Interdisciplinary Laboratory Business Engineering Soft Skills Management and Law LIASMAD, Faculty of Legal, Economic, and Social Sciences, Hassan II University of Casablanca (Aïn Sebâa Campus), Casablanca 21100, Morocco

² Multidisciplinary Research Laboratory in Economics and Management, Faculty of Economics and Management, Sultan Moulay Slimane University, Beni-Mellal 23000, Morocco

³ Research Laboratory in Economics, Management, and Business Administration, Faculty of Economics and Management, Hassan 1st University, Settât 26000, Morocco

⁴ Laboratory of Economic Intelligence and Territorial Governance, Faculty of Legal, Economic and Social Sciences, Abdelmalek Essaâdi University, Tangier 90000, Morocco

⁵ Educational Policies and Social Dynamics, Faculty of Education Sciences, Mohammed V University, Rabat 10090, Morocco

⁶ Department of Governance and Organizational Performance, National School of Business and Management, Abdelmalek Essaâdi University, Tangier 90000, Morocco

ABSTRACT

Climate change poses increasingly severe risks to ecosystems, livelihoods, and the socio-spatial dynamics of both urban and rural areas, particularly in semi-arid regions such as central Morocco. These territories, already marked by ecological fragility and water scarcity, are especially vulnerable to rising temperatures and recurrent droughts. While national strategies and institutional frameworks provide an essential backbone for climate adaptation, they often remain

*CORRESPONDING AUTHOR:

Redouane Kaiss, Research Laboratory in Economics, Management, and Business Administration, Faculty of Economics and Management, Hassan 1st University, Settât 26000, Morocco; Email: redouane.kaiss.doc@uhp.ac.ma

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top-down in orientation and insufficiently connected to local realities. In this context, the engagement of citizens emerges as a decisive yet underutilized factor for strengthening community resilience. This study investigates the ecological and participatory dimensions of adaptation in the municipality of Settat, combining conceptual analysis with field surveys and participatory assessments. It explores how local populations perceive ecological transformations, including biodiversity loss, irregular rainfall patterns, and soil degradation, and how they translate these perceptions into practices of adaptation. Although findings reveal a growing awareness of environmental risks, they also point to the limited inclusion of citizens in decision-making processes. The research underlines the importance of nature-based solutions and participatory ecological tools as levers for building both social and ecological resilience. By advocating for the integration of ecosystem-based approaches into local governance and inclusive frameworks that empower communities as co-managers of climate risks, the study contributes to bridging policy with practice. Aligning local strategies with the Sustainable Development Goals, particularly SDG 13 (Climate Action) and SDG 15 (Life on Land), it advances the field of applied and participatory ecology in climate-vulnerable contexts.

Keywords: Climate Change; Strategic Territorial Management; Adaptation; Resilience; Citizen Participation; Participatory Ecology

1. Introduction

Climate change has become one of the most pressing threats to humanity, affecting not only the physical environment but also the broader social, economic, and ecological systems that support human life. Despite increasing awareness, many experts argue that citizen engagement in addressing this crisis remains insufficient^[1].

This highlights the urgent need for more proactive efforts to reduce the environmental impact of individual and collective behaviors.

Strategic territorial management, although still an emerging concept, plays a vital role in responding to the challenges posed by climate change. It is not confined to a single discipline but spans various sectors, including environmental planning, infrastructure, governance, and community development. It is through this multidimensional approach that regions can develop sustainable, long-term strategies to adapt to climate disruptions.

The effects of climate change are now being felt with growing intensity worldwide. From extreme weather events to rising sea levels, their consequences are no longer distant possibilities but present realities. The international community continues to sound the alarm, urging governments to act. In a recent address, United Nations Secretary-General António Guterres warned that we have moved beyond a phase of global warming into a full-blown climate crisis, calling for immediate and coordinated responses (UNDP, 2023).

Strategic territorial management has become increasingly recognized as a key framework for addressing climate adaptation in urban and rural contexts worldwide. Anguelovski et al. (2016)^[2] emphasize the importance of integrating equity into urban land use planning, highlighting how climate adaptation efforts often reproduce or exacerbate existing social inequalities if not carefully managed. Their work underscores the necessity of inclusive planning processes that empower marginalized communities and ensure just outcomes in climate resilience strategies. This perspective is critical in understanding the social dimension of territorial governance, especially as adaptation policies need to be sensitive to diverse local vulnerabilities and capacities.

Complementing this social dimension, the Organisation for Economic Co-operation and Development on 2023 advocates for a territorial approach to climate action and resilience, stressing that local and regional governments play a central role in tailoring climate policies to specific territorial contexts. The OECD report highlights that decentralizing climate governance enables more precise identification of local risks and opportunities, facilitating coordination across sectors and scales. This approach promotes multi-level governance frameworks where national priorities align with sub-national capacities and knowledge, which is particularly relevant in developing countries where institutional capacities vary significantly^[3].

In developing countries, climate change adaptation is increasingly intertwined with questions of territorial gover-

nance, water resource management, and participatory planning. Strategic territorial management (STM) has emerged as a crucial framework for organizing spatial and institutional responses to climate challenges, particularly where climate impacts are uneven and governance capacities are fragmented.

Recent empirical work in sub-Saharan Africa highlights the importance of integrating local innovation and water management in climate adaptation. Mdemu et al. (2025), examining two small-scale irrigation schemes in Tanzania, demonstrate that the introduction of soil moisture monitoring tools and agricultural innovation platforms has significantly enhanced farmers' adaptive capacity. These interventions, by increasing household income, diversifying livelihoods, and reducing resource conflicts, contributed to rejuvenating irrigation systems and fostering collaboration. This case underscores how targeted investments in local infrastructure and institutional mechanisms can operationalize adaptation through improved territorial coordination and resource governance^[4].

Participation also plays a key role in shaping the ambition and effectiveness of climate action at the local level. Cattino and Reckien (2021) conducted a meta-analysis of climate adaptation planning and found that public participation is positively correlated with both the transformative potential of adaptation and the ambition of mitigation efforts. Their review identifies four enabling conditions for transformative action: recognition of all actors, meaningful engagement at all stages, public decision-making power, and a logic of collective welfare. In developing country contexts, these principles are particularly important for ensuring that local adaptation plans respond to lived realities and do not merely replicate top-down prescriptions^[1].

In this context, Morocco is confronted with significant climate-related challenges. Due to its geographical location, the country is increasingly exposed to heatwaves, persistent droughts, and severe water shortages. These changes not only strain the natural environment but also threaten economic stability, public health, and food security.

Territorial-scale water governance also faces mounting pressure from climatic variability, as shown in the Bouregreg watershed in Morocco. Mahdaoui et al. (2024) used the GR2M hydrological model to project streamflow under future climate scenarios and found significant reductions in

precipitation and streamflow by the 2040s under both RCP 4.5 and RCP 8.5. These findings highlight the urgent need to integrate hydrological forecasting into territorial planning, especially in regions where water scarcity is projected to intensify. Such insights are vital for informing long-term land use, agriculture, and water allocation decisions^[5].

From a land-use perspective, Alvarez and Govind (2025) provide a longitudinal geospatial analysis of climate and land dynamics in Morocco (2001–2023). By combining satellite data (MODIS, ERA5-Land) with surveys of over 3,000 farmers, they show how perceptions of drought and heatwaves align with environmental indicators such as declining vegetation indices and increasing land surface temperatures. Importantly, the study reveals a contraction of cropland and an expansion of barren land, suggesting both ecological degradation and changing land management practices. Farmers' reported adaptation strategies, such as drought-resistant crops, irrigation upgrades, and altered sowing dates, reflect a growing bottom-up response that must be acknowledged in territorial governance frameworks.

This study focuses on Morocco's current climate context, highlighting the central role that citizen participation can play in fostering resilience. The social sciences, particularly when applied to environmental issues, offer valuable insights into how individuals perceive and respond to climate change. By understanding these perceptions, it becomes possible to design better strategies for encouraging sustainable behaviors^[6].

Across the country, diverse efforts are already underway, from government-led initiatives to protect biodiversity to grassroots projects that promote responsible water use. These examples show that climate action is not limited to institutions, but that citizens, communities, and associations each have a role to play.

By examining the different dimensions of strategic territorial management from public policy to civil society involvement, this research seeks to understand how collaborative action can help Morocco move toward a more sustainable and climate-resilient future. It is only through shared responsibility and collective commitment that such a future can be built.

The core of the research problem addressed in this study is framed by the central question: how might citizen participation enhance territorial management strategies in response

to climate change challenges? This question serves as the foundation for concluding and underpins the entire scientific process.

This problem is a global phenomenon that poses significant environmental, social, and economic challenges worldwide. However, its impacts are often highly context-specific, varying greatly depending on local ecological conditions and socio-economic factors. In the case of Settat, a municipality located in a semi-arid region of Morocco, global climate change manifests through intensified local vulnerabilities such as recurrent droughts, water scarcity, land degradation, and threats to agricultural productivity. These local impacts reflect and amplify the broader global trends, making Settat a critical case study for understanding how global climate challenges translate into tangible, place-based risks. Strengthening this connection in the introduction is essential to frame the study's focus on how strategic territorial management and citizen participation can address these intertwined global and local climate challenges.

