

UNIVERSITY FOR DEVELOPMENT STUDIES, TAMALE



**ASSESSING MOBILE PHONE PENETRATION AND ITS ROLE IN ENHANCING
CLIMATE CHANGE COMMUNICATION IN TAMALE METROPOLIS**

ISSAKU SALIFU

UDS/MIC/0006/21

2025



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CLIMATE CHANGE COMMUNICATION IN TAMALE METROPOLIS**

BY

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**THIS THESIS SUBMITTED TO THE DEPARTMENT OF AGRICULTURAL INNOVATION
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FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF A MASTER OF
PHILOSOPHY DEGREE (MPhil) IN INNOVATION COMMUNICATION**

April, 2025

DECLARATION

Student

I hereby declare that this thesis is the outcome of my original research work and that it has not been presented, either in part or whole, for the award of another degree in this University or elsewhere:

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Supervisor

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(Supervisor)



DEDICATION

To my dear parents.



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My deepest gratitude goes to the Almighty Allah for His mercies and care for seeing me through this programme. My appreciation and thanks goes to my supervisor Dr. Samuel Safo K Allotey for his support and encouragement during the difficult times of my studies. I would also love to thank all the lecturers in the department for their patience and support throughout this programme. Finally, I want to specifically acknowledge all my friends and family for helping me survive all the stress and not letting me give up.



ABSTRACT

This study assesses mobile penetration and how it contributes to improving climate change communication in the Tamale Metropolis in Northern Ghana. A sample of 400 adult respondents was collected through stratified random sampling from three zones of the metropolis. Trained enumerators used face-to-face structured questionnaires to collect data. Descriptive statistics and logistic regression analysis were used for data analysis. Findings show that 80% of the respondents possessed mobile phones of which 56.2% were smartphone users and 43.8% were using basic feature phones. Double SIM card use was prevalent, used in balancing network reliability and affordability. Mobile phones were used extensively for voice calls, SMS, internet, social media, and mobile money services. Around 55% of the interviewees indicated to have received climate or weather information through mobile phones, mostly in the forms of SMS messages, voice calls, and social media. Logistic regression determined network coverage, access to electricity, affordability, literacy level, and education level to be the drivers of efficient use of mobile phones in climate communication. Income level, age, and gender were less related. The research therefore concludes that mobile phones are essential platforms in climate change communication in the Tamale Metropolis but infrastructural and socioeconomic constraints hamper their optimal use. It is, as per these findings, recommended that network infrastructure and power supply be improved by telecom operators and local authorities.



Table of Contents

DECLARATION.....	i
DEDICATION.....	ii
ACKNOWLEDGMENT	iii
ABSTRACT.....	iv
LISTS OF ABBREVIATIONS	x
CHAPTER ONE	1
INTRODUCTION.....	1
1.0 Background to the study	1
1.2 Problem statement	4
1.3 Research Questions	7
1.3.1 Main research question	7
1.3.2 Specific research questions.....	7
1.4 Objectives of study	8
1.4.1 Main objective of study	8
1.4.2 Specific objectives of study.....	8
1.5 Justification of Study	9
1.6 Definitions of key terms.....	10
1.7 Organization of Study.....	11
CHAPTER TWO	12
LITERATURE REVIEW	12
2.0 Introduction.....	12
2.1 Technology Acceptance Model	12
2.2 Definitions of Key Terms and Concepts	14
2.2.1 Mobile Phone Penetration	14
2.2.2 Climate Change.....	15
2.2.3 Climate Change Communication	16
2.3 Mobile Phone Penetration: Global and Local Perspectives	17
2.4 Trends in Mobile Phone Ownership and Access Globally and in Ghana	20
2.5 Mobile Phone Penetration Rates in Urban vs. Rural Areas, with Emphasis on Northern Ghana	22
2.6 The Role of Mobile Technology in Disseminating Climate Information	24
2.7 Types of Climate Change Information Communicated via Mobile Phones	27



2.8 Mobile-Based Climate Communication Initiatives in Ghana and Sub-Saharan Africa	30
2.9 Infrastructural Factors Influencing Mobile Phone Use for Climate Communication	33
2.10 Socioeconomic Factors Influencing the Utilization of Mobile Phones for Climate Change Communication	40
2.11 Climate Adaptation and Socioeconomic Disparities	44
2.12 Effectiveness of Mobile-Based Climate Communication Strategies	44
2.13 Conceptual framework	48
CHAPTER THREE	51
METHODOLOGY	51
3.0 Introduction	51
3.1 Profile of Tamale Metropolis	51
3.2 Research Approach	53
3.3 Research Design	54
3.4 Population	55
3.5 Sampling Procedure and Sample Size	55
3.5.1 Sampling Size	55
3.5.2 Sampling Procedure	56
3.7 Data Collection Process	58
3.9 Data Analysis	59
CHAPTER FOUR	64
RESULTS AND DISCUSSIONS	64
4. 0 Introduction	64
4.1 Demographic Information of Respondents in the Tamale Metropolis	64
4.2 The level of access to mobile phone technology among residents in Tamale Metropolis	69
4.3 How mobile phones are being used to access and disseminate climate change information in the metropolis	76
4.3.1 Access and Dissemination of Climate Change Information via Mobile Phones	76
4.3.2 Types of Climate-Related Information Received via Mobile Phones	80
4.4 The infrastructural and socioeconomic factors affecting the effective use of mobile phones for climate change communication	83
4.5 The effectiveness of existing mobile-based communication strategies in promoting awareness and adaptive responses to climate change in Tamale Metropolis	90
4.5.1 Respondents' Perceptions of Mobile-Based Climate Change Communication Strategies	90
4.5.2: Adaptation action used by respondents to adapt to climate change in Tamale Metropolis	96



CHAPTER FIVE	99
SUMMARY, CONCLUSIONS AND RECOMMENDATIONS.....	99
5.0 Introduction.....	99
5.2.0 Summary of findings.....	99
5.2.1 Socio-demographic characteristics of respondents	99
5.2.2 The level of access to mobile phone technology among residents in Tamale Metropolis	100
5.2.3 How mobile phones are being used to access and disseminate climate change information in the metropolis	101
5.2.4 The infrastructural and socioeconomic factors affecting the effective use of mobile phones for climate change communication.....	101
5.2.5 The effectiveness of existing mobile-based communication strategies in promoting awareness and adaptive responses to climate change in Tamale Metropolis.....	102
5.3 Conclusions on the study	103
5.3.1 The level of access to mobile phone technology among residents in Tamale Metropolis	103
5.3.2 How mobile phones are being used to access and disseminate climate change information in the metropolis	103
5.3.3 The infrastructural and socioeconomic factors affecting the effective use of mobile phones for climate change communication.....	104
5.3.4 The effectiveness of existing mobile-based communication strategies in promoting awareness and adaptive responses to climate change in Tamale Metropolis.....	105
5.4 Recommendations	105
5.5 Suggestions for future research	107
REFERENCES.....	109
APPENDICES	132
APPENDIX 1	132



List of Tables

Table 3.1: Sample Distribution by Zones, Areas	56
Table 4.1: Demographic Information of Respondents	67
Table 4.2: Mobile Phone Access and Usage among Respondents	71
Table 4.3: Overall Levels of Mobile Phone Access and Usage among Respondents	74
Table 4.4: Access and Dissemination of Climate Change Information via Mobile Phones	78
Table 4.5: Types of Climate-Related Information Received via Mobile Phones	82
Table 4.6: Logistic Regression Results: Factors Influencing Effective Use of Mobile Phones for Climate Change Communication	2
Table 5.7: Respondents' Perceptions of Mobile-Based Climate Change Communication Strategies	2
Table 4.8: Adaptation action used by respondents to adapt to climate change in Tamale Metropolis	4



List of Figure

Figure 3.1: Map of Tamale Metropolis

52



LISTS OF ABBREVIATIONS

AI	Artificial Intelligence
CC	Climate Change
GDP	Gross Domestic Product
GHS	Ghanaian Cedi (currency of Ghana)
GSMA	Global System for Mobile Communications Association
ICT	Information and Communication Technology
IPCC	Intergovernmental Panel on Climate Change
IoT	Internet of Things
MTN	Mobile Telecommunications Network
M4D	Mobile for Development
NCA	National Communications Authority
NOAA	National Oceanic and Atmospheric Administration
SMS	Short Message Service
SIM	Subscriber Identity Module
UNCCD	United Nations Convention to Combat Desertification



CHAPTER ONE

INTRODUCTION

1.0 Background to the study

Mobile phones have also become a significant part of global communication, of particular importance to developing countries such as Ghana. Within recent years, the mass production and use of cell phones have revolutionized the way people receive, disseminate, and react to information. Mobile phone penetration is a factor that includes a range of measures such as the penetration of SIM cards as the ratio of SIM connections to population; unique subscriber penetration, defined as the number of distinct individuals who possess mobile phones; and access penetration for mobiles, considering individuals accessing mobile phones on a regular basis whether or not they own them (GeoPoll, 2024). These activities play a significant role in defining the depth and range of mobile communication in certain environments, such as the cities of the Tamale Metropolis.

Worldwide, the uptake of mobile phones has accelerated with varying regional factors promoting penetration levels. Although China and India lead in sheer numbers of subscriptions, low-income high-regional wealth regions, for example, parts of Europe and East Asia, have significantly higher per capita penetration levels. For example, Hong Kong achieved over 290% penetration in 2021 (Infobip, 2024), based on multiple SIM possession and smart device culture. Ghanaian penetration of mobile phones has also come a very long way. GSMA (2019) states that Ghana recorded the highest subscription of mobile phones in West Africa, where mobile connections have surpassed the population as a result of multi-SIM holding. There were approximately 38.95 million mobile connections in the country as of early 2024, and they maintained a penetration rate of more than 113% (GeoPoll, 2024).





Mobile phones, in the case of Tamale Metropolis, have become critical instruments for personal, business, and public communication. Mobile technology diffusion has penetrated large sectors such as agriculture, health, and education. Notably, such diffusion of technology holds immense possibilities for climatic change-related communication improvement. Climate change poses a significant threat to the urban centers of Northern Ghana, with Tamale facing persistent environmental stresses like unpredictable patterns of rainfall, flooding, and temperature variability. Such effects undermine livelihood, public health, and the urban ecosystem. In that regard, mobile phones can be employed as channels for early communication of climate information, which enhances informed decision-making by citizens in anticipation of or in reaction to environmental change.

Mobile phones facilitate climate change communication in a number of ways. To start with, they offer direct connectivity to weather forecasts, early warning systems, and agro-advisories. This is especially beneficial for the smallholder farmers along the peri-urban and rural fringes of Tamale, most of whom engage in rain-fed agriculture and are susceptible to shifting climatic trends. Through mobile notifications and mobile-enabled platforms, farmers can alter planting schedules or introduce preventive measures to neutralize the impact of extreme weather patterns. Second, mobile phones play a critical role in achieving financial inclusion. Financial products such as mobile money enable customers to access credit, savings, and insurance products, which can be utilized to invest in climate-resilient technologies such as irrigation systems or drought-resistant seeds (GSMA, 2024). This fiscal planning increases household resilience to climate shocks.

In addition, mobile technology further ensures that aid delivery is efficient. In the case of climate-related disasters, cash transfer through mobile phones has been an effective substitute for in-person delivery of aid, cutting down on delay and logistics expenses. The recipients can have the



assistance credited to them directly and decide how they utilize the money according to their immediate needs, which is empowering and context-sensitive. The use of mobile platforms also facilitates monitoring and feedback loops that are capable of enhancing the targeting and impact of climate response programs.

There are some of these benefits, but some challenges remain outstanding in the complete use of mobile phones in climate communication in Tamale Metropolis. One of them is the digital divide, particularly literacy and technological awareness. Although the majority of the population have access to mobile phones, a significant number of them only utilize a few aspects such as calls and text messages. Use of more sophisticated services like mobile applications or climate portals depends on awareness and digital literacy. It is also not affordable. Available power sources for charging devices, smartphones, and data service may be a barrier to frequent and active use among low-income residents.

A second challenge is a lack of local climate data integration in mobile platforms. National-level alerts or generic weather forecasts are not necessarily responsive enough to real local environmental hazards faced by the individuals residing within Tamale. Localized and culturally appropriate messaging, even in local language, is needed to make information both accessible and actionable. The immediacy of climate change adds an additional layer of complexity to the communications environment. Scientific opinion mirrors ongoing increases in world temperatures, as proven by observed modifications of weather, sea levels, and biodiversity. In Ghana, and Tamale especially, these effects already have consequences. Inadequate infrastructure, poor institutional capacity, and high-rate urbanization exacerbate exposure to climate-related hazards. Therefore, the function of communication in particular through cell technology becomes even more significant in awareness raising, adaptive behavior, institutional and community resilience.

Evidence indicates that although global warming is partially accounted for by natural factors, human activities such as greenhouse gas emissions are a major contributor (McKay, 2020). Escaping the trap of emissions will call for concerted efforts that harness available tools and networks. The pervasive and multifunctionality of cellular telephones place them in a natural starting point for such interventions. But, with the lack of education in human factors, trust in computer systems, integration of local knowledge, and fair access, the potential of mobile communication to lead action on climate may not be maximized.

1.2 Problem statement

Climate change continues to pose a significant risk to human health and environmental sustainability. Greenhouse gas emissions must be significantly reduced within the next ten years to avoid crossing the critical 1.5°C warming threshold, beyond which harm to ecosystems and livelihoods will become irreversible (IPCC, 2023). Low- and middle-income nations (LMICs) like Ghana are particularly vulnerable to such effects as they possess structural constraints in their adaptation and communication abilities (Eckstein et al., 2020).

Effective communication forms the basis of climate risk management through facilitating preparation, response, and anticipation of climate events by individuals and society. Mobile phone technology represents a very promising medium for climate change communication with real-time transmission capacity of alerts, local weather forecasts, and adaptation messaging (Donner, 2022). In Ghana, there has been significant penetration of mobile phones, especially in urban cities like Tamale Metropolis (GSS, 2021). But this growing access does not necessarily translate into effective climate communication.



One of the striking practical issues is the absence of infrastructure for the uninterrupted use of mobile technology in some areas of Tamale Metropolis. Being an urban settlement, some of the metropolis still have poor network coverage and unscheduled power access, which denies timely access to climatic information (Nikoi et al., 2024). Poor infrastructure generates gaps in communication that restrict the capacity of households to make informed decisions based on climate forecasts and weather patterns.

Additionally, the levels of digital literacy for some segments of the population are low. Some people, particularly those with minimal formal education, can barely do more than rudimentary things on mobile devices. This limits their ability to play with mobile apps, interpret climate messages, or use such information in a meaningful way (Amoako & Owusu, 2023). Inability to use simple communication structures and limited digital storage on the side of end-users can decrease the efficiency of climate services and mobile-based warnings. Another everyday issue is the influence of socioeconomic characteristics like income, education status, and type of employment on cellular phone adoption. Less affluent families are less apt to have smartphones or regularly buy mobile data, thereby creating climate service disparities (Mensah et al., 2022). These socioeconomic obstacles are usually neglected in communication plans, resulting in asymmetric access and limited engagement in climate risk management activities.

Theoretically, the current climate communication models lack user-centered functionalities like feedback systems, local knowledge systems, and sociocultural understanding of technology (Owusu & Teye, 2022). The underlying assumptions of most communication models are centered on technological accessibility at the expense of situational factors, hence restricting their use in intricate urban environments like Tamale. There is minimal theoretical foundation on how communities interact with mobile platforms for environmental data, and whether experience,

relevance, and trust at local levels influence their responsiveness. Furthermore, the measurement of communication effectiveness is still a methodological flaw. The majority of research assesses only coverage of mobile interventions but does not assess changes in behavior or long-term use of climate services (Boateng et al., 2021). This impedes the capacity to formulate strategies that not only offer information but also are action-oriented and situation-specific. From this perspective, this study examines mobile phone penetration within Tamale Metropolis and its function in enabling climate change communication.



1.3 Research Questions

1.3.1 Main research question

What is the extent of mobile phone penetration, and how does it contribute to enhancing climate change communication among residents of Tamale Metropolis?

1.3.2 Specific research questions

1. What is the level of access to mobile phone technology among residents in Tamale Metropolis?
2. How are mobile phones being used to access and disseminate climate change information in the metropolis?
3. What infrastructural and socioeconomic factors affect the effective use of mobile phones for climate change communication?
4. How effective are existing mobile-based communication strategies in promoting climate change awareness and adaptive responses in Tamale Metropolis?



1.4 Objectives of study

1.4.1 Main objective of study

To assess the extent of mobile phone penetration and examine its role in enhancing climate change communication among residents of Tamale Metropolis.

1.4.2 Specific objectives of study

1. To determine the level of access to mobile phone technology among residents in Tamale Metropolis.
2. To examine how mobile phones are being used to access and disseminate climate change information in the metropolis.
3. To identify the infrastructural and socioeconomic factors affecting the effective use of mobile phones for climate change communication.
4. To evaluate the effectiveness of existing mobile-based communication strategies in promoting awareness and adaptive responses to climate change in Tamale Metropolis.





1.5 Justification of Study

The growing menace of climate change still threatens communities across the world, with low- and middle-income regions like northern Ghana being disproportionately affected. Tamale Metropolis, located in the savannah ecological zone, is especially at risk because of its dependence on rain-fed agriculture, poor infrastructure, and vulnerability to climate-related hazards like floods and prolonged rains. Here, access to timely and accurate climate information is important in allowing local people to prepare for, anticipate, and respond to threats to their livelihood and health.

The justification as to why such research is also carried out is due to the fact that evidence-based planning and intervention by the policymakers, the development agencies, and climate communication practitioners must be guided. Without some data regarding mobile phone penetration and the effectiveness of mobile-based strategies in this specific urban locale, interventions for enhancing climate resilience will not reach those who are most vulnerable. In addition, determination of the precise challenges either technical, economic, or social that impact on mobile communication adoption can direct the design of specific interventions like site-specific mobile application or training programs at the local community level to widen communication channels and facilitate informed responses to climatic variability.

Besides scholarly uses, this research also has organizational implications for institutions like the Ghana Meteorological Agency, the National Disaster Management Organisation (NADMO), and other non-governmental stakeholders interested in Tamale's environment. It will present situational data required to maximize the provision of climate services through mobile platforms, improving citizens' responsiveness to early warnings and adaptation recommendations in the end.

1.6 Definitions of key terms

Mobile Phone Penetration: Mobile phone penetration is the percentage of individuals in a particular set of people who have or are able to access a mobile phone. It encompasses basic feature phones as well as smartphones and is employed as a measure of the availability and extent of mobile communications technology. It is here that it has been applied to describe the level of usage and exposure of mobile phones among residents of Tamale Metropolis for general purposes and those climate change-related.

Climate Change Communication: Climate change communication is the sharing and dissemination of information for the causes, effects, and adaptation options of climate change. It aims at raising awareness, triggering behavioral change, and aiding decision-making at the community and individual levels. It can be used to refer to the means of communication of weather information, adaptation tips, and environmental education by the old mobile phones in the context of Tamale Metropolis.

Socioeconomic Determinants: Socioeconomic determinants are social and economic determinants that affect the behavior of individuals and exposure to resources. They include income, educational attainment, employment, and standard of living. Socioeconomic determinants in this research are taken into account in relation to the degree to which they impact the ownership and utilizable use of mobile phones in accessing climate change information in Tamale Metropolis.

1.7 Organization of Study

The first chapter of this research has an introduction that gives the general theme and direction of the research. It offers background to the research, presents the research problem, posits the research questions, and establishes the general and specific objectives. It also outlines the significance of the research and defines definite terms that are used in understanding the research topic. Chapter Two introduces literature on climate change communication and mobile phone penetration from local and global research to provide a conceptual and theoretical background for the study. Chapter Three gives the research design, sampling procedures, data collection instruments, and data analysis techniques used in the study. Chapter Four states the findings of data analysis and outlines the findings with regard to the research questions and objectives. Last but not least, Chapter Five summarizes the key findings, concludes, and suggests for practice, policy, and future research based on the study findings.



CHAPTER TWO

LITERATURE REVIEW

2.0 Introduction

This chapter provides a literature review that is pertinent to the study, divided into three broad sections. The first section analyzes theoretical models that guide knowledge of adoption of mobile phones and climate change communication. The second section is a review of empirical research that sheds light on adoption of mobile technology, information exchange, and adaptation mechanisms to climate change, with focus on contexts like Tamale Metropolis. The third section presents the conceptual framework of the study.

2.1 Technology Acceptance Model

The Technology Acceptance Model (TAM), as initially presented by Davis (1989), is one of the most frequently used theoretical frameworks describing individuals' adoption and utilization of new technology. TAM focuses on two central constructs, namely perceived usefulness and perceived ease of use. These affect an individual's attitude towards using technology, which in turn affects their behavioral intention and actual behavior. The model has been applied across different contexts to predict and explain technology adoption, and it is hence the relevant framework for explaining the penetration of mobile phones in Tamale Metropolis and their impact on climate change communication.

Perceived Usefulness here refers to how much citizens perceive that the use of mobile phones enhances their capacity to receive, understand, and respond to climate change information. For rural farmers and urban dwellers in Tamale Metropolis, mobile phones have the potential to be instrumental tools in accessing timely weather forecasts, obtaining climate adaptation information,





and linking with extension services. Provided that mobile technology is seen as an invaluable tool for all of these uses, its users should utilize it as part of their daily decision-making practices.

Perceived Ease of Use captures the extent to which citizens find it easy and convenient to use mobile phones for these climate-related tasks. It encompasses physical ease of use of the device, clarity of received messages, and ease of use of mobile applications or platforms providing climate information. In consideration of the fact that some of the users in Tamale Metropolis could have differing levels of digital literacy, simplicity is at the forefront. Unless technology is perceived to be too intricate or ambiguous, even the most beneficial of information can be unused.

Despite possessing some merits, TAM is flawed and needs to be recorded. The model is more concerned with individual cognitive decisions towards technology and does not provide enough regard for extrinsic considerations like infrastructural limitations (e.g., network availability, electricity supply), socioeconomic impediments, or cultural norms that control technology utilization in actual environments (Venkatesh & Davis, 2000). For instance, in Tamale Metropolis, intermittent existence of mobile networks or no power can discredit perceived usefulness and ease of use despite an individual's intentions to utilize technology.

Second, social context contributes to acceptance of technology. Source credibility for climate data, social norms for mobile phone use, and collective action all have the potential to impact adoption patterns. Although these are not necessarily modeled within TAM, their effect needs to be acknowledged to allow for significant interpretation of findings.

Use of TAM in this research offers a structured means of evaluating the relationship between technology and individuals through climate change communication using mobile phones. It offers a means of examining how the population of Tamale Metropolis perceives the advantages and

constraints of using mobile phones in their climate information dissemination, and this offers insight into possible constraints and enablers of efficacious climate information communication.

2.2 Definitions of Key Terms and Concepts

In analyzing the extent of mobile phone penetration and its influence on climate change communication in Tamale Metropolis, there must be a clear understanding of key concepts of mobile phone penetration, climate change communication, and climate change. The terms, though in common usage, are prone to interpretation depending on the technologies, social, and institutional environments they are being examined in.

2.2.1 Mobile Phone Penetration

Mobile Phone Penetration has traditionally been operationalized as the number of persons or households that own or have access to a mobile phone (International Telecommunication Union, 2015). It has been quantified across the globe and has given the impression of being an easy measure of technological diffusion. This is reductive in its coverage of the access complexity in places like Tamale, where infrastructure problems, economic inequalities, and digital literacy converge to determine useful use. Whereas most of the reports for developed nations correlate high penetration rates with increased connectivity and effectiveness in communication (Pew Research Center, 2018), Sub-Saharan Africa's is a more complex scenario. For example, as is evident from a study in Ghana, physical ownership of mobile phones doesn't always translate to consistent availability of networks or even frequent use for information-seeking purposes, particularly within rural or poor societies (Nyarko & Boateng, 2019). This translates to the fact that penetration should not only be thought of as access but also in the sense of the quality, consistency, and functionality of mobile connectivity, and the ability of the user to utilize it for certain uses such as climate information exchange.



2.2.2 Climate Change

Climate change is most appropriately defined as extreme, long-term changes in mean weather patterns, long linked to human activities that increase atmospheric concentrations of greenhouse gases (IPCC, 2021). Such a definition, though world-wide accepted, is not without differences between disciplines, geographies, and timescales. Climate change has previously been in existence in a more constrained sense, defined largely in terms of natural climate system variability. Yet, the majority scientific opinion acknowledges anthropogenic emissions—particularly carbon dioxide, methane, and nitrous oxide—when they acknowledge the majority cause, changing the Earth's climate balance (Stern, 2007).

Most importantly, climate change is not just temperature or rain variation but involves a system of multidimensional environmental perturbations such as sea-level rise, more frequent extremes of weather events, and changing ecosystems (Adger et al., 2009). This multidimensionality necessitates interdisciplinary examination to comprehend, since physical science cannot account for the social, economic, and cultural parameters forming the shapes in which communities experience and react to the experience of climate.

In contrast to high-income nations where mitigation remains the center of climate policy and debate, certain Sub-Saharan African countries—Ghana being one—are concentrated on adaptation (Niang et al., 2014). The difference is a result of diversity in emission patterns, degrees of economic development, and institutionality. While the industrialized world struggles with reduction of emissions, low-income economies like Ghana are facing current vulnerabilities like drought, flooding, and hunger, which erode livelihoods and perpetuate poverty (AfDB, 2019).