The general objective is to consider climate change as a significant challenge for strategic territorial management, and to seek to meet climate change challenges through adaptation and resilience actions, using citizen participation. The dimension of the study is the municipality of Settat, and while we will focus on Settat, we want to try to get insights into new aspects that we should consider.

In this context, it is important to discuss in more depth the local vulnerabilities of Settat's semi-arid ecosystem, particularly in the introduction. Settat is characterized by a fragile ecological balance, where water scarcity, soil degradation, and increased frequency of droughts exacerbate the region's exposure to climate change. These local vulnerabilities create a pressing need for targeted and context-specific adaptation strategies.

More specifically, the objectives of the study are: to analyze the dimensions of the strategic territorial management of Morocco regarding climate change; to study the adaptation policies undertaken regarding climate challenges; and to describe the role of citizen participation in favoring adaptation to climate impacts, while at the same time identifying key aspects of citizen participation.

To address the research problem, this study follows a systematic framework encompassing the contextual background, key issues, research relevance, and methodological

approach. It begins with a conceptual and theoretical review of strategic territorial management in the context of climate change, identifying key theoretical perspectives and adaptive territorial practices, while emphasizing the role of citizen participation. The subsequent section outlines the methodology, detailing the research design, sample composition, and data collection and analysis techniques. This methodological framework ensures scientific rigor and supports the validation of the findings.

In the third part, we will examine the climate situation in Morocco and present the principal challenges that the country is facing regarding climate change. Based on the climate situation in Morocco, we will analyze the territorial actions that have been implemented to respond to these issues through public policies, local initiatives, and international cooperation. Finally, we will examine our specific study area, the municipality of Settat. We will examine the results of our investigation to allow us to make relevant conclusions and recommendations for more effective and sustainable territorial management in relation to climate change.

In addition to social and governance-related challenges, the Settat region faces several ecological consequences related to climate change. Interviews and literature indicate a gradual alteration in local ecosystems. Residents and agricultural workers noted the decline in traditional vegetation, increased soil degradation, and lower yields from local biodiversity-dependent crops such as olives and cereals.

Moreover, changing precipitation patterns and prolonged droughts have contributed to the drying of seasonal water bodies, reducing the habitat availability for amphibians and migratory birds. Invasive plant species are becoming more dominant in peri-urban zones, replacing native grasses and shrubs and threatening the ecological balance. These changes reflect the broader vulnerability of semi-arid ecosystems to climate stressors, particularly when they are not accompanied by adequate ecological management and restoration efforts.

The observed ecological degradation reinforces the importance of integrating environmental dimensions into territorial management strategies, highlighting that citizen participation should also focus on ecological stewardship to safeguard long-term sustainability.

This study focuses specifically on the municipality of Settat, a semi-arid region in central Morocco that presents a

compelling case for analyzing local climate adaptation dynamics. Settat was chosen for its strategic geographic location, functioning both as an agricultural hub and as a rapidly urbanizing area, and for its exposure to climate stressors such as declining rainfall, recurring droughts, and soil erosion. In addition, Settat reflects many of the challenges common to secondary cities in developing countries, including limited local governance capacity, underdeveloped participatory mechanisms, and increasing pressure on natural resources due to urban expansion and land-use change.

By narrowing the scale of analysis to this municipality, the study seeks to assess not only the ecological transformations underway but also the degree to which citizens are engaged in shaping local adaptation responses. This localized focus enables a deeper exploration of the intersection between institutional planning and everyday environmental experience, revealing both the potential and the limitations of citizen-driven strategies for territorial resilience in climate-vulnerable contexts.

In the face of accelerating climate change, semi-arid regions such as Settat in central Morocco face mounting environmental pressures, including biodiversity loss, water scarcity, soil degradation, and increased vulnerability of local livelihoods. While Morocco has adopted national strategies to confront climate challenges, these top-down approaches often lack effective mechanisms to engage citizens at the local level. This gap weakens the potential for community-based adaptation and limits the impact of resilience-building efforts on the ground. Furthermore, the ecological dimension of adaptation, particularly the use of nature-based solutions, remains underexplored in local governance. How can citizen participation and ecosystem-based approaches be better integrated into climate adaptation strategies in Settat to enhance both ecological and social resilience? Addressing this question is essential for developing inclusive, place-based responses that align with global goals such as the Sustainable Development Goals, while being rooted in the lived realities of vulnerable communities.

This study starts from the hypothesis that stronger citizen engagement, combined with ecosystem-based approaches, can significantly enhance climate resilience in semi-arid regions like Settat, Morocco. While national strategies provide a necessary framework, it is at the local level, through participatory and nature-based solutions, that the

most adaptive and sustainable responses to climate change can emerge.

2. Theoretical and Conceptual Framework of the Research Topic

2.1. Strategic Territorial Management: A Literary Perspective

The notion of strategic territorial management remains fairly recent and has not yet been entirely stabilized or operationalized^[7]. Although the word management is usually aligned with the private domain, where the sole purpose is to earn money for the firm through some productive activity, it needs to be clearly differentiated from the logic of the public sector. The state does not aim for profit because it will not have bank-related monetary profit; the purpose of public management is to fulfill collective needs in terms of education, health, security, etc. Hence, the effectiveness of public action is determined not by profits, but obviously through how well society's expectations are met, and if the well-being of citizens has been improved^[8].

Therefore, strategic territorial management can be understood as a kind of public governance that considers spatial, institutional, and social perspectives in the design and implementation of public policies. It integrates several policies, actions, and projects initiated by public authorities and carried out in specific spatial contexts. Some will see its role distinctly to ensure potential coherence, effectiveness, and outcomes through their public interventions while considering the multi-level nature from local governance bodies to international governance bodies^[9]. Others will reference it as a way to enhance social cohesion through public action across territories.

It also determines the ability to think about and act towards the development of territory in a coordinated way. It revolves around the three main objectives: to encompass the total complexity of the territorial dimension, to provoke local dynamics to engage collectively, and to act progressively over time. Therefore, strategic territorial management is a regulated and planned approach to coordinate territorial actions towards sustainable development and resilience^[10]. Moreover, to bring together integrated strategies aimed at increasing the attractiveness and competitiveness of regions. This includes marketing the territory, linking together net-

works of actors, and adjusting and fitting the territories into human-centered governance of relational spaces, taking into account dynamic socio-spatial contexts^[11]. More generally, territorial strategic management results as an inductive process to regulate territorial dynamics, or as Sellami and Rougani (2023) commented: “managing all human interrelations whose contributions were to create territories”. In this way, the concept combines a number of theoretical avenues: it links public management to spatial planning; it brings governance into contact with social equity; it connects local action to global demands, including climate adaptation and sustainability. It also depends on various factors, including the political will to act, the available institutional capacity or capability, the value of citizen engagement, and the interconnectedness of multi-level policies. Overall, strategic territorial management serves as a concept, but also as a practical mechanism for facilitating collective action to address the present challenges in the territory^[12].

2.1.1. Why Territorial? And Why Strategic?

The notion of strategy in management science represents the totality of actions or decisions made to achieve an objective in an uncertain and dynamic system. Strategy is a system that binds long-term ambitions with medium-term objectives and short-term actions. At the level of the organization, strategy comprises the establishment of a clear corporate future vision for the organization, human strengths and weaknesses, the external opportunities and threats, and plans to engage. It must be aligned with the values and mission of the organization while acknowledging stakeholder expectations. A similar situation exists for territories: stakeholders from multiple social, economic, or institutional sectors have divergent concerns, addresses, and geographical domains of intervention, making it more complex to unify individual projects into a collective undertaking. In this sense, the concept of strategic action allows tensions and problems resulting from the conflicting short-term interests to be ameliorated through future-oriented projection. The newly constructed solidarity creates the capacity to limit uncertainties and, as far as a temporary isle of tranquillity in an uncertain environment^[13].

2.1.2. Objectives of Territorial Management

Management practices and objectives must adapt to this new context. The Swiss school also identifies two main

objectives for territorial management. First is the strategic objective, which is to lead the development of the territory through a long-term participative process. The second is the operational objective, as territorial management seeks to strengthen the power of a community and stakeholders to manage territorial change and its associated threats and opportunities through management methods and tools and processes of consultation, collaboration, and information^[9].

2.1.3. Territorial Management and Territorial Governance

Territorial governance is a mode of managing a territory (rural, urban, regional, etc.) where decisions are not made solely by the central government, but in consultation with local actors such as municipalities, businesses, citizens, associations, and others. This approach leads to decisions that are better adapted to local realities, more inclusive, and more effective (Torres & Sanz-Cañada, 2018). In contrast, territorial management focuses on the operational and technical implementation of those decisions. It involves planning, organizing, and administering land use, infrastructure, and public services within the territory. While governance defines what should be done and why, management is concerned with how it is done in practice.

In short, territorial governance sets the direction and involves dialogue among actors, while territorial management carries out concrete actions based on those collectively defined goals^[8].