Notably, in the case of Tamale Metropolis, climate change is experienced as heightened uncertainty in rainfall and temperature fluctuations impacting agricultural production, water



supply, and health (Issifu et al., 2020). Local experience of climate change may, however, vary from scientific interpretations. Citizens can perceive environmental change with the model of customary ecological knowledge and attribute changes to religious or cultural forces and material natural occurrences (Orlove et al., 2010). One therefore wonders, then, how terms used in labeling climate change are refracted through epistemologies and cultural knowledge at the local level—a key determinant for the willingness of communities to adopt climate adaptation strategies.

In addition, while the majority of the international literature tends to equate climate change as a homogeneous threat, empirical evidence registers high heterogeneity triggered by institutional quality, policy regimes, and sectoral dynamics (Obeng et al., 2017). Institutional poor performance in climate response coordination and risk information dissemination, for instance, often triggers mixed messages and circumscribed options that have direct impacts on local adaptive capacity (Addo et al., 2020). This organizational culture is at the center of defining how climate change is conceived, talked about, and responded to in places such as Tamale.

This heterogeneity in the definition of climate change is therefore a byproduct of more general theoretical disagreements on the social construction of environmental danger. While paradigms of natural sciences emphasize objective measurement and predictability, social science paradigms emphasize the cultural, economic, and political contingency of representations of climate change (Zhou et al., 2018). Of most relevance to the African example, the tension between scientific accountancy and local knowledge is a persistent theme, which impinges both on policy design as well as on adaptation at the local level.

2.2.3 Climate Change Communication

Climate Change Communication is conventionally imagined in the field of risk communication, which has been described as the intentional release of scientific information with the aim of

inspiring awareness and behavioral change to environmental hazards (Moser, 2010). Conventional models conceive communication as a unidirectional process where information is transferred from experts to the public. But this model is highly criticized, especially in the developing world where socio-cultural context and trust in institutions influence reception and uptake of messages. More specifically, in Africa, indigenous knowledge patterns interacting with existing scientific discourse complicate communication dynamics (Ziervogel et al., 2014). This inconsistency calls for an alternative climate change communication as a participatory and locally embedded process instead of a delivery of facts. Therefore, the mobile phone is a potentially groundbreaking vehicle for multi-directional communication flows, with localized message modification sensitive to culture experience and values. However, such a form of communication depends on how various languages are framed, on literate contexts, and on sources' credibility, all being vastly diverse in the Tamale Metropolis (Awotide et al., 2016).

2.3 Mobile Phone Penetration: Global and Local Perspectives

Mobile phone penetration as a term conveys the degree to which mobile telephony has penetrated across populations and is being used as a proxy for access to communication technology. To the degree that it has become mainstream usage among academics and policy-makers, defining and measuring mobile phone penetration brings out nuances that are reflective of technological, social, and economic dynamics. Penetration is typically measured globally in terms of active mobile subscriptions per 100 residents—a seemingly direct measure (GSMA, 2020). Yet this measure masks enormous disparities in the way mobile phone use translates into effective connectivity, membership, and digital participation.

Critically, although mobile subscriptions offer an easy quantitative measure, they do not capture qualitative measures like device sharing, service diversity consumed using mobile devices, or

network coverage inequalities (Donner, 2008). Subscription levels are likely to be over 100% in rich nations, indicative of the ownership of multiple SIMs, but this is not necessarily indicative of universality or equality (Pew Research Center, 2019). In contrast, several low- and middle-income nations, such as the countries of Sub-Saharan Africa, have lower but increasingly appreciable levels of penetration, one subscription being close to one person, illustrating the measure's asymmetrical interpretability.

Substantively, the methods of measurement for mobile phone penetration are not standardized, varying from national telecommunication reports, household surveys, to stand-alone field investigations. Reliance on government statistics, typically collected by operators or regulators, introduces institutional biases; there is a tendency to over-report the number of subscribers in a bid to report growth in the market or investment prospects (Heeks, 2010). Conversely, survey-based approach highlights usage patterns but suffers from respondent accuracy and sampling bias. This dualism is problematic for researchers trying to pinpoint actual mobile phone access, especially in rural or marginalized settings where there is widespread informal sharing and intermittent connectivity (Aker & Mbiti, 2010).

Theoretical arguments on mobile penetration also overlap with digital divide research. While some scholars place mobile phones in the category of democracy tools that transcend infrastructural shortcomings (Donner, 2008; Qiang et al., 2011), others express reservations about over-projecting their potential without consideration of socio-economic and cultural limitations (Warschauer, 2003; James, 2017). Of particular importance in the developing economies is that gender, income, education, and location strongly mediate access and use (Hilbert, 2011). For instance, rural Sub-Saharan African mobile phone ownership is often linked with rising socio-economic status and



male household leaders, contrary to reports of universal access (Gillwald et al., 2010). Penetration rates thus have to be seen within broader structural imbalances that underlie technology take-up. Empirical differences between regions also make interpretation more complicated. While Asia saw quick mobile development with profound penetration into rural areas (ITU, 2019), most African nations see slow gains in penetration in the face of the challenges of infrastructure and regulatory regimes (GSMA, 2022). In part, this difference is attributed to policy regimes and institutional quality. Those nations with active universal service policies, contestable markets, and network infrastructure investment will enjoy greater penetration (World Bank, 2016). Meanwhile, regions plagued by regulatory bottlenecks or political instability often lag despite demand (Obeng-Odoom, 2013).

In the African continent, current research highlights how mobile penetration is no longer simply a matter of availability but is also closely associated with social practices and cultural acceptability (Mutsvairo, 2016). For instance, shared communal conventions of device sharing, reliance on technology, and digital literacy impact the way penetration is manifested as functional tools of communication (James & Versteeg, 2017). It consequently suggests the necessity of shifting the conceptualization of mobile penetration away from mere subscription rates to more qualitative assessments of significant uses and empowerment.

This is a problem: how can policymakers and researchers quantify and qualify mobile phone penetration in such a way that it is able to sufficiently capture its impact on social change? New research supports multi-dimensional approaches that combine quantitative subscription data with qualitative measures like use intensity, digital literacy, and perceived usefulness (Pew Research Center, 2021; Hilbert, 2019). Such combined strategies are especially important in the evaluation of the ability of mobile phones to facilitate climate change communication in such environments

as the Tamale Metropolis, where infrastructure deficits are outweighed by information demand imperatives.

2.4 Trends in Mobile Phone Ownership and Access Globally and in Ghana

Mobile phone use and ownership have been historically unprecedentedly growing during the past two decades, reconfiguring the patterns of communication, information dissemination, and socio-economic behavior worldwide. Mobile technology's propagation globally is usually referred to as a revolutionary power driving connectivity and digital divides through the facilitation of inclusive development (ITU, 2022). However, patterns of access and ownership reveal complex regional differences and shifting socio-technical patterns that are in defiance of the simplistic conception of world connectivity.

At the global level, mobile phone penetration has evolved from a 2000s niche use to nearly blanket coverage of most areas of the world, the International Telecommunication Union (ITU) reporting in 2023 more than 67% global mobile subscription penetration. This is in accordance with the diffusion of innovation theory that confirms speeding-up technology adoption as soon as costs and network coverage reach tipping points (Rogers, 2003). However, the pace and character of adoption vary significantly between and within nations, based on socio-economic levels, rural-urban division, and policy contexts (Warschauer, 2003).

Of more importance, in developed nations, mobile phone ownership frequently means the ownership of high-quality smartphones and broadband Internet, enabling advanced applications such as mobile banking, telemedicine, and e-government services (Smith, 2017). Conversely, vast parts of the developing world still experience pervasive feature phone basicness, limited data access, and affordability ceilings (Donner, 2015). This divergence is reflective of the reality of an



existing "second-level digital divide" where device ownership does not necessarily mean effective access or ability (van Dijk, 2006).

In Sub-Saharan Africa, mobile phone uptake has been especially intense. With the region having traditionally fallen behind in telecommunication infrastructure, mobile telephony has bypassed fixed-line structure, penetration levels exceeding 80% in most nations by 2022 (GSMA, 2023). Ghana is a typical example of the fast uptake; National Communications Authority (NCA) statistics show mobile subscription levels rising to over 140% by 2024, a rate which takes multiple SIM ownership and increasing market competition into consideration.

Yet, the sheer numbers conceal interrelated inequalities and situational barriers. Various studies indicate that mobile phone use in Ghana is still stratified along urban-rural, gender, and income divisions (Aker & Mbiti, 2010; Boateng & Narteh, 2016). For example, city dwellers tend to own more smartphones fueled by improved coverage of networks and access to electricity, whereas rural dwellers utilize plain phones with minimal functionality (Mensah, 2019). This city-countryside dichotomy is not Ghana-specific but depicts wider trends within Sub-Saharan Africa (Muto & Yamano, 2009).

Second, while some literature hails mobile reach's positive socio-economic effects, e.g., access to more market information, health communication, and social networking (Jack & Suri, 2011), empirical evidence portrays nuance. Precisely, institutional quality and policy regimes play a mediating function of utmost significance. Where regulatory environments are stable and digital inclusion policies are in place, mobile adoption is better translated into development gains (Kenny, 2017). Where investment in infrastructure is lacking or where governance is poor, though, mobile technology can actually exacerbate differences or consolidate power relations (Gillwald et al., 2012).

Methodological variation between studies also makes comparison difficult. Quantitative surveys tend to report high levels of ownership on the basis of subscription rates, whereas qualitative findings identify issues of shared use, sporadic access due to cost, and sociocultural impediments to use—particularly women and minority groups (Donner & Gitau, 2009). This variation poses key questions about the sufficiency of existing measures and the necessity for more sophisticated measures that reflect meaningful access over ownership.

Mobile telecom market dynamism is also responsible for altered patterns. While early adoption cycles were driven by the affordability of handsets and primitive connectivity, recent years have witnessed a trend of emphasis on data services and penetration of smartphones gaining momentum, driven by international technology leaders and indigenous innovation hotspots (GSMA, 2023). In Ghana, the growth of cheap smartphones and mobile money has been spurring new forms of contact, yet rural infrastructural shortfalls continue as stubborn challenges (Yeboah & Appiah, 2021).

2.5 Mobile Phone Penetration Rates in Urban vs. Rural Areas, with Emphasis on Northern Ghana

Mobile phone penetration, also known as cellular access or adoption, does not just quantify the spread of cellular telephones but also usage patterns, ownership rates, and incorporation into socio-economic life. As there is growing ubiquity of cellular technology to global trends, beneath the statistics there remains a crude difference between city and country societies—difference glaringly apparent in low- and middle-income nations. The situation in northern Ghana provides a rich soil for examining these tensions since it presents a history of infrastructural underprivilege, spatial disparities, and socio-cultural idiosyncrasies.



Diffusion of Innovations theory (Rogers, 2003) has been the best place to start analyzing technological uptake for decades. It suggests that innovations—like cell phones—are embraced step by step through social structures, under the influence of modes of communication, time, and perceived innovation characteristics. Such a diffusion model on a linear scale, however, ignores structural hindrances such as variations in income, levels of education, and gender-based power relations (Warschauer, 2004; Donner, 2008). In the urban environment, where infrastructure and income are generally more robust, there is nearer correspondence between the theory and actual takeup of mobile phones.

Latin American and Southeast Asian empirical studies underpin these discrepancies. Brazil, for instance, has seen availability of mobile phones in favelas induced by extralegal market agents and shared ownership practices (de Souza e Silva & Frith, 2012), whereas Cambodian villages see low literacy and electricity availability strongly limiting use (Zainudeen et al., 2010). These results are reinforced in sub-Saharan Africa, where the widespread coverage extension of mobile telephone services has the propensity to conceal structural inequalities underlying.

Although the story of "mobile leapfrogging" in Africa has been largely hailed—quoting that more than 80% of adults in nations like Kenya and Nigeria own a mobile phone—such strength could be deceptive (Aker & Mbiti, 2010). Mobile penetration is not synonymous with access to all. In Ghana, local estimates can report more than 120% of mobile subscriptions against the population since individuals hold multiple SIMs (NCA, 2023), yet such a measure conceals disparity between urban areas like Accra or Kumasi and rural Northern, Upper East, and Upper West regions.

The availability of mobile telephones in northern Ghana is brokered through intersecting income, network coverage, gender, and language axes. A research conducted by Asaka and Debrah (2021) brings to light that despite mobile phone ownership in Tamale city being fairly good, rural



communities in the outskirts still lack a good signal strength, network disconnection frequently, and scant electricity sources to recharge their phones. Similarly, Owusu and Salifu (2020) add that rural consumers have the tendency of using mobile technology in ad-hoc manners—utilizing mobile phones for voice calls only, with little use of SMS or internet services because of concerns about digital literacy and cost.

Cities will likely gain from competitive telco markets, greater population densities that make it worth investing in mobile towers, and greater availability of ancillary services like repair outlets and mobile money agents (James & Versteeg, 2007). Low settlement density and bad road conditions in rural areas weaken the business case for telco operators to extend. This has generated what some analysts have described as "pockets of disconnection" (Gomez & Pather, 2012)—locales where mobile phone use is aspirational more than it is functional.

There is a new social pattern of adaptation in northern Ghana, by surprise. Mobile phones can be shared within a household or among groups of friends, a pattern dissimilar from the Western pattern of individual ownership. This raises questions about whether existing metrics for gauging mobile penetration are sufficient. Is penetration merely a function of SIM card ownership, or should it also encompass shared use, quality of service, and functional capability? This definitional ambiguity makes cross-country comparisons as well as policy design difficult.

2.6 The Role of Mobile Technology in Disseminating Climate Information

Mobile technology use in climate communication has changed the tempo, range, and degree of climate information dissemination across contexts. Whereas the function of mobile phones as agents for promoting environmental awareness and adaptive decision-making is widely recognized, it is the mechanisms by which such technologies effectively influence behavior in contexts bounded by infrastructural or information asymmetries that are eminently a topic of

controversy among academic commentary. Worldwide, the contribution of mobile technology to climate communication is generally described within the widest paradigm of information and communication technologies for development (ICT4D). The research from technologically advanced societies has examined the use of early warning systems through mobile, weather forecasting applications, and locational alarms in mitigating climate vulnerability (Rogers & Tsirkunov, 2011; Meier, 2015). They are typically greeted with institutionalized data infrastructures and weather networks, which provide guarantee to the accuracy and timeliness—two aspects highly associated with public trust and acceptance (Hammer et al., 2019).

But this rosily presented vision is leavened by accounts elsewhere, in which mobile-enabled climate services are beset by access, localization, and adoption constraints. Thus, while mobile weather alerts have taken off in rural India, success relies substantially on rates of literacy, local-language enablement, and users' capacity to make prognostications actionable (Mittal & Mehar, 2016). This calls into question the extent to which functional communication can be ensured through mobile access in isolation, or must be supplemented by embedded socio-cultural and educational structures.

In Sub-Saharan Africa, where penetration of mobile phones has accelerated exponentially in the past two decades, the potential of mobile technology for climate communication is particularly relevant. Mobile phones have become a critical instrument in bridging the intermediary function between official climate information and grassroots-level response, particularly for farmers, herders, and fisherfolk who live and subsist based on seasonal pointers (Fafchamps & Minten, 2012). But even so, the success of mobile platforms is uneven, dependent on infrastructural differences, regulatory settings, and heterogeneity in users.



Whereas nations like Uganda and Kenya have established fairly sophisticated mobile agro-advisory tools—like iCow and Farm Radio—they are likely to benefit targeted groups of users and hence ensure digital exclusion for the elderly, the illiterate, or women (Aker & Ksoll, 2016). In Ghana, such interventions as the mobile alert system of the Ghana Meteorological Agency and Esoko have been observed to enhance seasonal forecast and weather information access. However, it is extremely variable by region, institutional actor trust, and assessment of message validity (Codjoe et al., 2014). This variation requires context-responsive design, and participatory communication strategies that ensure technological content is adapted to conform to local systems of knowledge.

One of the main conflicts in the literature is between information transmission and behavior change. Although mobile phones are commonly used to transmit information, comparatively few studies look at whether and how such information leads to concrete adaptive actions. For instance, Latin American and Southeast Asian studies indicate that two-way communication channels where the user is allowed to query, give feedback, or report conditions are more effective in enforcing adaptive behaviors compared to one-way message systems (Vincent et al., 2018). Contrarily, a majority of the African mobile climate communication space is still predominantly top-down with little or no adaptation or user interaction.

More than anything else, in the African case, message framing and trust are drivers. Tall et al. (2014) conclude that even true climate information can be disregarded if it is felt as irrelevant or if the communicator of the message lacks credibility. This underlines the role of intermediary actors—extension agents, radio announcers, or credible NGOs—who have the ability to mediate between abstract climate messages and local meaning frames.



Theoretically, the use of mobile technology to deliver climate information has been validated by the Technology Acceptance Model (TAM) and its extensions that assume perceived ease of use and perceived usefulness to be core determinants of adoption of technology (Davis, 1989). The models tend to ignore contextual factors such as institutional trust, social networks, and cultural norms that may moderate or even replace rational utility calculations. Conversely, socio-technical systems theory and practice-centred approaches believe that technology is not necessarily adopted, but developed simultaneously with ordinary practice, policy infrastructures, and user participation (Orlikowski, 2000).

Empirically, most of the literature remains short of longitudinal and mixed-methods analyses more appropriate to track the dynamic of climate communication through mobile-based media. For instance, while randomized control trials are possibly able to quantify short-term effects on knowledge or behavior, they are not as well-suited to track the recursive, negotiated process whereby individuals and communities internalize, reinterpret, or dismiss information. Especially in contexts of fragile environments where climate communication would be required to vie with overlapping matters of poverty, political instability, and environmental uncertainty.

2.7 Types of Climate Change Information Communicated via Mobile Phones

The spread of cell phones across urban and rural environments in developing economies has brought with it a reordering of the modalities through which climate information is accessed, interpreted, and responded to. At the theoretical and empirical levels, cell phones are significant media for the communication of different types of climate information—e.g., weather forecasts, early warnings, and adaptation advice. However, the nature, usefulness, and adoption of information are significantly different across geographies, institutional settings, and capacities.



At a global level, weather forecasts are the most widespread type of climate information available on mobile phones. They are more likely to be hyper-local, forecast-driven, and overlaid with high-end modeling software such as satellite imagery and AI-based analysis (Hewitt et al., 2012). Conversely, in low- and middle-income nations—predominantly Sub-Saharan Africa—weather forecasts that are broadcast via mobile phone are less accurate and less frequent due to underdeveloped infrastructure as well as poor coordination between meteorological organizations and mobile phone companies (Tall et al., 2014). And then there is the question of reliability: although forecasts enable farmers and small-scale fishers to make decisions, imprecise or overly general information may dissipate confidence and validity.

Early warning systems are another vital type of climate information communicated through mobile technology. They are highly applicable in areas that have sudden-onset disasters like floods, droughts, or storms. The theoretical relevance of mobile phones as an unplanned alert system is very valid in the literature on disaster risk communication (Glade & Nadim, 2005). Practically, their suitability depends on institutional coordination and last-mile connectivity. For example, in Ethiopia and Kenya, mobile-based early warning drought information has dramatically enhanced response times and mitigated livestock loss (Birkmann et al., 2019). On the other hand, similar systems in much of West Africa have struggled with problems resulting from poor linguistic localisation, network coverage, and absence of integration into local governance models (Aker & Mbiti, 2010). This contrast is representative of a wider contradiction between socio-political uptake and technological promise.

Adaptation guidance, the third of these categories, will probably prove to be most challenging for mobile-mediated climate information. Warnings or predictions may just have to be relayed, but adaptation guidance involves not only the dissemination of information but a change in behavior—



usually where there is resource scarcity, low literacy levels, or ingrained tradition. It has resulted in the emergence of SMS-based extension services providing season-specific advice on drought-tolerant crops, planting strategies, and water management. Whereas pilots in Senegal and Uganda have succeeded (Mittal & Mehar, 2016), longer-term trials pose scalability and uptake challenges. In Ghanaian settings, moreover, mobile-phone-based adaptation messaging generally fails to consider the gendered access to technology, cultural risk perceptions, and heterogeneity of climate effects within ecological zones (Doss et al., 2011). This differentiation makes it harder to assume digital transmission by itself will see climate adaptation. In theory, the theory of diffusion of innovations (Rogers, 2003) provides one eye through which mobile-based climate information delivery might be viewed. It suggests rural community early adopters are key to bringing new means of communicating to the mainstream. But subsequent studies contradict the applicability of such a framework to climate communication, contending that credibility of message sources, perceived climate vulnerability, and existing exposure to environmental messages could be more useful predictors than innovation traits in themselves (Tschakert & Dietrich, 2010). In contrast to the individualist approach, institutional models should focus on the function of policy, regulatory regimes, and co-ordination among multiple stakeholders. For example, whereas India's mKRISHI system has succeeded courtesy of fruitful government-private partnerships, their Ghanaian counterparts have failed due to fragmentation of institutional mandates (FAO, 2018).

In an African setting, the human aspects of communication—language, proximity, and interactivity—are more significant than technical issues. Drawing from Nigeria and Tanzania, evidence indicates that two-way communication styles like call-in radio programming and SMS reminders are more effective in inducing understanding and behavior change compared to one-

way short text messages (Barrett et al., 2017). This innovation renders assumptions regarding efficiency problematic: what is technically efficient is not necessarily efficacious locally.

2.8 Mobile-Based Climate Communication Initiatives in Ghana and Sub-Saharan Africa

The mobile telephony-climate change adaptation interface in Sub-Saharan Africa is an uneven but dynamic reality. Whereas global discussion of climate information services increasingly highlights the potential of digital technologies (World Bank, 2016), the application of mobile phones as media for climate communication in low-capacity contexts remains susceptible to conflicting institutional, socio-economic, and infrastructural limitations. In Ghana and the wider regional context, mobile-based innovations are becoming key facilitators of information flows between technical producers of climate information and local communities, but outcomes are very variable depending on contextual and structural determinants.

More and more Ghanaian mobile climate services (MCS) are embracing this trend. For instance, the Esoko platform, originally created to provide farming price data, now also provides weather information and climate notifications for farmers (Nyantakyi-Frimpong & Bezner Kerr, 2015). Esoko provides hyper-local weather forecasts and drought notifications via SMS and voice calls in local languages and can be utilized for planning planting and irrigation. While it has differed in performance, its performance has remained inconsistent. Pilot outcomes indicated enhanced readiness and yields for the target population, but research has established that adoption remained mainly by smartphone-accessible male farmers and formal networks (Carr, 2014). The matter of concern is how inclusive climate communication has extended through mobile-based strategies, especially among women, illiterate populations, and resource-poor farmers who experience the worst impacts of climate.





In the same vein, the Farmerline program, which works in Ghana and other West African nations, offers voice-based climate information as well as training modules in more than 15 local languages (Owusu et al., 2018). In contrast to SMS-based platforms, Farmerline's voice communication is designed to overcome literacy limitations. However, the success of these kinds of platforms is not just in message content and form but also trustworthiness and local relevance. Some readers read or ignore climatic reports that are pulled from indigenous knowledge systems, and this creates a space of tension between external scientific narrations and everyday life.

Compared to the relatively advanced mobile agricultural setting of Ghana, there are varying levels of advancements in other Sub-Saharan nations. For example, Kenya has a platform and M-Farm initiative, with real-time market and climate information, more incorporation of geospatial analysis, and customized advisory services (Mittal & Mehar, 2016). The Kenyan example, used in the classical tradition as a model, illustrates how policy incentive, donor support, and private sector investment can trigger innovation. But it is exceptional. Poor infrastructure, limited digital literacy, and a lack of state-market integration still dampen the scalability and sustainability of mobile-based communication platforms in Burkina Faso, Malawi, and Sierra Leone, among several other countries (Vincent & Cull, 2014).

The achievements of mobile-led climate communication must be put into perspective, then. While supporters contend that the technology puts people on the "same informational page" and closes the knowledge gap in rural relative to urban areas (Donner, 2015), others warn against technologically determinist strategies. In reality, access to mobile services is never uniform. Owning a mobile does not ensure effective use; gendered norms, phone sharing, language, and unstable networks frequently compromise access (Huyer, 2016). In addition, the knowledge asymmetry in climate where science bodies have epistemic power could restrict the acceptability

of local societies with their own explanations and perceptions of weather variation hardly ever being considered.

Another area of complexity lies in message delivery and design. According to research, message frequency, tone, and format influence user behavior change and engagement (Tall et al., 2018). To illustrate, overly technical or vague warnings will be ignored, and overly urgent warnings have the potential to generate alarm rather than well-informed response. This has created increasing demand for co-designing messages with the end users, something that is not yet widely practiced in most West African settings.

Notably, government and regulatory structures also decide outcomes. In Ghana, the Ghana Meteorological Agency (GMet) is principally responsible for producing forecasts but is hindered from effectively partnering with telecom operators and NGOs by finance, bureaucratic resistance, and coordination (Ampadu et al., 2020). In others, the gap between national climate information systems and mobile platforms results in replicated efforts or competing messages—undermining credibility and user trust.

The scholarship accordingly promises and cautions. Although cell phones have unleashed new frontiers of real-time, scalable, and localized climate talk, their success hangs on an interdependent web of social, institutional, and technological configurations. The plurality of efforts in the region highlights the importance of contextual adaptation rather than replication. Platforms that tap into local knowledge, are sensitive to gender and literacy relations, and integrate users in message production are likely to lead to sustainable consequences. These approaches, however, require greater investment in technology and human and institutional capacity.