2.2. Explanation of the Concept of Climate Change

2.2.1. Conceptual Clarification

For thousands of years, Earth's climate has changed over time and across space, often over long-time scales that made it difficult for human societies to perceive. However, in recent decades, these changes have become more pronounced, leading to an increased public concern and questions about the existence of climate change, the cause of climate change, and the impacts of climate change (both short-term and long-term) on everyday life. Research, science is all about addressing concerns through systematic and objective research; scientific research is nevertheless never final (Académie des sciences, 2010). Therefore, it is necessary to clarify the fundamental concepts to understand

climate change.

“Climate” can be defined as the average weather of a given location over a long time period, typically defined as a 30-year average^[14]. The average weather conditions provide the basis for comparison to current weather and the long-term average. The climate system is comprised of relevant factors that dictate climate change, such as solar radiation, greenhouse gases, and the dynamic interactions of the atmosphere and oceans^[15].

The greenhouse effect is a natural and essential process that sustains life on Earth by maintaining surface temperatures through certain atmospheric gases. However, human activities, primarily fossil fuel combustion and land-use changes such as deforestation, have increased concentrations of greenhouse gases (GHGs), particularly carbon dioxide (CO₂), to more than three times their natural levels. These elevated levels have intensified not only the natural greenhouse effect but also the complex interactions within climate systems^[16].

Global warming refers to a long-term increase in Earth's average surface temperature. The natural average temperature of approximately 15 °C is maintained by the greenhouse effect. However, the excessive release of greenhouse gases from anthropogenic activities alters this natural effect and destabilizes climate systems worldwide^[17].

“Climate change” is defined and understood in a more general sense than simply global warming. Based on the recognized information by the Intergovernmental Panel on Climate Change (IPCC), climate change refers to changes in climate that are statistically significant and that persist for decades or longer. Climate change may result from natural phenomena or external forcing, or from sustained human activity (e.g., atmospheric pollution, land use change) (IPCC, 2001). The United Nations Framework Convention on Climate Change (UNFCCC) emphasizes that current climate change is anthropogenic in origin and defines climate change as “a change in climate which is attributable directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural variability” (UNFCCC, 1998). The distinction between natural and anthropogenic influences on climate change is important for political and scientific purposes^[18].

2.2.2. Historical Reflections on Climate Change

In 1988, the establishment of the IPCC initiated a global negotiation process that culminated in the Rio Earth Summit in 1992. Although this summit was an important milestone in increasing awareness and priorities, it did not create binding commitments for all states that participated. The Kyoto Conference and the ensuing negotiations subsequently revealed very different visions for action on climate change. The European bloc strongly supported government-led responses such as technical improvements, changing regulations, and minimum standards, whereas the United States wanted market-led approaches such as tradable permits that could incentivize emissions reductions. While controversial, market mechanisms such as emissions trading and the Clean Development Mechanism, and Joint Implementation in the Kyoto Protocol^[19], became the primary elements of creating emissions reductions.

Although the scientific framing of climate change related to anthropogenic GHG emissions is relatively new, human views of climate and climate variation have a much longer history. Locher and Fressoz (2015) characterize the past of climate as a narrative alongside societal responses that reflect climate representation, and, as such, they argue climate was “socially constructed” well before anthropogenic climate change began. Pre-modern societies were already engaged in conversations about climate and its consequences. During the Renaissance, “climate” meant the spatial zones between latitudes, but by the 17th century, climate came to mean the local air quality, winds, waters, and soils relative to their interaction with crops—in other words, climate described human health, agriculture, and economy. Landscape mitigations of timber harvesting, reforestation, and ‘land clearing’ to farming, and maintains a significant focus on climate recognition. Seventeenth- and eighteenth-century discussions arose with the climate in North America markedly colder than in Europe, given several possible explanations, where the cooling effects of dense forests emerged as a likely solution to the climate differences. Buffon, a French philosopher and naturalist, explained that land clearing and cultivation could also warm and help develop a more productive society. In the 19th century, concern for deleterious climate effects began to be recognized in France. A well-known response was Callon Rauch's reforestation infrastructure and larger-scale

reforestation project to try to reverse the climate effects of European deforestation, but it will not work. All the financial support available for Rauch's visions for reforestation met his demise and his financial failure^[20].

2.2.3. Adaptation and Resilience: Keys to a Sustainable Future

Adaptation as a response to environmental pressures can be traced as far back as Anaximander and Aristotle; early thinkers noted that climate modified animal morphology and influenced behavior^[21]. The idea of adaptation became more formalized in early evolutionary paradigms, particularly Lamarck's notion of adaptation articulated as the development of new traits as an outcome of environmental conditions; however, Darwin's natural selection replaced this paradigm, viewing adaptation as an incremental process effected by selection.

By the 20th century, developments in genetics, systems theory, cybernetics, and thermodynamics advanced knowledge of adaptation to a dynamic and multi-level component representing the individual, their community, and the ecosystem. However, the concept of adaptation is still ambiguous; it is ambiguous because it refers to both the process of adjustment and the outcomes of that adjustment. Piaget distinguished between "adaptation-state" and "adaptation-process"^[22].

The transition from general climate adaptation to "adaptation to climate change" underscores a shift in scale and level of urgency. While humans have always adapted to changes in the environment, the rapidity and degree of human-induced climate change serve to compound the nature of the uncertainty (Füssel, 2007). Adaptations such as bipedalism and cultural change over the last few million years have been profoundly influenced by changes in climate. We can now take into account how history has informed the responses societies have taken, not only as individuals, but in the context of governments, markets, and civil society^[23].

Resilience derives from the Latin *resilientia*, meaning "to spring back." Like resiliency, resilience was originally used in physics to refer to the ability of a material to absorb and dissipate shock. In psychology, it refers to the ability to fit together and transform traumatic experiences without succumbing to mental anguish^[24]. Resilience, thus, is a process resulting from the interaction between an individual and environmental resources made up of both internal ca-

pacities (emotional fortitude) and external resources (Social networks).

Resilience at the group level takes on different forms. Organizational resilience refers to the ability of organizations to recover from disruption, while community or territorial resilience involves anticipating environmental changes and acting to mitigate risks. Communities will have to rearrange roads and other infrastructure to convert to more sustainable urbanization to prepare for rising sea levels or desertification. So, territorial resilience will also require social and economic sustainable urban design, ecodesign, and renewable energy usage.

Resilience is also relevant on the individual level. Individual resilience is expressed through individuals' eco-friendly behaviors, including recycling, responsible consumption, and sustainable development. When individual behaviors shift, they contribute to the resilience of the community and climate adaptations.

To combat climate change, there are mitigation measures and adaptation measures to remedy environmental degradation and promote both ecological and socio-economic resilience. Mitigation measures are very important because we need to achieve GHG mitigation in line with international commitments, like the Paris Agreement, and we must stop climate change before it is too late. However, some of the impacts of climate change are unavoidable. Therefore, we are going to need adaptation measures, and both mitigation and adaptation require that we develop sustainable responses that encourage green behavior change, technological changes, and provide policy measures that advance ecological protection in conjunction with socio-economic opportunities (i.e., green innovation, renewable energy development, and biodiversity protection). In summary, we can think about resilience to climate change as a virtuous cycle of ecological stewardship and social solidarity along with economic innovation. That is to say, ecological stewardship, social solidarity, and economic innovation hold each other accountable to create a sustainable and equitable future.

2.3. Citizen Participation

The rise of citizen participation as a dominant theme in democratic governance really picked up steam in the late 1960s when Sherry Arnstein published her famous article "A Ladder of Citizen Participation" (1969), which is one

of the most referenced articles in participatory theory. This article, along with the contributions of theorists like Pateman (1970), also reaffirmed participation as foundational to the democratic process and countered traditional, top-down forms of governance. The participatory movement began to permeate public administration in the 1980s and reached new heights in the 1990s^[25]. Although the level of success and implementation has varied, citizen participation is still mainly viewed as a core value of modern democracies^[26].

The justification for citizens to have a role in public consultation and decision-making is founded on normative democratic principles, but also has substantive and pragmatic justifications. Recognition of “citizen knowledge” as a valuable counterpart to expert knowledge^[27], has built the framework for our evolving conception of governance as co-productive. Involvement of citizens in public decisions shapes legitimacy, increases transparency, and social acceptance, which can accelerate implementation^[28]. Even the private sector is embracing participatory processes in ways they have never done before as a consequence of rising public expectations for accountability and the desire for the inclusion of lived experience, referencing public administration models and strategic conversations^[29]. Often, citizen participation is described as a response to growing legitimacy crises of political institutions and changing the state-civil society relationship to facilitate new types of democratic interaction^[30].

Recent research underscores that adaptation to climate encompasses not only behavioral and technological adjustments but also physiological responses, whereby the human body gradually adjusts to local thermal conditions over time. For instance, studies examining thermal indices such as PET, UTCI, and SET* across latitudinal gradients have shown that residents in higher-latitude, cooler climates experience lower neutral temperatures (NTs), reflecting subjective physiological adaptation to ambient temperatures^[31]. Recognizing this form of adaptation emphasizes the importance of designing policy measures that leverage individuals’ inherent capacities while providing targeted support during periods of extreme heat or when physiological thresholds are exceeded.