2.9 Infrastructural Factors Influencing Mobile Phone Use for Climate Communication

The application of mobile phones to discuss climate is rooted in infrastructural environments that condition both accessibility and usability. On the global South, and in Sub-Saharan Africa specifically, the structural environment of which the mobile technology commands from network availability and accessibility to the provision of electricity to price systems has direct consequences in the ways through which climate information arrives, is interpreted, and responded to

Network Quality and Coverage

The infrastructure backbone, which underlies mobile communication, is paramount in any such deployment of mobile technology for climate change communication. Quality and coverage of networks provide the necessary foundation upon which the entire process of information transmission is based. However, while cell phones become increasingly ubiquitous throughout the Global South, there remain vast disparities in cellular networks' spatial and functional extent, as regions like the rural and peri-urban Tamale Metropolis continue to be structurally confined.

At the international level, mobile infrastructure investment has been widely quoted as a change driver in achieving climate shock resilience (Donner, 2008; ITU, 2020). With mobile phones, real-time weather alert, early warning, and information on adaptive practices are disseminated. This depends on having access to trustful connectivity. Under urban and high-income contexts, fourth-generation (4G) or fifth-generation (5G) connectivity has supported high-quality multimedia-based climate communication. Conversely, northern Ghana and much of the rest of Sub-Saharan Africa continue to lack basic second-generation (2G) coverage and intermittent availability (GSMA, 2022).

Although mobile network operator (MNO) infrastructure installations have enhanced national data, disaggregated information typically illustrate a dramatic digital divide. In the Tamale

Metropolis, for example, network congestion, signal inconsistency, and tower coverage unevenness limit the capacity of mobile phones to serve as climate communication tools. Boateng and Owusu (2021) conducted a study that uncovered serious signal blackspots in rural towns around Tamale, and even in the city, quality of service differed immensely between neighborhoods. Such heterogeneity prevents access to weather information in a timely manner and discourages the use of digital systems as reliable information sources.

Additionally, the focus by the telecom companies on profit-maximizing urban markets has the tendency of resulting in under-serviced peri-urban and rural areas (Aker & Mbiti, 2010). This indicates an underlying institutional and policy-level issue: how much is the liberalized telecommunication regime in Ghana encouraged to ensure equal infrastructure allocation? While public-private partnerships have been suggested as a solution (World Bank, 2019), their application has been patchy and poorly tracked. Infrastructural deficiencies are, therefore, more than mere technical shortcomings; they are indicators of governance decisions, regulation permissiveness, and an uneven policy environment.

To this infrastructural pessimism, researchers cite the establishment of community-owned or decentralized communication networks as second-best alternatives. For instance, trials of low-cost, solar-powered cellular masts in certain Kenyan and Ugandan regions have shown how to sidestep classic infrastructure limitations with ingenuity (Murphy & Carmody, 2015). Such approaches are poorly implemented in Ghana, at least partially because of institutional fragmentation and unavailability of local technical expertise.

Empirically, network quality and the dynamics of climate communication are nonlinear. While there is a need for greater coverage, this is in itself inadequate. As Madon et al. (2016) classified it, the use of mobile platforms to disseminate public information effectively also relies on



trustworthiness in content, language competency, as well as the response readability of institutional actors. The limitations in northern Ghana include recurrent power shutdowns, sluggish data rates, and delayed network maintenance. This implies the necessity for more integrated infrastructural solutions—solutions that reconcile hardware upgrade with user-centric service design and inter-agency planning.

In addition, environmental and climatic conditions themselves exacerbate infrastructural vulnerabilities. During rainy seasons in Tamale, mobile towers become vulnerable to weather damage, and floods generally lead to outages in base transceiver stations. Ironically enough, at times of greatest need for climate information, communication systems are equally most vulnerable. This situational paradox highlights the importance of climate-proofing ICT infrastructure as part of overall adaptation strategies (van den Homberg et al., 2018).

Especially in Africa, infrastructural inequalities also often overlap with wider socio-economic inequalities. Women and poorer communities in northern Ghana are disproportionately likely to live in areas of low coverage and are less likely to be in a position to pay the cost of switching networks or information services via the mobile (GSMA, 2021). These inequalities need to be accounted for in any examination of mobile phone usage for climate communication because infrastructure lies in social structures mediating access and utility.

Electricity and Power Supply

Proximity to the mobile phone is not enough for successful climate communication; the supporting infrastructure—most notably, dependable electricity—is still a prerequisite for technology use, especially in poor and climate-exposed settings. Although mobile technologies provide unequalled access to climate risk communication, notification for early warnings, and adaptive behavior (Donner, 2008), such advantages are typically balanced out by infrastructural system deficits.



Preeminent among these are the widespread unreliability of the power supply, particularly in Sub-Saharan Africa, where access to energy is radically unequal both within countries and between nations.

In wider literature, infrastructure has been characterized as a "baseline requirement" for digital communication systems (Castells, 2011), but these sorts of broad generalizations do tend to obscure nitty-gritty realities in contexts with precarious power grids. Cell phones, as versatile and convenient as they are, are not independent appliances; their application is entirely dependent on the supply of electricity for charging and connection for signal reception. In power-constrained environments, users make use of alternative or unofficial charging locations—solar kiosks, community generators, or battery exchange—which raise the cost and dampen the urgency of communication (Aker & Mbiti, 2010; GSMA, 2019). This physical constraint inherently limits the potential of mobile phones as a medium of real-time climate communication.

Unlike high-income nations where energy reliability is a consideration, empirical studies in rural and peri-urban regions of developing economies have attested that unreliable power supply has a significant impact on information flow based on mobile phones. For example, Okello et al. (2014) discovered that in Uganda, intermittently connected houses were extremely unlikely to get and respond to SMS weather-related alerts during severe weather conditions. Likewise, in northern Ghana, for example, Tamale, societies that experience frequent power outages report delay in getting weather updates and agricultural tips, compromising their adaptive decision-making (Ampong & Owusu, 2021).

This leads us to wonder if technology interventions can ever truly be transformative without pairing with investments in physical infrastructure. Utopian models like the Digital Divide 2.0 (van Dijk, 2006) are a reminder that access to devices is only one level of inequality; meaningful



use (by frequency, depth, and autonomy) is what has actual impact. Without power, even the most excellent mobile communication strategies are fantasies, not facts.

In Africa, decentralized energy solutions are emerging as a means of digital inclusion. Off-grid microgrids and solar-powered community centers have both been proposed as alternatives to unpredictable national grids (IRENA, 2020). But even with all their potential, these kinds of solutions are unevenly available and are but loosely accessible to economically isolated or remote communities. In addition, maintenance problems, expenses, and technological skills deficits can lower their long-term viability (Osiolo et al., 2022). This gap between technological optimism and practice reality is where policy reactions based on communication objectives and infrastructural realities emerge.

Methodologically, current research differs broadly in conceptualization and measurement of electricity access effect. While others take recourse to provide domestic surveys or infrastructural designs to measure energy availability (World Bank, 2021), others employ ethnographic or participatory methods to document end-users' everyday understandings of infrastructural shortage (Sambuli & Whitt, 2017). This sort of diversity in method has a tendency to result in divergent findings. For instance, quantitative findings may provide evidence for increased ownership of mobile phones in Tamale, but qualitative data reveals that absence of charging points restricts usage during peak hours, e.g., flooding.

The second contradiction in literature is the presumption of linear advancement. Most digital development models in general assume infrastructural shortages as temporary impediments on a linear trajectory to connectivity. Nonetheless, data from poor or poorly governed contexts reveal that collapse of infrastructure, through conflict, corruption, or climate shocks, can reverse gains in mobile communication capacity (Mann et al., 2021). Infrastructure in such instances is not a fixed

platform upon which to use technology but an active, contested, and often poor system forming who communicates, how, and when.

Availability and Affordability of Mobile and Data Services

The spread of cell phones in developing nations has long been praised for its possible ability to bridge information gaps. Already in the 2000s, African mobile penetration was increasing exponentially, as GSMA (2020) puts the figure for mobile subscriptions in the region at over 45% of the population. The availability of cell phones, however, is not the same as equitable access and constant use. Availability is frequently limited by affordability—handset as well as the airtime or data needed to access climate-relevant services.

Moderate achievement in leveraging mobile platforms to disaster risk reduction is noted in studies in South Asia and Latin America (Ahmed et al., 2019), but matching findings from Sub-Saharan Africa are more differentiated. For example, Aker and Ksoll (2016) depict how the use of mobile phones in rural West Africa is highly segmented by income, education, and gender and hence constrained by who can receive and reply to SMS-based early warnings. Inequality is no exception in Ghana. Even though there has been advancement in telecommunications infrastructure in the country, the poor in northern Ghana are still excluded by expensive mobile phones and intermittent data bundle availability (Boateng et al., 2021). It poses the question: how can climate communication strategies be effectively targeted when access to infrastructure is inherently unequal?

Informal sharing of mobile phones, wherein people share a mobile phone among communities, is very common in the African setting—tended to be described as a "communal connectivity" challenging simplistic assumptions of access (James & Versteeg, 2007). While communal





consumption enhances coverage, it introduces delays in delivery or breaks in information flows, rendering climate warnings useless.

Timeliness plays an important role in the effectiveness of climate communication. Protection Motivation Theory indicates that the efficacy of warning systems relies not only on message content but also on the promptness with which they are delivered (Rogers, 1975). In high-income nations with solid telecommunications capacity and duplicate mechanisms designed into alert systems, warnings are most often distributed in minutes. Conversely, Sub-Saharan rural and peri-urban regions have poor signal coverage, unstable availability of electricity, and cell towers obscured during adverse weather conditions (Williams et al., 2018).

These risks are evidenced empirically. For instance, in Uganda, rural customers complained about the receipt of flash flood warnings up to several hours after flooding had begun due largely to power outages and network unreliability (Nakileza & Taylor, 2020). In northern Ghana, studies found that mobile-based delivery of climate warnings was frequently interrupted by weather-driven infrastructural breakdowns themselves—a paradox that reveals the vulnerability of mobile-based communication to the same disasters it is designed to prevent (Alhassan & Kuwornu, 2022). Such infrastructural vulnerability is further exacerbated by institutional fragmentation. Inefficient coordination between meteorological authorities, telecommunication companies, and local authorities is a common reason that results in delayed release of warnings (Tall et al., 2014). While Kenya and Rwanda have tried to eliminate this through centralized early warning systems with the integration of telecom, Ghana's remains mostly decentralized and in disarray. This is one of larger governance: technological systems are not autonomous—they exist within institutional frameworks that delimit their scope as well as their responsiveness.

Interpreting Infrastructure through a Socio-Technical Lens



One common thread throughout the literature is being forced to transcend techno-determinist explanations where infrastructure is merely described as a material enabler. Rather, a socio-technical perspective presents a richer account, one that highlights the fact that not only is infrastructure constructed but inhabited too. As Star and Ruhleder (1996) contend, infrastructure reveals itself through failure. Within climate messaging, this "visibility" typically takes place when emergencies happen and warnings are delayed or do not get to the most vulnerable.

Secondly, infrastructural effectiveness is not only physical availability but also user confidence in the system. In certain Ghanaian societies, alarm delivery failure, when repeated, has resulted in public disillusionment and lower confidence in information obtained through mobile (Abubakari et al., 2023). Thus, technical fixes aside, adoption is determined by past experiences of system reliability, social self-confidence, and perceived institutional confidence.

On the other hand, pilot programs in Malawi and Ethiopia, under which mobile weather forecasts were complemented by community-based interpretation sessions, showed higher levels of response and consumer trust among rural consumers (Dercon et al., 2014; Patt & Gwata, 2002). Such research suggests that infrastructure must be socially embedded and context-sensitive in order to facilitate effective climate communication.

2.10 Socioeconomic Factors Influencing the Utilization of Mobile Phones for Climate Change Communication

Comprehending the place of cellular phones in climate change communication requires intensive examination of the socioeconomic determinants that regulate access and usage of technology. Income, education, employment status, and broader forms of social inequality all play a role in the formation of mobile technology adoption and integration into everyday existence. These are most pertinent to settings like Ghana's Tamale Metropolis where mobile inequalities reflect more

profound structural inequalities. This review examines the intersection of socioeconomic status and mobile phone possession with attention to implications for climate change communication. The analysis draws on a selection of empirical research and theoretical reasoning in global, Sub-Saharan African, and Ghanaian contexts.

Income and Mobile Phone Use

Throughout the world, income remains a powerful predictor of use of the mobile phone and the type of use. In wealthier countries, smartphones are everywhere, and use is multiplexed across social, working, and information spaces (Pew Research Center, 2021). In poorer contexts, ownership is barely ubiquitous but rather more likely income stratified. Donner (2008) finds in a study that in much of Sub-Saharan Africa, mobile phone ownership is strongly correlated with household income in the sense that lower-income groups tend to depend on shared use or on feature phones.

This tendency is also observed in Ghana, according to statistics from the Ghana Statistical Service (2021), in the sense that while there is high penetration of mobile phones in general, there are urban/rural and income-class differentials. In Tamale Metropolis, lower-income households are less probable to own smartphones, which restricts access to cellular internet and wide-ranging media material on climate change. This constraint does not merely restrict information consumption but also the capacity to leverage participatory platforms, for instance, early warning systems or smartphone-based weather applications and data connectivity.

Education and Digital Literacy

Income gives mobile access, but education gives the capability to utilize it efficiently. Education's role goes beyond literacy to include the skills, analytical mind, and capability to judge and respond to information. In the age of the information society, Castells (2010) states that the disadvantages



are exacerbated for those who are unable to move around in digital space, reinforcing socioeconomic inequalities.

Climate change communication digital literacy teaches individuals how to understand meteorological information, correct people from misinformation, and respond to risk communication messages. Empirical confirmation by Asongu et al. (2018) affirms that higher levels of education are positively linked with mobile internet use in Sub-Saharan Africa, intermediating access to climate and environment information. But in Tamale Metropolis, access is being curtailed for older age groups and women coming from low-literacy households, thus limiting the impact of mobile communication interventions.

Occupation and Technology Involvement

Mobile phone usage is also determined by occupational history. Rural economies like Ghana's Northern Region tend to have livelihoods connected to seasonal and weather-sensitive activities. Farming, a dominant group of the population in Tamale, would stand to gain significantly from climate services based on mobile phones. Yet these same groups are typically least served by formal communications.

These and other studies, like Mittal et al. (2010) and Nyamba & Mlozi (2012), also point to the ways in which occupational requirements shape mobile use. Business and information services use of phones is made by professionals and traders, while subsistence farmers use phones mainly for voice calls, often as a result of low literacy levels or availability of digital options. This brings about the question of whether mobile phones are being used maximally towards climate adaptation in such communities or if they are still being used in peripheral and utilitarian manners.

Beyond Ownership to Effective Use



Ownership and use do not directly correlate. BARRIERS that include the absence of electricity, network coverage, and data cost disproportionately affect poor households (James, 2015). In the Ghana case, infrastructural constraints act to exacerbate the digital divide for peri-urban and rural populations in the Tamale periphery.

In addition, technology and gender social norms can restrict cellular use across certain demographic segments. Although non-economic by nature, these sociocultural conditions correlate with income and education to exclude women, the elderly, and minority ethnic groups from digital engagement (Buskens & Webb, 2009). Socioeconomic status then has to be understood in material and relational category terms, formed through power relations and institutional exclusion.

Digital Divides and Inequalities

The digital divide offers a useful canvas upon which to consider variations in mobile phone use. Well established as the gap between information and communication technology (ICT) haves and have-nots, the digital divide has since broadened to include second- and third-level divides—differences in quality of use and subsequent effects of such use (van Dijk, 2005).

Although some of the earliest ICT for development (ICT4D) paradigms were predicated on the hope that technology would spread and empower itself, more contemporary critiques propose that without first stabilizing underlying disparities, digital technologies will reproduce or even widen existing inequalities (Unwin, 2009). In Tamale, this criticism especially holds true. Other studies, such as Ahiataku-Togobo et al. (2020), attribute the inability of mobile interventions to reach the most climate-exposed groups as a result not of a shortage of innovation, but of technological design failure to match local context.



2.11 Climate Adaptation and Socioeconomic Disparities

The lack of consideration of socioeconomic heterogeneity in cell phone adoption has major climate adaptation implications. In principle, cell phone technologies can provide timely provision of climate information, allow for community feedback, and support coordinated action. But in practice, socioeconomic differences limit who is included and how.

Here, in the African setting, most adaptation strategies based on mobile anticipate a uniform approach. Smallholder farmers in Tamale and other groups like young people in urban areas or professionals differ in their needs and capabilities. For instance, voice messages may be more appropriate for low-illiterate users, while applications and SMS alerts are appropriate for smartphone users and better-educated segments (Ospina & Heeks, 2010). This necessitates segment-specific communication strategy based on users' socioeconomic conditions.

Secondly, there is the policy challenge. As NGOs and governments increasingly digitize environmental governance, they somehow underinvest in the infrastructure facilitators—power infrastructure, accessible data, and digital literacy initiatives—that lie behind inclusive participation. This indicates more serious institutional weaknesses, as Ayele et al. (2017) point out, where well-intentioned climate policy fails at the implementation stage through disjointed mandates and gaps in coordination.

2.12 Effectiveness of Mobile-Based Climate Communication Strategies

Development of mobile technologies over the last few decades has revolutionized the climate communication landscape, especially in developing countries whose conventional media landscape is still in its nascent stage or in limbo. SMS texts to smartphone applications—mobile-focused strategies of communication—are being used more and more to provide climate information for awareness, perception, and finally adaptive action to vulnerable populations. But



efficacy must be considered seriously in terms of pluralistic indicators, situational setting, and research rigor.

At the center of studying mobile climate communication approaches is the tri-dimensional "effectiveness" construct traditionally operationalized by three interconnected measures: reach, comprehension, and behavioral effect (Rogers, 2003; Muralidharan et al., 2015). Reach addresses the scope and generality of exposure to audiences, comprehension speaks to the extent to which recipients learn and internalize messages, and behavioral impact monitors observable alterations in attitudes or habits improving climate resilience.

While global accounts typically highlight these efforts, results are empirically disparate. As an example, in endemically penetrated high-income environments, reach can be virtually universal, and understanding due to literacy and language equivalence so high (Green et al., 2017). Sub-Saharan African environments commonly experience literacy rates, linguistic heterogeneity, and infrastructural underdevelopment that diminish reach and understanding (Aker & Mbiti, 2010). This disconnect begs the question of whether there exists a common framework for evaluation that really reflects observed realities of target groups in areas such as Tamale Metropolis.

Most controversial and recalcitrant, however, is behavioral impact. Although a number of studies associate mobile communication with expanded knowledge and awareness, evidence of lasting behavior change is weaker (Ashraf et al., 2019). This variety partly accounts for the intricacy of behavior, subject to socio-economic limitations, social norms, and institutional settings that can repress or enable accommodation irrespective of message exposure.

Theoretically, the underlying models shaping mobile climate communication are varied. Davis (1989) formulated the Technology Acceptance Model (TAM), which continues to shape user acceptance of mobile phones, listing perceived usefulness and ease of use as drivers of



engagement. The exclusive specialization of TAM has, nevertheless, been seen as not comprehensively explaining broader socio-cultural and institutional dynamics (Venkatesh & Bala, 2008). Therefore, scholars increasingly recommend integrated socio-technical approaches that leverage social influence, infrastructural limitations, and cultural considerations (Heeks, 2018).

Parallel to TAM, diffusion of innovations theory (Rogers, 2003) provides some explanation of the processes by which climate information on mobile diffuses across social networks, such as determinants of relative advantage and compatibility that influence adoption. Empirical use in Sub-Saharan Africa, however, indicates that diffusion processes are highly mediated by existing leadership systems within local areas and member trust within communities, factors less prevalent in initial conceptualization (Musya et al., 2017).

Additionally, risk communication models are useful in the development of climate messages which are able to communicate urgency without inducing fatalism. Extended Parallel Process Model (Witte, 1992), for example, argues about the need for threat and efficacy message balance in order to trigger adaptive behaviors. Yet, deployment on low-resource mobile devices is not without challenge since it would impose message brevity constraints and the lack of feedback loops, whose implications can constrain message nuance and emotional engagement (Takahashi et al., 2015).

Empirical assessment of mobile-initiated climate communication intervention in Ghana and similar contexts presents mixed findings that highlight context specificity. SMS alert was employed by the Ghana Cocoa Forest REDD+ program to alert farmers against climatic hazards, registering moderate awareness with minimal measures of altered farming behavior (Asante et al., 2020). Significantly, the blockage brought about by unavailability of networks, low literacy levels, and absence of localized language content to message penetration emerged in a prominent manner.



In the same vein, in Kenya, the "M-Farm" platform offered mobile weather forecasts and market information to smallholder farmers, which significantly enhanced timely decision-making by some participants (Aker, 2011). Nevertheless, Aker's study also realized a digital divide in which marginalized groups—the poorer households and women were considerably among them—had fewer opportunities to use the technology and hence fewer gains. This imbalance is in line with Nigeria-based research where mobile climate advisory services were plagued with skewed distribution as a result of socio-economic and gendered inequalities (Ojo et al., 2019).

In the Tamale Metropolis, there is preliminary and sporadic mobile phone usage for climate information in spite of relatively good levels of ownership, as shown in recent studies (Issifu et al., 2021). Limited digital literacy and linguistic limitations consistently limit use, with socio-economic realities preponderating over climatic concerns over the long term to survival requirements in the short term. In contrast are urban coastal cities in Ghana where media ecologies are heterogeneous and complement mobile messaging, in what may render climate communication more efficient (Nyarko & Boachie, 2018).

A key element affecting the efficacy of climate communication through mobile is user interaction and the existence of feedback mechanisms. Interactive two-way possibilities like query choices, voice comments, or two-way SMS may enhance understanding and self-efficacy through message adaptation and clearing doubts (Patel & Burke, 2020). Yet most interventions in Sub-Saharan Africa are mostly one-way because of the limitations of infrastructure and finance (Duncombe, 2017).

Barriers to successful mobile communication go beyond technological to encompass socio-cultural and institutional factors. Language heterogeneity in Tamale, which has common local languages as well as English and Hausa, makes message design more challenging. Although there are some



apps that play around with multilingual messaging, granularity and cultural appropriateness of translations are very uneven, affecting understanding and perceived salience (Oppong et al., 2021). Institutional quality also has a role to play. Poor coordination between the government agencies, NGOs, and telecom operators tends to produce disjointed messaging, variable schedules, and duplication of effort (Addo et al., 2019). It can confuse the recipients and lower the degree of confidence in mobile climate information, especially where there is contradictory advice. On the other hand, combined community-based methods, which integrate mobile communication with local intermediaries and indigenous tradition custodians, have provided more positive results to enhance adaptive behaviors (Boakye et al., 2022).

Moreover, digital divides are an insurmountable obstacle. Notwithstanding spectacular increases in mobile phone ownership, inequalities continue to be associated with income, education, gender, and rural-urban differences. These differences limit fair access to climate information, posing risks of domesticating already hardened vulnerabilities instead of mitigating them (Munyua et al., 2019). For instance, women have less telephone access compared to men and no authority over its use in Northern Ghana with direct impacts on their use of mobile-based climate warnings (Aidoo et al., 2020).

2.13 Conceptual framework

The conceptual framework for this study depicts the dynamic relationships between several key variables that influence the effective use of mobile phones for climate change communication among residents of Tamale Metropolis. Central to the framework is the dependent variable—the effective use of mobile phones for climate change communication—which captures the degree to which individuals successfully access, comprehend, and share climate-related information via

mobile technologies. This effective use ultimately aims to foster greater awareness and promote adaptive responses to climate change within the community.