Moreover, environmental and urban features can further shape physiological adaptation. Other authors demonstrate that local elements, such as rivers and their surrounding contexts, significantly influence pedestrians’ summer ther-

mal perceptions in Cfa-climate cities^[32]. This indicates that adaptation is not only an internal bodily process but also closely linked to urban ecological and spatial conditions.

Digital transformation in society is fundamental for facilitating participation. Social Media and different online systems are generating new ways of digital sociability and political engagement beyond traditional public spaces^[33]. Digital tools can therefore be facilitators of territorial decision-making by allowing more engaging and inclusive participation. Communication strategies, both physical (i.e., posters, signage) and digital, are important for raising awareness and engaging active citizens in the local governing process^[34].

The rise of participatory governance is highly relevant in the context of climate change, given the importance of representation and inclusion of diverse perspectives. Hajer (1995) highlighted how environmental discourse and narratives shape public policy, and that the legitimacy of climate action, when aligned with citizens’ values and perspectives, can be bolstered. Fischer (2000) extended participatory democracy and deliberative processes as collective governance can contribute towards the power of local actors and thereby lead to more just and equitable environmental governance and action. These ideas helped to inform the concept of Participatory Climate Governance^[35,36]. This takes the form of a deliberative space where different voices influence decision-making. Dryzek further emphasized the values of transparency, accountability, and information accessibility as prerequisites for effective citizen engagement.

The theory of democratic deliberation, as articulated by Warren (2017), adds to this framework by describing the importance of inclusive, informed dialogue. In this way, deliberation enables citizens to debate serious problems, such as climate change, in relation to evidence, shared concerns, and the recognition that everyone is doing their best to understand the situation. Not only does it promote high-quality decision-making, but it also provides the wider social resilience that helps to strengthen democracy^[37]. Bäckstrand (2006) similarly described how public engagement in the design of climate policy interacts with democratic legitimacy, the policy outcome, and the extent to which the public will accept mitigation or adaptation measures^[38]. New scholarship has also pertained directly to undertaking practical aspects of citizen engagement around climate adaptation. For example, Jones and Russo (2024) analyzed the benefits and chal-

lenges of citizen engagement in local and regional adaptation planning and recognized the importance of participatory processes in strengthening adaptive capacity, particularly in the delivery of inclusive, quality, and resilient green infrastructure for climate adaptation in the UK^[39]. Chitsa et al (2022) examined how communities can co-create and co-implement local adaptation strategies, and noted that in doing so, the involvement of citizens will improve community responses to climate risk^[40].

Building upon this, Ling et al (2022) assessed the efficacy of citizen participation in climate adaptation projects. They considered the role of public participation in the process of planning and implementing local adaptation projects, evaluating how effectively the public participated, the impacts of participation, and key obstacles to participation. Lastly, Ling et al proposed strategies to enhance civic engagement processes, including inclusive planning, enhancing capacity, and developing mechanisms for sustained collaborations. In conclusion, citizen participation has diversified and become an essential element of democratic governance in environmental policy and territorial management. The urgency of the climate crisis, recognizing the need for inclusive, adaptive, and place-based responses, dictates that all parties be engaged during these processes^[41].

2.4. Role of Nature-Based Solutions in Enhancing Territorial Resilience

In recent years, Nature-Based Solutions (NbS) have emerged as effective tools for climate adaptation by leveraging ecological processes to reduce vulnerabilities and promote sustainability. In the context of Settat, such approaches could involve reforestation of degraded land, creation of green infrastructure in urban areas, and restoration of riparian zones along the Ben Moussa River.

Citizen-led NbS offer a valuable opportunity to bridge the gap between environmental policy and on-the-ground ecological action. By involving local communities in tree planting campaigns, urban gardening, or the construction of infiltration zones for rainwater, municipalities can foster both ecological and social resilience. These projects not only reduce greenhouse gas emissions and heat island effects, but also improve biodiversity and water retention in soil.

Integrating NbS into territorial planning requires institutional support, but also benefits from bottom-up civic engage-

ment. This aligns closely with the participatory governance model advocated in this study and presents an ecologically grounded pathway for long-term adaptation in Moroccan municipalities.

3. Research Methodology

In the context of our research, we have chosen to focus on the contribution of citizen participation in strengthening the effectiveness of climate change adaptation strategies. The study upon which we based our work adopted an exploratory qualitative descriptive approach aimed at deepening knowledge on the issue of climate change. This approach facilitated an in-depth exploration of the Moroccan perspectives and experiences regarding the implementation of strategies to combat this phenomenon, using a participatory approach that involves local populations in the adaptation process.

The choice of the qualitative descriptive approach is justified by the limited empirical knowledge regarding the strategic management of territories. Our goal is to fill this gap by examining the experiences and perceptions of citizens involved in the implementation of climate change adaptation policies. Through this exploratory approach, we also aim to identify the key factors that promote citizen participation in a context marked by climate challenges.

In addition to traditional qualitative tools such as semi-structured interviews and field observations, we applied ecological participatory assessment methods to better capture the interactions between communities and their local environments. These methods differ from standard survey techniques in that they actively involve citizens not only as respondents, but also as co-creators of knowledge. These tools allowed participants to visualize and share their environmental knowledge collectively, fostering both reflection and dialogue. This approach not only enriched the quality of data collected but also strengthened the relevance of findings for strategic territorial planning and community-based adaptation.

In this sense, the methodology is closely tied to the concept of strategic territorial management, which requires an understanding of how local actors perceive, respond to, and participate in climate strategies. By focusing on citizen engagement, the study provides insights into the local dynamics that shape or hinder effective territorial planning.

The participatory tools and qualitative data collected help reveal how institutional strategies are received at the grassroots level and how they can be adjusted to align more closely with the lived realities of affected communities. This connection ensures that the analysis does not remain abstract but is instead grounded in practical, place-based insights essential for informing strategic territorial decision-making.

3.1. Study Area

The fieldwork took place in Settât, a municipality situated in central Morocco, about 57 kilometers (35 miles) north of Casablanca and 166 kilometers (103 miles) south of Marrakech. The city is located along the Ben Moussa River, which flows from north to south in the region and historically acted as a transit route for travelers between the two Chaouia regions to the north and south. The city's establishment originates from a spring located on the river's right bank, which once served as a stopping place for travelers. According to the latest population census by the High Commission for Planning in 2014, Settât has a total of 142,250 residents^[9]. Settât is characterized by social, economic, and geographical diversity and faces significant difficulties and challenges related to its semi-arid climate and vulnerability to extreme climate events that impact agriculture, infrastructure, and local livelihoods. In this context, **Figure 1** illustrates the geographical location of the city of Settât.

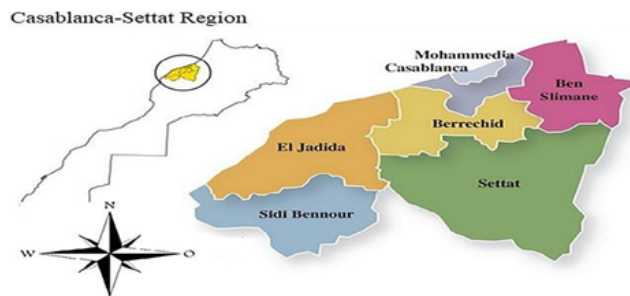


Figure 1. Geographic Positioning of the Municipality of Settât^[42].

The choice of central Morocco, and more specifically the municipality of Settât, as the study area was not arbitrary. This region presents a semi-arid climate marked by recurrent droughts, irregular rainfall, and increasing water scarcity, which makes it one of the most climate-vulnerable areas in the country. In addition, Settât faces severe soil degradation and biodiversity loss, phenomena that directly threaten agricultural productivity and local livelihoods. Be-

yond the ecological dimension, the region also experiences important social challenges, including rural poverty, migration pressures, and limited institutional capacity to respond to environmental stressors. These combined climatic and social vulnerabilities provide a highly relevant context for investigating the role of citizen participation and ecosystem-based approaches in climate change adaptation. Studying Settât thus allows us to highlight the significance of integrating local realities into territorial management strategies, while also drawing lessons applicable to other semi-arid regions in Morocco and beyond.

3.2. A very Worrying Climate Situation in Morocco

Figures 2 and 3 illustrate the trends in temperature and precipitation observed in Morocco over the period 1981–2010, highlighting the main climatic variations during these three decades.

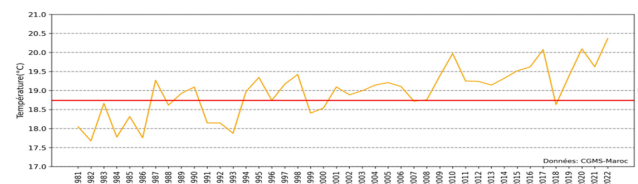


Figure 2. Temporal evolution of the national annual average temperature (Tmoy); the red line represents the climatological normal of Tmoy for the period 1981–2010^[43].

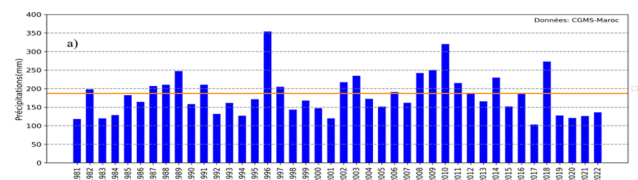


Figure 3. Temporal evolution of national annual rainfall; the orange line represents the climatological normal for the period 1981–2010^[43].

3.2.1. Temperature

In 2022, the annual average temperatures in Morocco ranged between 4 °C and 20.5 °C across the national territory. In the various regions of the country, the annual average temperatures were between 18 °C and 22 °C (**Figure 2**).

3.2.2. Precipitation

The year 2022 was marked by a 27% deficit compared to the normal, placing it as the 12th driest year. However,

the four-year period from 2019 to 2022 has been the driest since at least the 1980s, with a rainfall deficit reaching 32% (**Figure 3**). This has had significant repercussions on agriculture, the environment, and the daily lives of the population^[42].

3.3. Sampling Method and Sample Size

For this study, purposive sampling was employed. This non-probability sampling method enables the selection of participants based on their relevance to the research topic. Key informants were identified due to their expertise or active involvement in areas related to climate change, territorial governance, or citizen participation. The method, guided by the researcher's judgment, aimed to ensure the inclusion of participants capable of providing informed and context-rich insights. While purposive sampling is widely used in qualitative research for its effectiveness in targeting knowledgeable individuals, the present study did not identify existing references explicitly validating the relevance of this approach in similar research contexts, indicating a potential area for further methodological justification.

The choice of purposive sampling was further motivated by the specific objectives of the study, which sought to capture perceptions and practices among professional and social groups most directly engaged in climate-related issues. Nevertheless, we acknowledge that this approach may introduce potential biases, particularly in rural areas where digital divides can restrict participation. To address this limitation, digital surveys were complemented with in-person interviews when feasible, thereby including respondents who might otherwise have been excluded. In addition, triangulation across categories of respondents and cross-validation with secondary data sources were applied to enhance the robustness of the findings. While purposive sampling does not allow for full representativeness, its use in this exploratory and context-specific study provided a depth of understanding that probabilistic methods would not have achieved. The limitations are explicitly acknowledged, and results are interpreted with caution, prioritizing insights and patterns over statistical generalization.

In addition to the survey and interview methods, the study employed participatory ecological tools to enrich data collection and strengthen the validity of the findings. These tools included community mapping exercises, focus group

discussions, and participatory observation, which enabled respondents to collectively identify local environmental changes and adaptation practices. By engaging participants in visual and dialogical processes, these tools helped to capture ecological knowledge that might not emerge through conventional questionnaires alone.

The impact of participatory ecological tools on data collection was twofold. First, they facilitated the co-production of knowledge, allowing participants to articulate their experiences of biodiversity loss, soil degradation, and irregular rainfall in a way that was grounded in local realities. This participatory process increased the accuracy and contextual relevance of the ecological information gathered. Second, these tools enhanced inclusiveness by providing an accessible platform for participants with varying literacy levels or limited digital access, particularly in rural settings, to actively contribute to the research. As a result, the integration of participatory ecological tools not only broadened the scope of data collection but also reinforced the legitimacy of the findings by embedding them within the lived experiences of the communities studied.

The sample size was calculated using the standard formula for estimating proportions at a 95% confidence level and a 5% margin of error:

$$n = (Z^2 \times p \times (1 - p)) / E^2$$

Where n is the sample size, Z is the z-score (1.96), p is the estimated proportion (usually 0.5 when unknown), and E is the margin of error (0.05). This calculation yielded a sample size of approximately 384.16, rounded up to 385 respondents.

3.4. Sociodemographic Profile of Respondents

To better interpret the collected data, a detailed analysis of the sociodemographic profile of the participants was conducted. This focused on gender, professional category, and education level. Gender distribution allowed the identification of potential differences in perception and participation based on gender. The examination of the professional background of participants provided insight into how occupation influences awareness and involvement in local adaptation strategies. Finally, education level was considered as a key variable likely to impact the respondents' ability to understand and engage with environmental issues and participatory governance processes. These characteristics served as a foundation for the contextualization and interpretation of

the study's findings.

3.5. Data Collection Tools

The research employed a combination of data collection methods, drawing on established methodologies in social science research^[44,45]. Firstly, document analysis was conducted to review relevant academic literature, official reports, and technical documents. This method provided the theoretical framework and contextual background on climate governance and citizen participation^[46,47]. Secondly, a structured questionnaire was developed and administered online via Google Forms. Designed in French to enhance accessibility among respondents, the questionnaire consisted of 26 questions divided into four sections: personal demographic information, perceptions of strategic territorial management, perceptions of climate change, and citizen engagement in adaptation policies. A total of 385 questionnaires were distributed, of which 261 were completed and returned, resulting in a response rate of approximately 67.8%, which is considered satisfactory for online surveys^[48].

However, the use of online surveys in this study also presented certain limitations. In rural and urban areas, especially within the municipality of Settât, access to digital tools and internet connectivity remains uneven. This digital divide may have limited the participation of non-tech-savvy individuals, including older adults or residents with low digital literacy. As a result, some community perspectives, particularly those from the most vulnerable or isolated populations, may be underrepresented in the data. To mitigate this limitation, online data collection was complemented by in-person interviews and participatory workshops where possible. Nonetheless, this issue highlights the importance of using inclusive and multimodal approaches in participatory climate research.

3.6. Supplementary Data Sources

In addition to document review and the questionnaire, participation in relevant academic forums and professional events enriched the research. Notably, the study benefited from insights gathered during the "International Conference on Entrepreneurial Ecosystems: Cultivating Entrepreneurial Resilience for an Unpredictable Future," held on April 25, 2024, at ISCAE Group in Casablanca. This event offered

valuable perspectives from experts, practitioners, and academics working on climate resilience, governance, and participatory planning, further reinforcing the empirical and theoretical dimensions of the study.

4. Results

As outlined earlier, a total of 385 individuals were initially targeted to complete the questionnaire. Of these, 261 completed and returned the survey, resulting in a response rate of approximately 67.8%. This rate is generally considered high for online surveys and provides a robust basis for analysis^[48]. The key findings regarding the respondents' demographic characteristics are presented in **Table 1**.

Table 1. Distribution by Gender and Residential Area.

Gender/Residence Area	Rural	Urban	Total
Male	8.47%	33.9%	42.4%
Female	5.08%	52.5%	57.6%
Total	13.6%	86.4%	100%

Male respondents account for 57.63% of the sample, with 52.54% residing in urban areas and 5.08% in rural areas of the Settât province. In contrast, female respondents represent 42.37%, including 33.90% from urban settings and 8.47% from rural areas within the same province.

The **Table 2** presents the distribution of respondents by education level.

Table 2. Distribution by Education Level.

Education Level	Percentage
Primary Education	1.69%
Secondary Education	10.2 %
Higher Education (Bachelor's, PhD, Master's)	88.1%
Total	100%

The finding that 88.14% of respondents possess a high level of education adds considerable scientific value to our study, reinforcing the credibility and relevance of the responses obtained.

The **Table 3** presents the professional category of respondents.

The diversity of professional backgrounds among respondents reflects a well-balanced representation across various occupational groups, thereby contributing to a broader scope and a more inclusive understanding of the research topic.

Table 3. Professional Category.

Professional Category	Percentage
Employee (private sector)	15.2%
Civil servant (public sector)	16.9%
Elected officials	8.47%
Entrepreneur	33.9%
Self-employed (freelancer, home worker)	11.9%
Unemployed	13.6%
Total	100%

The **Table 4** presents the respondents' perceptions regarding territorial management, providing insights into how different stakeholders understand and evaluate the current practices and challenges associated with managing territorial resources.

Table 4. Perceptions regarding territorial management.

Territorial Management	Percentage
All actions aimed at managing and developing a territory in an integrated, coordinated, and sustainable manner	83.3%
Management of natural resources in a region	7.7%
Exclusive management of local businesses	10%
Total	100%

Guided by negotiation, participation, and innovation, the implementation of a policy rooted in strategic territorial management reflects the commitment of the state to a renewed way of managing territories. While state development previously occupied a dominating and almost unique role, relegating local community development to a secondary, supportive role for the state, this situation is radically different today. The state is engaged in a new style of territorial governance by working with other actors over conflicts. While the actors involved in the production of territory are multiple and territorial processes are complex, the partnerships formed between the state and other actors are linked to a clear shift in practice from top-down to territorial governance. Hence, instead of exercising the centralized action that characterized intervention during the Makhzen^[49], the state now shares responsibility with other actors who can have the greatest impact on the territory turned into an action. The results of the surveys show that the majority of respondents, regardless of region, view territorial management as pertaining to all actions that are intended to govern (direct, develop...) a territory in a coherent, integrated, and sustainable way, suggesting a good understanding of the concept on

the part of the respondents surveyed. However, even with this understanding, in this case with respect to the theoretical context provided, we must nonetheless reflect on the primary finding of this research which was the practically limited participatory dimension of territorial management within the municipality of interest, and how 'one-off' and aligning development projects and policies may not respond to the character and needs of local territory which prevented labour or wealth creation, which seemed contradictory to the imperative of both strategic territorial management and the approach of Hmid & Abbadi, 2024, which included the importance of developing effective strategies according to the context, and a necessity of focusing on locally relevant and sustainable development.