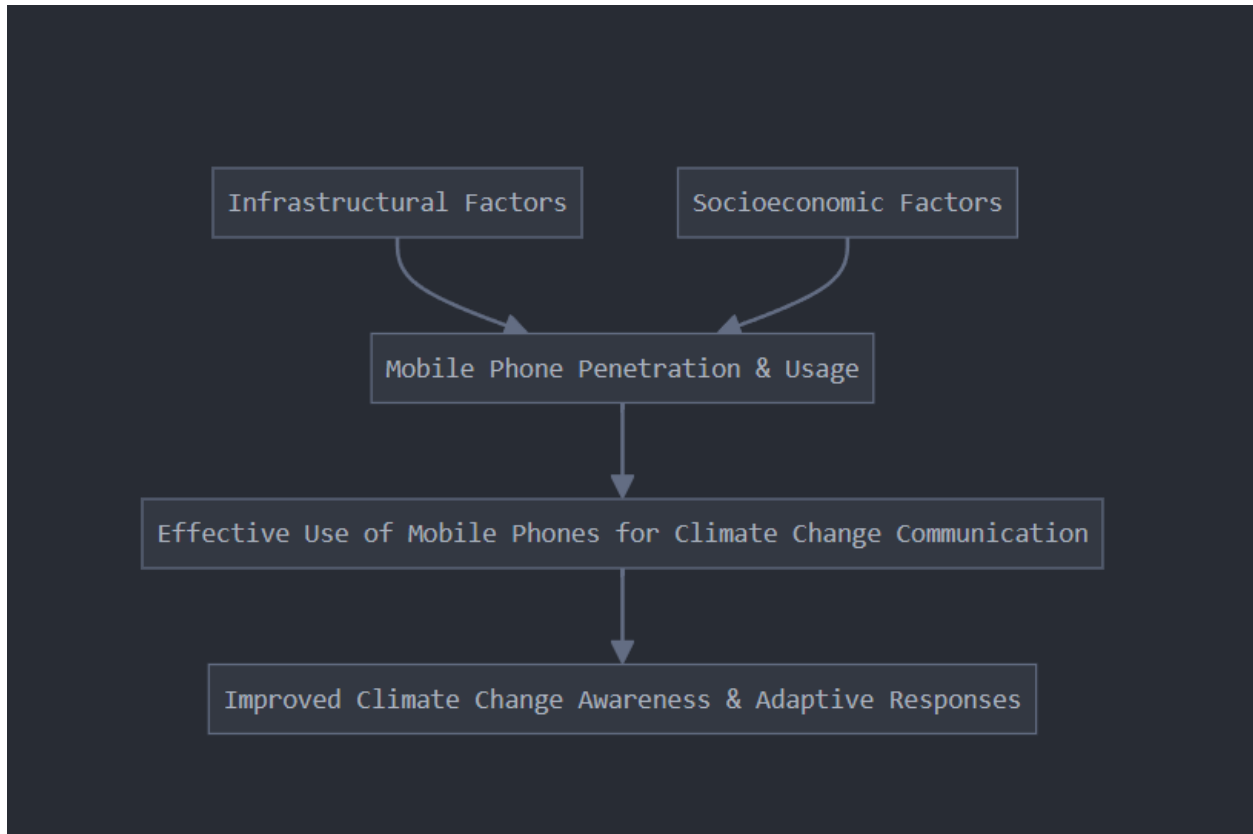


Figure 2.1: Conceptual framework

Source: Authors own construction (2024)

The framework identifies two main categories of independent variables that directly influence this dependent variable: infrastructural factors and socioeconomic factors. Infrastructural factors encompass elements such as network coverage, electricity availability, and affordability. Network coverage refers to the quality and availability of mobile network signals, which is critical for users to maintain consistent and reliable communication channels. Without adequate network infrastructure, even individuals who own mobile phones may face barriers in accessing climate information. Electricity availability is another vital component, as access to a stable power supply





is necessary for charging mobile devices and sustaining their use. Additionally, affordability plays a significant role, determining whether residents can economically sustain ownership of mobile phones, purchase airtime, or data bundles required to engage with climate communication platforms.

Complementing these are the socioeconomic factors that shape the ability and willingness of individuals to utilize mobile phones effectively. Literacy and education levels significantly impact users' capacity to understand climate messages disseminated via mobile platforms. Those with higher literacy and education are more likely to interpret information accurately and apply it meaningfully in their daily lives. Income level further influences access by determining the financial feasibility of owning and maintaining mobile technology. Age and gender also factor into this equation; younger individuals often exhibit greater familiarity and comfort with modern technologies, while gender disparities may affect differential access and usage patterns due to socio-cultural norms.

Between these independent variables and the dependent variable lie mediating variables such as mobile phone penetration and usage patterns. Mobile phone penetration refers to the proportion of the population owning or regularly accessing mobile phones, whether smartphones or feature phones. High penetration rates indicate a broad potential audience for climate change communication via mobile channels. Usage patterns delve deeper into how individuals interact with their devices—considering factors like frequency of use, preferred services (e.g., calls, SMS, internet browsing, social media, mobile money), and the phenomenon of multi-SIM card ownership. These mediating factors shape the practical ways mobile technology is embedded in daily communication habits, thereby influencing the reach and impact of climate change messaging.

CHAPTER THREE

METHODOLOGY

3.0 Introduction

This section discusses the research method employed in the study, as well as the data collection and analytical methods used. Given this, a brief description of the study area, instruments used to collect needed data, the design of the study, the procedure of sampling, methods of data collection and data analysis are all presented in this section.

3.1 Profile of Tamale Metropolis

Tamale Metropolis, situated in the Northern Region of Ghana, is the region's economic and administrative center. It is distinct with a fast-expanding population, which stood at about 374,744 individuals according to the 2021 Population and Housing Census carried out by the Ghana Statistical Service (GSS, 2021). The growth is fueled by both natural increase and rural-urban migration, and hence Tamale is among the fastest-expanding regions in the nation.

The city possesses a young population, with more than 60% of the population below the age of 35, meaning a mainly youthful demographic composition (GSS, 2021). This demographic factor affects the adoption and acquisition of mobile technologies as young populations are disposed towards adopting new communication technologies.

Economically, Tamale is supported primarily by agriculture, petty trade, and services. The urban life, however, has increasingly shifted to trade and administrative activities. Albeit all these, the area faces climate variability-related issues that include uneven rainfall patterns, drought, and flooding with effects on agricultural productivity and livelihoods (GSS, 2021).

Mobile phone coverage in Tamale Metropolis has also steadily been increasing with complement from improved telecommunication network and improved affordability of mobile phones. The diffusion of technology is key to successful climate change communication through the ability to provide timely provision of weather forecasts, climate-smart agriculture, and emergency alert to victims (GSS, 2021)..



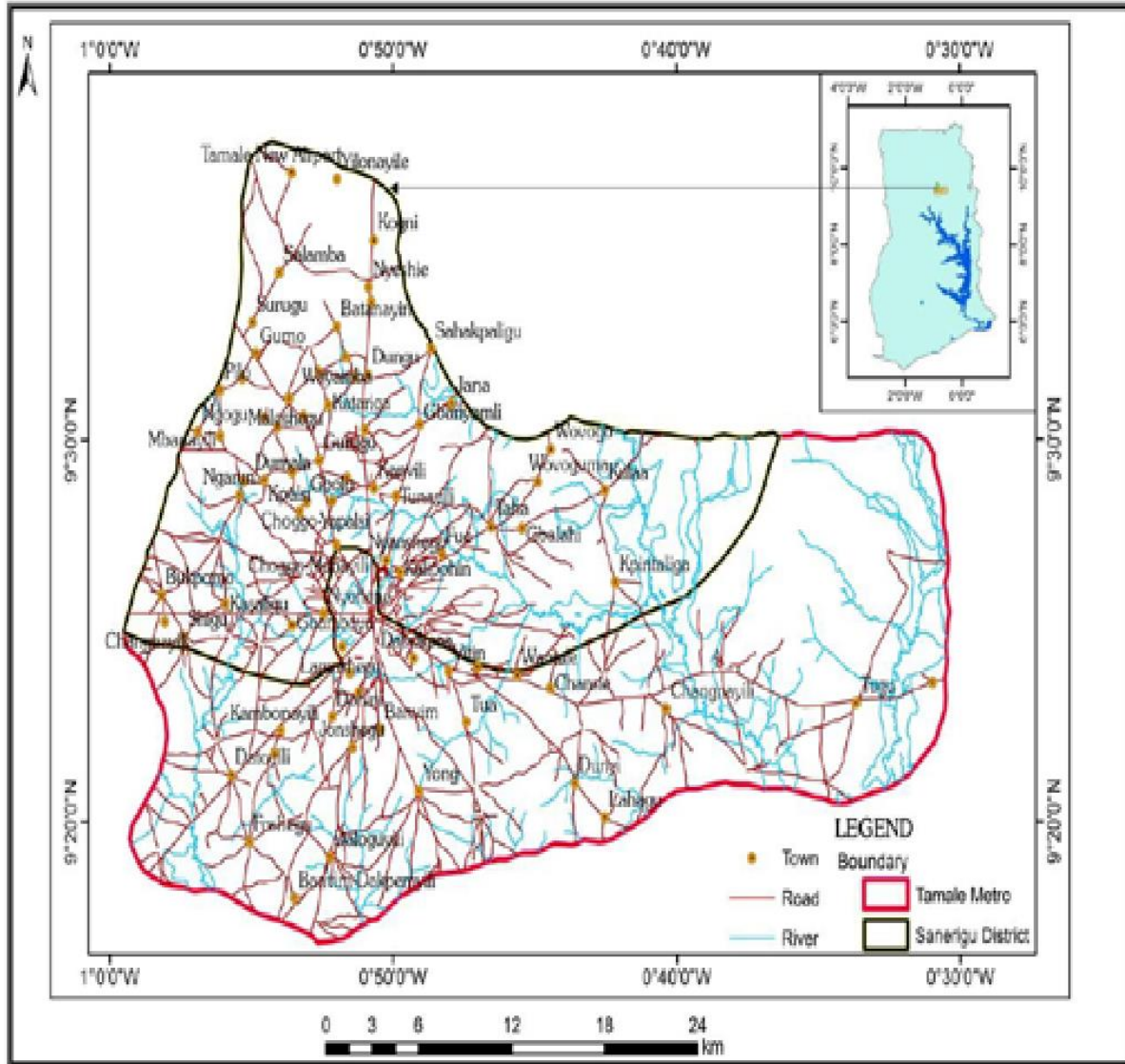


Figure 3.1: Map of Tamale Metropolis

Source: GSS (2022)

3.2 Research Approach

The research adopts a quantitative method to evaluate the prevalence of mobile phones and how they can improve climate change communication within the Tamale Metropolis. Quantitative method is aiming at numerical facts from an extensive sample population such that patterns, trends,

and statistical connections concerning the use of mobile phones and its efficiency in the delivery of climate change messages are determined.

By applying standardized questionnaires completed by a representative sample of Tamale Metropolis residents, this study strives to quantify important variables like mobile phone ownership, usage rate, access to climate messages, and perceived effects of mobile communication on climate knowledge and adaptive behavior. This method allows for the measurement of mobile penetration rates and analysis of drivers of adopters of climate change communication through the utilization of mobile phones. Quantitative data has the benefit of generalizability, which enables the results to be extended to the larger population of the metropolis (Nardi, 2018; Schreier, 2018). It also permits statistical analysis to investigate correlations between socio-demographic variables (such as income, age, education) and mobile phone use for climate communication interventions, providing measurable data on the reach and impact of mobile-based interventions.

3.3 Research Design

Research design is the general master plan and layout that directs data collection, analysis, and interpretation to answer explicit research questions (Rea & Parker, 2014). Descriptive research design is used in this paper with the aim of providing a precise and elaborate description of the existing state of the penetration of mobile phones and how it contributes to increased climate change communication in Tamale Metropolis. Descriptive method is best applied for quantification and analysis of the residents' profile, usage behavior, and attitude towards mobile phone accessibility and how the phones assist in the provision of climate information (Omair, 2015).

Through a descriptive design, the study aims to identify the existing conditions of mobile phone ownership, usage level, and communication channels employed in disseminating climate change



information among the people. This can be done through a descriptive design since it allows for in-depth understanding of how mobile technology is integrated into climate change communication interventions and its effectiveness in portraying climate change information to different demographic groups in Tamale Metropolis (Rea & Parker, 2014).

3.4 Population

The population under study are the inhabitants of Tamale Metropolis, which is within Ghana's Northern Region. The population of Tamale Metropolis was 374,744 and was made up of 185,051 (49.4%) males and 189,693 (50.6%) females, as per the GSS 2021 Population and Housing Census. This is a largely urban population, whereby 80.8% of the population resides in urban areas and 19.2% in rural areas. The age distribution is also that of a young population with a high percentage under 35 years, which is appropriate to the subject matter of the study of use of mobile phones and climate change communication.

The research focuses on the adult population aged 18 years and older who are living in the metropolis. This is the targeted prime user segment of mobile telephony technology and would most likely be using mobile-based climate change communication platforms. The research attempts to target the 18-year-old and older population with the objective of determining the level of mobile phone penetration and potential towards improving climate change communication among Tamale Metropolis' adult population.

3.5 Sampling Procedure and Sample Size

3.5.1 Sampling Size

Sample size is the number of individual units, for instance, people or data points, drawn from a combined aggregate population to participate in a study (Esser & Vliegthart, 2017). Determining the right sample size is crucial, as it affects the validity, reliability, and generalizability of the

research outcomes. Larger samples provide more accurate estimates and larger power for statistical detection of significant relations or differences (Kyriazos, 2018).

In this research, the sample was obtained from the adult population of Tamale Metropolis (above 18 years) which is about 230,000 persons based on the overall population of 374,744 and adults percentage published by the Ghana Statistical Service (GSS, 2021). Using the approximate adults' number, a representative sample size was determined using Cochran's (1977) sample size formula:

$$n = \frac{N}{1 + Ne^2} \dots\dots\dots (1)$$

Where:

n = sample size

N = target population (230,000 adults)

e = margin of error (0.05 or 5%)

$$n = \frac{230,000}{1 + 230,000 (0.05)^2} = 399$$

Hence, a sample size of approximately 400 respondents was considered adequate to achieve statistically reliable results for the study.