The results of this study, using a questionnaire aimed at examining citizen perceptions of climate change, demonstrated some significant trends. When looking at the responses of residents in the municipality studied (**Table 5**), 71% indicated that they definitely perceived environmental and climatic changes, while 29% believed that they had not observed any significant changes in their environment or climate trends.

Table 5. Perceptions of Climate Change.

Citizen Perceptions	Percentage of Respondents
Perceive significant changes in the environment	71%
Do not perceive significant changes in the environment	29%
No response	0%

In addition to the perceptions by respondents, meteorological records from the General Directorate of Meteorology spanning several decades also showed clear weather-related changes, confirming the perceptions. Particularly, at the levels of temperature trends, there was a clear and sustained increase in average temperature trends over a period of time that verified the global warming trends that have been reported in the scientific literature.

Interestingly, the recorded maximum temperatures did not result in a statistically significant increase. This, however, is likely due to a variety of factors, such as climate variation over a shorter period of time or meteorological-specific events that occurred during the reference period. However,

that does not mean that, even though the maximum temperatures did not significantly increase, global warming is not extant, and in fact, simply highlights the congruency between citizens' instances of observation and scientific records.

To measure perceptions related to precipitation, the questionnaires included four central variables: precipitation amounts, instances and timing of precipitation, increased frequency of precipitation, and the length of dry intervals. Within these dimensions that were measured, they are pressing to highlight how participants experience and interpret changes in precipitation and drought conditions, which are some of the most salient indicators of a changing climate. The responses indicated a general perception of decreased

precipitation (amount and frequency) by most respondents. This is ultimately a reflection of growing concerns over total water availability and the changing hydrological cycle. Moreover, according to **Table 6** many of the respondents noted a change in the timing of rainfall events, which can cause lasting impacts to agriculture, water resource management, and climate change risk prevention. Also, the respondents mentioned the lengthening of dry periods, indicating trends toward drier conditions and increased droughts. This is particularly important because it highlights the emerging issues concerning total water availability, sustainable management of natural resources, and ecosystem viability in the face of climate change.

Table 6. Perceptions of Precipitation and Temperature.

Citizen Perception	Increase	Decrease	No Response
Temperature	78%	3%	19%
Precipitation	4%	81%	15%

4.1. Citizen Participation in Climate Change Adaptation Policies

To obtain data on public engagement in climate change adaptation, a set of relevant independent variables was identified from a review of existing literature, particularly pertinent to climate adaptation, which surveyed what was already known. By utilizing literature, we captured dimensions essential to understanding the nature of public involvement. The variables selected as relevant included participatory democracy, the degree of civic engagement, citizen involvement in decision-making processes concerning their territory, and citizen access and mobilization of resources for adaptation.

Figure 4 illustrates the concept of participatory democracy, allowing a better understanding of how citizen involvement and collective decision-making are integrated into the territorial governance process.

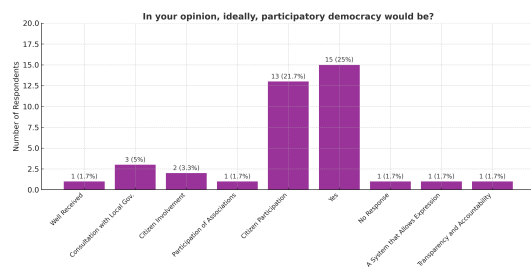


Figure 4. Participatory democracy.

The review of the data presented in **Table 7** offers several important insights into how citizen involvement in climate change adaptation varies based on the professional background of the respondents. One of the most striking findings is the variance in the degree of participation across different sectors of citizens. For example, elected officials show a high level of engagement compared to other groups, such as entrepreneurs. The level of involvement for elected officials is explained by the role they have in creating and implementing public policy about climate change adaptation.

Table 7. Precision of the level of involvement.

Professional Category	Strongly	Moderately	Weakly
Employee - Primary	0%	0%	0%
Employee - Secondary	0%	0%	0%
Employee - Higher	13%	15%	72%
Civil Servant - Primary	0%	0%	0%
Civil Servant - Secondary	0%	0%	0%
Civil Servant - Higher	25%	35%	40%
Elected Official - Primary	0%	0%	0%
Elected Official - Secondary	0%	0%	0%
Elected Official - Higher	25%	33%	40%
Entrepreneur - Primary	0%	0%	8%
Entrepreneur - Secondary	0%	7%	12%
Entrepreneur - Higher	9%	12%	75%
Self-employed - Primary	0%	0%	0%
Self-employed - Secondary	0%	0%	9%
Self-employed - Higher	9%	88%	87%

Furthermore, the data indicate that elected representatives have the highest percentage of having high levels of

strong involvement. Their roles, which are officially governed and influence over forms of territorial governance, put them in a position of leadership, fundamentally at the nexus of climate-related decisions at the site and community level. Thus, their participation is implied and expected. Other groups of citizens can be characterized as more moderate. A significant number of respondents across all categories identified themselves as being moderately involved in climate change adaptation. This finding could serve as an indicator of varying degrees of awareness of climate change issues without an apparent level of depth of personal commitment or action.

While younger groups, specifically entrepreneurs and unemployed people, reported the lowest levels of actual involvement. This can be for various reasons, such as considerations of immediate career or economic priorities, or little awareness about climate adaptation actions and policies.

Overall, the results show that citizen engagement in climate adaptability was largely dependent on a professional context and role in climate-related responsibility. Public servants and elected officials report higher levels of involvement, whereas other groups, specifically those outside of formal governance, reported lower levels of involvement. These trends indicate how we might need to engage with different professional groups in different ways to engage them in climate action.

The **Figure 5** illustrates the role of citizen involvement in adaptation policies, highlighting the extent to which local populations participate in shaping strategies to address climate change and territorial challenges.

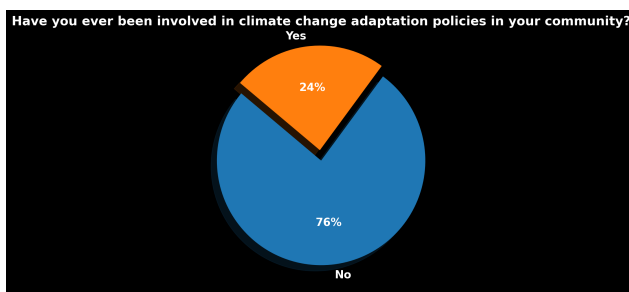


Figure 5. Citizen Involvement in Adaptation Policies.

Figure 6 illustrates the level of climate change awareness among respondents, shedding light on their perceptions, knowledge, and sensitivity to the impacts of environmental transformations on territorial management and local livelihoods.

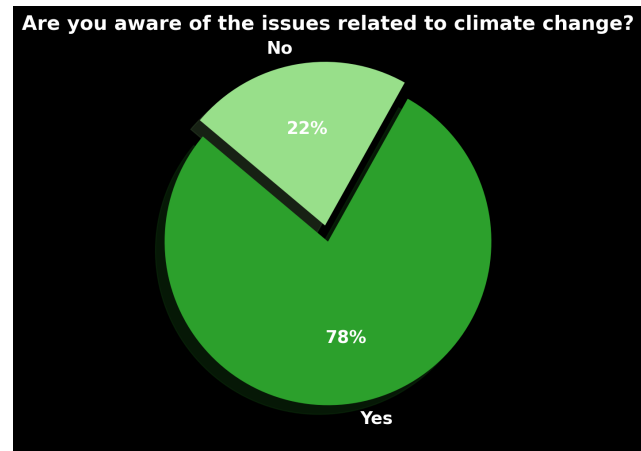


Figure 6. Climate change awareness.

The examination of the data in **Table 8** reveals a clear positive relationship between the level of education and the level of awareness pertaining to climate change. Interestingly, the respondents with the highest education specifically university degrees with either the bachelor's, master's, or doctoral designation—demonstrate the highest awareness and concern pertaining to climate change adaptation.

Table 8. Accuracy of the degree of awareness.

Professional Category	Strongly	Moderately	Weakly
Employee - Primary	0%	0%	0%
Employee - Secondary	0%	0%	0%
Employee - Higher	8%	15%	54%
Elected Official - Primary	0%	0%	0%
Elected Official - Secondary	7%	0%	0%
Elected Official - Higher	77%	15%	82%
Entrepreneur - Primary	0%	0%	0%
Entrepreneur - Secondary	0%	0%	0%
Entrepreneur - Higher	0%	10%	85%
Unemployed - Primary	0%	0%	0%
Unemployed - Secondary	0%	6%	91%
Unemployed - Higher	6%	64%	91%

There may be several explanations for this observation. First, those who have an education beyond a basic level tend to possess stronger critical thinking and analytical skills. These abilities help individuals in critically assessing information about climate risks and whether the physical changes to the environment impact their community or livelihood. Therefore, these individuals are aware of the urgency for climate adaptation and the potential engagement within these strategies.

Additionally, education increases environmental awareness. Being academically initiated into environmental issues may promote more sustainable behaviors and lead to engaging in activities to mitigate the impacts of climate change.

Education completion is frequently associated with a greater sense of social responsibility. This sense of civic duty might motivate individuals to be involved in projects that promote environmental stewardship and climate resilience.

It is important to stress that while there is considerable evidence suggesting education correlates with awareness around climate change, the conclusion should not oversimplify the relationship into a causal relationship. Multiple variables, including, but not limited to, personal experiences with extreme weather, access to information media, value systems and cultural upbringing, and individual interest in environmental topics, could all relate to environmental awareness and involvement. Education is clearly an important factor, but climate awareness should be viewed through a complexity of dynamic variables that shape individual awareness and engagement.

Evaluating the results shown in **Table 9** highlights a few trends regarding participants' preferred sources of climate change information, depending on their professional classifications. Undoubtedly, the internet is the strongest source of information, with the most respondents in each professional classification using the internet as their primary method for finding climate change information. Although the exact percentages differ slightly among the professional classifications, the internet always came first, where the internet was used by 41 to 56% of participants, indicating that this source was typically the most commonly available and usable medium.

Table 9. Participants' preferred sources of climate change information.

Professional Category	Internet	TV	Radio	Experts
Employee	56%	32%	12%	0%
Civil Servant	48%	38%	14%	1%
Elected Official	41%	31%	28%	0%
Entrepreneur	55%	24%	21%	0%
Self-employed	51%	35%	14%	0%
Unemployed	53%	39%	8%	0%

Television is another source, but it is less emphasized than the internet. Public servants and self-employed individuals indicate a stronger reliance on television, with 38% and 35% of respondents identifying this as an important source, respectively. This finding supports the notion that traditional media have relevance, especially among certain segments of the population, for reasons such as ease of access or habitual usage. Radio, in contrast, is considerably the least

used source for climate change information. Before considering professional categories of respondents, unemployed respondents have the highest reliance on radio, though the proportion remains low (approximately 8%). This lack of use could indicate a wider trend away from media formats such as radio, with audiences opting for more flexible and consumer-led media messages.

Importantly, no group of respondents (by profession) cited experts as their primary source of information. The lack of experts as an information source for all professional groups indicates a broad-based activity by the population to utilize mass media, particularly the internet, television, and radio, rather than to contact scientists/technical experts directly. The lack of preference offers explanations such as limited access to scientists, difficulty interpreting technical jargon, or preferring access to familiar and usable media.

Overall, these results reveal the relative importance of the internet as the preferred source for climate information, highlight the continued role of television, and acknowledge that confusion about radio and expert sources has declined. With this context, we can better measure and relate more appropriate and effective communication based on the population's media use preferences across professional groups.

4.2. Statistical Analysis: Logistic Regression Results

Beyond descriptive statistics, we applied a binary logistic regression model to identify the key factors influencing citizen participation in climate change adaptation policies. The dependent variable was the level of participation (coded as 1 = active participation, 0 = no or limited participation). Independent variables included gender, place of residence (urban/rural), education level, and professional category.

The regression results indicate that education level and professional category were significant predictors of citizen participation ($p < 0.05$). Respondents with higher education were more likely to engage in adaptation initiatives compared to those with secondary or primary education. Similarly, public officials and elected representatives showed significantly higher probabilities of participation than entrepreneurs or unemployed respondents. In contrast, gender and place of residence did not exhibit statistically significant effects on participation ($p > 0.05$).

This model highlights that structural and institutional factors, particularly professional responsibilities and educational attainment, play a stronger role than demographic characteristics in shaping civic engagement in climate adaptation. These findings reinforce the need for targeted awareness and capacity-building programs among less represented groups, such as unemployed citizens and young entrepreneurs, in order to broaden participation in territorial resilience strategies.

Table 10 presents the results of the logistic regression model predicting citizen participation in climate change adap-

tation policies. The model shows that education level (OR = 2.34, $p < 0.001$) and professional category (OR = 1.87, $p = 0.002$) are significant predictors of participation. Respondents with higher education were more than twice as likely to actively engage in adaptation initiatives compared to those with lower education levels. Similarly, individuals working as public officials or elected representatives were significantly more likely to participate than entrepreneurs or unemployed respondents. In contrast, gender and residence (urban vs. rural) were not significant predictors of participation ($p > 0.05$).

Table 10. Logistic regression results for predictors of citizen participation.

Predictor Variable	Odds Ratio (OR)	Standard Error	z-Value	p-Value	Significance
Gender (Male = 1)	1.12	0.25	0.45	0.652	n.s.
Residence (Urban = 1)	0.89	0.27	-0.41	0.681	n.s.
Education Level	2.34	0.41	3.95	<0.001	***
Professional Category	1.87	0.36	3.12	0.002	**
Constant	0.45	0.19	-2.14	0.032	*

Notes: n.s. = not significant; * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

Figure 7 presents a forest plot summarizing the logistic regression results for the predictors of citizen participation in climate change adaptation. The plot displays the estimated odds ratios along with their corresponding confidence intervals, allowing for a clear visualization of both the strength and direction of each predictor's effect.

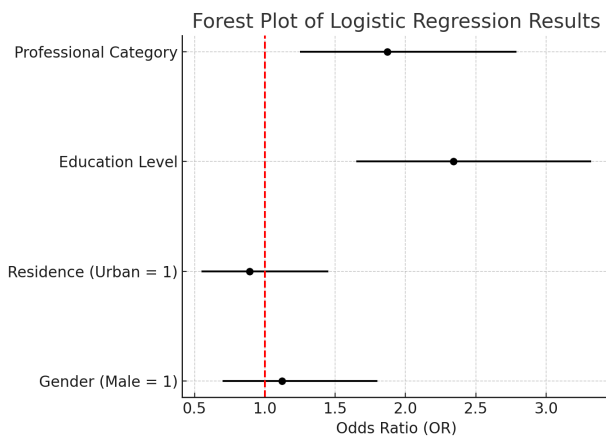


Figure 7. Forest plot of logistic regression results for predictors of citizen participation in climate change adaptation.

5. Discussion and Interpretation

The findings of this study reveal a paradoxical situation in Settat: while awareness of climate change impacts

is relatively high, levels of citizen participation in adaptation initiatives remain limited. This gap between awareness and action has also been identified in other contexts^[1], suggesting that knowledge of climate risks does not automatically translate into civic engagement. Our data confirm that sociodemographic factors play a significant role. Higher levels of education were associated with greater awareness of climate risks, which is consistent with earlier findings showing that education enhances environmental literacy and adaptive capacity^[6]. However, professional status strongly differentiated participation rates: public officials and elected representatives demonstrated higher involvement than entrepreneurs or unemployed respondents. Similar patterns were observed in comparative studies where institutional actors, by virtue of their positions, tend to report greater engagement in adaptation planning^[41].

Yet individual attributes alone cannot explain participation outcomes. Structural and cultural barriers also emerged as major determinants. Limited trust in local authorities, weak institutional frameworks, and insufficient mechanisms for dialogue appear to hinder inclusive participation. These findings resonate with Anguelovski et al.^[2], who highlighted that inequities in planning processes often reproduce social exclusion in adaptation governance. In Settat, communication barriers, reflected in citizens' reliance primarily on mass

media (Internet and television) rather than expert consultations, further exacerbate this disconnect between institutions and the public.

The role of local governments in supporting citizen-led initiatives, particularly Nature-Based Solutions (NbS), is therefore crucial. Evidence from other regions demonstrates that when municipalities provide technical and financial support, NbS projects achieve stronger legitimacy and sustainability^[40]. In Settat, initiatives such as community-led afforestation or the restoration of riparian zones could mirror successful cases observed in sub-Saharan Africa, where small-scale irrigation and ecological monitoring significantly improved adaptive capacity^[4]. Conversely, failed NbS experiences elsewhere, often linked to institutional fragmentation and lack of coordination^[3], serve as cautionary lessons for Settat.

Digital platforms and technologies also represent underutilized opportunities. As suggested by Verhoef et al, 2021^[32], online participation tools can broaden engagement, overcome logistical barriers, and foster transparency. In Settat, where digital divides persist, hybrid mechanisms combining face-to-face participatory forums with digital platforms could ensure greater inclusivity.

Public-private partnerships (PPP) offer another pathway to enhance participation. By bringing together citizens, municipalities, and businesses, PPPs enable resource sharing and co-responsibility for adaptation. Successful examples from Southern Europe show that PPP-based NbS projects diversify governance arrangements and increase territorial resilience (Bulkeley & Betsill, 2005). Such models could be adapted to Settat's institutional realities, especially in engaging entrepreneurs who showed lower levels of participation in this study.

Finally, institutional barriers remain a significant challenge in Settat. The absence of a clear regulatory framework and weak inter-institutional coordination hinder the implementation of NbS. As Ostrom's theory of polycentric governance emphasizes, adaptive and collaborative institutional models are essential for managing complex environmental issues. In this sense, governance approaches that prioritize co-production, inclusiveness, and iterative learning Dryzek, 2002^[37] could provide valuable insights for strengthening Settat's climate adaptation strategy.

Settat, located in Morocco's semi-arid central region,

is increasingly confronted with acute climate-related challenges, the most pressing of which is water scarcity. Rising temperatures and declining rainfall have led to recurrent droughts, depletion of groundwater resources, and heightened competition between agricultural, industrial, and domestic uses of water. These pressures are particularly evident in the agricultural sector, which remains the backbone of the local economy but is increasingly vulnerable to rainfall variability and soil degradation.

The situation in Settat mirrors broader global trends observed in other semi-arid and Mediterranean regions, where climate change is intensifying hydrological stress and exposing structural weaknesses in water management systems. According to the IPCC (2021), semi-arid regions worldwide are projected to experience more frequent and prolonged droughts, reinforcing the urgency of adaptation. Settat's experience thus provides a microcosm of these global dynamics, illustrating how localized impacts are shaped by both biophysical vulnerabilities and socio-economic dependencies on natural resources.

Local adaptation efforts in Settat, including the promotion of water-saving irrigation techniques, crop diversification, and the integration of ecosystem-based approaches, demonstrate how community-level practices can contribute to resilience. However, the persistence of digital divides and limited citizen participation in water governance reveals gaps that hinder effective adaptation. Strengthening participatory mechanisms and aligning local strategies with global frameworks such as the Sustainable Development Goals could enhance the capacity of Settat to cope with water scarcity while offering lessons applicable to other climate-vulnerable regions.

Overall, this study reinforces the notion that awareness is a necessary but insufficient condition for meaningful participation. Bridging the gap requires deliberate institutional reforms, innovative participatory mechanisms, and stronger local governance. When compared with previous studies, our results converge on the idea that citizen engagement depends not only on individual capacity but also on structural trust, cultural norms, and the inclusiveness of governance frameworks. For Settat, integrating these lessons offers a critical pathway toward more resilient and citizen-centered adaptation strategies.

5.1. Ecological Impacts of Climate Change in the Settât Region

Climate change in the Settât region is not only a social and governance issue but also an ecological concern. The increasing frequency of droughts, irregular precipitation patterns, and rising temperatures has directly impacted the local environment. Field observations and citizen testimonies indicate a noticeable degradation of natural vegetation, especially in semi-arid areas around the city. Farmers and local residents reported shifts in flowering seasons, the disappearance of certain native plant species, and the growing dominance of invasive plants in peri-urban zones.

Furthermore, reduced rainfall and the drying of natural water bodies have threatened the survival of amphibians and migratory birds that once used these zones as seasonal habitats. Soil degradation and reduced agricultural biodiversity are becoming increasingly evident, with local varieties of cereals and legumes exhibiting lower resilience to climatic stress.

These changes highlight the need for integrated ecological monitoring within territorial management strategies, as biodiversity loss and ecosystem imbalance may jeopardize the long-term sustainability of the region.

5.2. The Role of Nature-Based Solutions in Enhancing Territorial Resilience

In the face of environmental degradation and climatic stress, Nature-Based Solutions (NbS) represent an opportunity to strengthen both ecological and social resilience. These solutions involve leveraging natural processes such as reforestation, wetland restoration, and green urban planning to address climate challenges while enhancing biodiversity.

In the Settât region, NbS could take the form of community-led afforestation programs, rooftop gardening initiatives in urban neighborhoods, and the restoration of riparian zones along the Ben Moussa River. Such actions provide dual benefits: they mitigate environmental risks (such as soil erosion and water scarcity) while also delivering social co-benefits, including food security, community cohesion, and environmental awareness.

Importantly, the success of NbS in Settât depends not only on institutional support but also on the integration of local traditions and knowledge. The region has a long his-

tory of community-based resource management, including traditional water-sharing practices, soil conservation techniques, and collective tree planting efforts. Incorporating these cultural practices and indigenous ecological knowledge into NbS design can improve their legitimacy, strengthen local ownership, and enhance their long-term sustainability. This cultural dimension also helps ensure that NbS are not perceived as externally imposed interventions but as community-driven strategies that resonate with local values and practices.

Encouraging citizen participation in NbS planning and implementation is therefore crucial to ensure both ownership and durability. By combining scientific expertise with local traditions, Settât can advance an adaptation model that is ecologically effective, socially inclusive, and deeply rooted in the territory. These approaches align closely with the principles of strategic territorial management by embedding ecological functionality and cultural relevance into climate adaptation policy.

5.3. Participatory Approaches and Tools for Ecological Governance

Beyond conventional survey techniques, participatory ecological tools can enhance citizen engagement and provide actionable knowledge for local adaptation. Methods such as participatory mapping, community-based biodiversity monitoring, and seasonal calendar planning help communities express environmental knowledge in structured ways. For instance, farmers can document changes in phenological events (e.g., flowering, fruiting, or migration patterns) linked to climate shifts.

In Settât, such approaches can support municipalities in identifying vulnerable zones, prioritizing ecological restoration areas, and co-designing green infrastructure projects. These tools not only increase the quality of local environmental data but also empower communities by recognizing their ecological expertise. By integrating participatory tools into environmental governance, local authorities can strengthen both adaptive capacity and ecological sustainability. The integration of ecological perspectives into participatory territorial management reaffirms the importance of citizen-led action in climate adaptation. Moreover, the results of this study align with key Sustainable Development Goals (SDGs), including SDG 11 (Sustainable Cities and Communities), SDG

13 (Climate Action), and SDG 15 (Life on Land).

Promoting inclusive governance, climate resilience, and biodiversity restoration at the municipal level is not only a national imperative but a contribution to global environmental efforts.

6. Conclusions

This study focused on climate change adaptation strategies with particular attention to citizen participation in the municipality of Settât. It contributes to the understanding of local climate risks by highlighting public perceptions and assessing the extent of civic engagement in local adaptation efforts. Our findings show that while citizens demonstrate substantial awareness of climate change impacts, their direct participation in decision-making and implementation remains limited.

Meteorological trends identified in the study, including temperature increases and irregular precipitation, are consistent with official data from the General Directorate of Meteorology. This alignment confirms the scientific validity of our analysis. However, our research also highlights a lack of effective communication between local authorities and the general public, which contributes to low levels of engagement. Where participation exists, it is often limited to public officials or elected representatives, rather than the broader community.

Several factors influence levels of engagement, including professional status, education, gender, and geographic location. These variables shape both perceptions of climate change and the capacity or willingness to participate in adaptation initiatives.

Based on these findings, we propose the following actionable policy recommendations:

Remove structural barriers to participation:

Local and national governments should conduct participatory assessments to identify political and institutional obstacles limiting citizen involvement. These should inform reforms that embed inclusive governance mechanisms into climate planning processes.

Strengthen local communication channels:

Municipalities should establish formal spaces for dialogue between citizens and public authorities, such as local climate forums, citizen panels, or participatory budgeting

processes that include adaptation priorities.

Leverage digital technologies for engagement:

Governments should develop user-friendly digital platforms that provide real-time meteorological information, facilitate two-way communication between weather agencies and communities, and support citizen input on adaptation planning at the village or neighborhood level.

Invest in climate education and outreach:

National education ministries and local governments should implement targeted awareness campaigns and community training programs. These should be tailored to different social groups, including youth, women, and rural populations, and aim to improve public understanding of climate data and encourage proactive participation.

Integrate citizen knowledge into adaptation planning:

Local authorities should recognize and incorporate local and traditional ecological knowledge into official adaptation strategies. This can improve the cultural relevance and effectiveness of interventions.

Plus these recommendations, to translate the study's findings into actionable strategies, policy recommendations should prioritize multi-level and participatory approaches that bridge ecological sustainability with social inclusion. For Settât, three concrete steps can be proposed. First, strengthen local water governance by institutionalizing participatory platforms where farmers, civil society, and municipal authorities jointly design and monitor water-use strategies. This would reduce the gap between top-down planning and community needs. Second, promote ecosystem-based solutions, such as reforestation of degraded areas, rehabilitation of rangelands, and the integration of green infrastructure into urban planning, to simultaneously address biodiversity loss and climate adaptation. Third, develop capacity-building programs that target vulnerable populations, particularly smallholder farmers and youth, by providing training on climate-smart agricultural practices, digital tools, and alternative livelihoods.

Beyond Settât, similar semi-arid regions would benefit from national policies that incentivize the adoption of water-efficient technologies through subsidies and public-private partnerships, while ensuring equitable access for marginalized groups. Regional cooperation mechanisms should also be strengthened, given that climate impacts and resource

pressures transcend municipal boundaries. Finally, aligning local initiatives with international frameworks, notably the Paris Agreement and the Sustainable Development Goals, can enhance policy coherence and attract external funding for adaptation. By embedding actionable, inclusive, and ecosystem-based strategies into governance, Settat and comparable regions can transform climate risks into opportunities for sustainable resilience.

In conclusion, while climate awareness is growing among the population, a significant gap persists between knowledge and active engagement. Bridging this gap requires deliberate policy efforts to improve communication, accessibility, and education. Empowering citizens to take an active role is essential for building inclusive and resilient local responses to climate change.

Author Contributions

Conceptualization, A.H.; methodology, A.H.; software, A.H.; validation, A.H.; formal analysis, A.H. and Y.F.; investigation, A.H.; resources, A.H.; data curation, A.H.; writing, original draft preparation, A.H.; writing, review and editing, A.H.; visualization, A.H.; supervision, A.H.; project administration, A.H. and R.K.; funding acquisition, B.S., A.R., H.e.M., R.K., Y.F. and A.A. All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest

The authors declare no conflict of interest.

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