3.5.2 Sampling Procedure

Sampling involves the process of selecting a smaller subset of members from the broader population to stand for the entire group (Sharma, 2017). The intention is to generalize the findings from the sample to the broader population with consideration of practicality (Martínez-Mesa et al., 2016).



In order to descriptively describe the geographic and demographic heterogeneity of the Tamale Metropolis, sampling was done in two phases. The metropolis was first delineated into three extensive zones by the name of Tamale South, Tamale Central, and Tamale North that are administrative and socio-economic classifications.

Second-level respondents were randomly selected based on a stratified random sampling method by zone. The objective was to ensure a representative proportion by socio-demographics and population size. The ideal respondents were resident adults aged 18 years and older owning or utilizing mobile phones since the area of focus was communication and mobile phone penetration.

The last sample of about 400 respondents was split evenly across the three zones in ratio to cover various demographic categories like farmers, traders, students, and professionals. The strategy helped in enhancing the representativeness and credibility of the results on the use of mobile phones and climate change communication in the Tamale Metropolis as evident in the Table 3.1.

Table 3.1: Sample Distribution by Zones, Areas

Zone	Areas Included	Population Estimate¹	% of Total Population	Sample Size
Tamale South	Aboabo, Lamashegu, Vitting	110,000	29.4%	118
Tamale Central	Central Market, Kuku, Sakasaka	130,000	34.8%	139
Tamale North	Kalariga, Kalpohin, Sagnarigu	110,744	29.6%	143
Total		350,744	100%	400



3.7 Data Collection Process

This research used a quantitative research design, which gathered primary data from just the structured questionnaires administered among Tamale Metropolis residents. The questionnaire was designed in a way that it gathered systematic numerical data on the existence of mobile phones, usage habits, and perceptions of climate change communication. This approach facilitated effective gathering of data consistent with the research goals, such as measuring mobile phone penetration, means of accessing and spreading information on climate change, infrastructural and economic determinants of mobile phone usage, and impacts of mobile-based climate communication programs.

Secondary data from enabling reports and publications, including the Ghana Statistical Service (GSS) statistics, were referred to in order to further complement and inform the primary data gathered.

3.8 Instruments for Research

Research tools are the tools that are used when gathering data from research participants (Taherdoost, 2021). For this study, a structured questionnaire was used as the only tool for gathering quantitative data from respondents of Tamale Metropolis.

3.8.1 Questionnaire

A structured questionnaire was the only tool employed to gather data for this study. The questionnaire was mostly composed of closed questions, which were used to gather quantifiable data based on the research goals. Of particular interest were the socio-demographic characteristics of respondents including age, gender, level of education, profession, and income. The questionnaire also asked respondents about access to mobile phone technology at different levels

of ownership and frequency of use. Besides that, it also studied the use of mobile phones in accessing and sharing information on climate change.

The questionnaire also included questions to ascertain infrastructural limitations such as network coverage and the presence of electricity, socioeconomic determinants such as affordability and literacy, which can affect the effective use of mobile phones for communication about climate change. Finally, the tool set respondents' views on the effectiveness of existing mobile-based interventions towards improving climate change awareness and adaptive practices among the community.

To guarantee data quality, the survey instrument was personally administered through interviews by enumerators with training. Personal interviewing allowed respondents to seek clarification when necessary, thereby minimizing errors and increasing the validity of their answers. Personal contact with the respondents also guaranteed consistency in reading questions and marking answers, overall increasing the reliability of collected data.

3.9 Data Analysis

The data collected through structured questionnaires was systematically processed and analyzed using quantitative data analysis techniques. Upon completion of data collection, all responses will be coded and entered into statistical software such as SPSS for analysis. The analysis involved both descriptive and inferential statistics to provide meaningful insights aligned with the study objectives.

Descriptive statistics including frequencies, percentages, means, and standard deviations will be used to summarize and describe the socio-demographic characteristics of respondents and key variables related to mobile phone penetration and climate change communication. These statistics



provided an overview of the distribution and general trends within the data. Furthermore, inferential statistics such as chi-square tests, correlation analysis, and regression models was employed to explore relationships between variables, and to identify factors influencing mobile phone use for climate communication.

To determine the level of access to mobile phone technology among residents in Tamale Metropolis:

Descriptive statistics will be used to analyze responses on mobile phone ownership, type of phone (basic, smartphone), frequency of use, and accessibility across different socio-demographic groups. This will provide a clear picture of the extent of mobile phone penetration in the study area.

To examine how mobile phones are being used to access and disseminate climate change information in the metropolis:

Frequencies and cross-tabulations will be conducted to assess the different ways mobile phones are utilized for climate change communication, including receiving alerts, sharing information via calls, text messages, social media, and other mobile platforms. Analysis will also compare usage patterns across age, gender, and education levels.

To identify the infrastructural and socioeconomic factors affecting the effective use of mobile phones for climate change communication:

To identify the infrastructural and socioeconomic factors influencing the effective use of mobile phones for climate change communication, the study will employ logistic regression analysis, a robust multivariate statistical method suitable for modelling binary outcome variables. In this context, the dependent variable will be the effective use of mobile phones for climate change



communication, operationalized as a binary variable (e.g., 1 = effective use, 0 = ineffective use or non-use). Effective use may be defined based on respondents' reported frequency and quality of accessing and sharing climate change information via mobile phones.

The independent variables will include key infrastructural and socioeconomic factors hypothesized to affect mobile phone use, such as:

Network coverage: Availability and reliability of mobile network signals in respondents' areas (measured as good or poor coverage).

Electricity availability: Access to consistent electricity supply necessary for charging mobile devices.

Affordability: The economic capacity of respondents to own and maintain mobile phone services, including costs of airtime and data bundles.

Literacy level: Respondents' ability to read and understand information accessed via mobile phones.

Income level: Household or individual income, which influences the ability to afford mobile phone-related expenses.

The logistic regression model will take the following general form:

$$\log \left(\frac{P}{1-P} \right) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \epsilon$$

Where:

P is the probability of effective use of mobile phones for climate change communication

X₁ = Network coverage (coded as 1 for good coverage, 0 for poor).



X_2 = Electricity availability (1 = consistent, 0 = inconsistent or none)

X_3 = Affordability (measured as ability to pay for airtime/data)

X_4 = Literacy level (1 = literate, 0 = illiterate)

X_5 = Income level (continuous or categorized income brackets)

β_0 = Intercept term

$\beta_1, \beta_2, \dots, \beta_5$ = Regression coefficients for each predictor

ϵ = Error term

Dependent Variable: Effective use of mobile phones (Q1) coded as binary (1 = effective use, 0 = ineffective use).

Independent Variables:

Network coverage binary coded: Good/Fair/Very Good = 1, Poor/Very poor = 0

Electricity availability binary coded: Reliable = 1, others = 0

Affordability coded into affordable (1) and not affordable (0) categories; expenditure can be categorized or used continuously

Literacy binary coded: literate = 1, illiterate = 0

Income in categories

To evaluate the effectiveness of existing mobile-based communication strategies in promoting awareness and adaptive responses to climate change in Tamale Metropolis

The study assesses respondents' perceptions of the effectiveness of current mobile-based communication strategies through a series of survey items measured using a Likert scale. These



items asked participants to rate statements related to the clarity, relevance, timeliness, and trustworthiness of climate change information received via mobile phones. For example, respondents may be asked to indicate their level of agreement with statements such as:

- “The information about climate change that I receive on my mobile phone is easy to understand.”
- “Mobile phone messages have helped me learn how to adapt to changes in weather patterns.”
- “I trust the sources of climate change information communicated through mobile phones.”
- “Mobile-based communication encourages me to take specific actions to cope with climate change.”

Each statement will be rated on a 5-point Likert scale ranging from 1 (Strongly Disagree) to 5 (Strongly Agree). Responses will be aggregated to create an overall score reflecting perceived effectiveness of mobile communication strategies.



Means, frequencies, and percentages) were summarised how respondents perceive various aspects of the communication strategies. The adaptation measures employed by respondents to adapt to climate change in Tamale Metropolis were ranked using Kendall Wall’s Coefficient of Concordance (W). That helped to determine the overall level of agreement among the respondents.

CHAPTER FOUR

RESULTS AND DISCUSSIONS

4.0 Introduction

Chapter Four describes the findings and discussions of the study on the measurement of mobile phone penetration and its role in improving climate change communication in Tamale Metropolis. Chapter Four is structured into five core sections, corresponding to each of the research goals. The initial section gives an overview of respondents' socio-demographics. The second section provides results on the level of mobile phone technology access among urban dwellers. The third section provides results on mobile phone utilization to access and share information on climate change. The fourth section illustrates infrastructural and socioeconomic determinants of successful mobile phone use for climate change communication. The last section assesses the effectiveness of current mobile-based communication interventions in raising awareness and influencing adaptive coping with climate change in the Tamale Metropolis.

4.1 Demographic Information of Respondents in the Tamale Metropolis

The socio-demographic characteristics of the respondents give us valuable information regarding the setting in which mobile-based communication interventions are delivered to attain climate change awareness and adaptation in the Tamale Metropolis.

The majority of the interviewees (77%) fell within the 25-34 age category, which means that the sample was primarily composed of young adults of working age. This is in agreement with Bempong et al. (2020), who clarified that young adults between 25 and 35 years are the most likely to dominate Northern Ghana's urban dwellers and are gradually becoming the dominant consumers of digital content. Furthermore, Okello et al. (2018) in a study in Northern Uganda noted that young individuals are likely to embrace mobile technologies for climate and agricultural



information because they have greater digital literacy than other age brackets. But unlike the research by Adomako et al. (2021) that revealed the more relatively even age composition in Brong Ahafo rural, the present observation prescribes a youthful population with a dense concentration in Tamale, perhaps triggered by urban migration and economic prospects.

The gender split indicates that women made up 58% of the respondents and men accounted for 42%. The gender split was in line with a research study carried out by Alhassan and Boateng (2019) with an overwhelming percentage of female involvement in market and informal economy activities in Northern Ghana. Similarly, Tambo and Abdoulaye (2012) discovered that women across the majority of West Africa are significantly involved in information-seeking activities, particularly when the information is agricultural or household welfare. Dominance by women has the advantage of delivering gender-sensitive climate communication strategies, particularly because women are likely both to receive and share household information. On the other hand, Nyarko and Odame (2016) had noted a male predominance in their own research on ICT use in Central Ghana, and regional disparities in economic activity and literacy could reasonably explain such differences.

Education levels among respondents further reinforce the potential for effective mobile-based communication. Half of the respondents had tertiary education, while 30% had completed secondary education. Only 5% had no formal education. This comparably high level of education among the sample population is in line with the work of Oppong and Awuah (2020) in Accra, in which more than 60% of mobile phone users accessing climate-related platforms had been at or higher secondary-level education. Likewise, Mtega and Msungu (2013) in Tanzania obtained a positive correlation between the educational level and the utilization of mobile phone-based agricultural services. The greater level of education within the Tamale sample would represent an

increased likelihood of comprehending messages and subsequent behavior reactions to climate reports delivered through mobile. These statistics, however, are contrasted against other research in more rural areas, like Ibrahim and Asuming-Brempong (2017) conducted in Bawku, where low literacy levels restricted effective use of SMS-based services for climatic awareness.

Occupationally, the farmers (35%) were predominant, followed by traders (20%), artisans (12.5%), students (15%), civil servants (10%), and the unemployed (7.5%). Farmers' dominance corresponds with the agrarian character of the Northern Region, as emphasized in the literature by Abdulai and Alhassan (2021), who emphasized the exposure of farmers to climatic variability and the need for timely climate information. The presence of other occupations like traders and artisans also bears witness to Tamale having a diversified urban economy. This diversification is very much applicable in mobile communication strategy, with Dossou and Glehouenou-Dossou (2007) noting that farmers only require weather news, whereas traders and artisans are concerned with infrastructure disturbance and price changes associated with the effects of climate change. This labor heterogeneity addresses the need of the differential communication strategies that resonate to the diverse informational needs through the various economic segments.

The distribution of income reveals that 40% of the respondents receive between GHS500 and GHS1000 per month, with 20% receiving less than GHS500. A paltry 5% received above GHS2000. This indicates that the majority of the respondents are in lower-income classes, as established by research like that of Agyekumhene et al. (2019), whose research identified affordability as the primary issue for long-term mobile phone use among low-income earners in Ghana. In Burkina Faso, Sawadogo et al. (2018) observed that precarious income regulated the capacity of the households to buy data bundles or repair broken phones and deprived the household

of useful climate information. Mobile phones, however, remain the cheapest digital products among low-income consumers as they are less expensive relative to other ICT devices.

Table 4.1: Demographic Information of Respondents

Attributes	Frequency	Percentage
Age of Respondent:		
18-24	18	4.5
25-34	308	77.0
35-44	30	7.5
45-54	30	7.5
55 and above	14	3.5
Sex of Respondent:		
Male	168	42.0
Female	232	58.0
Educational Level of Respondents:		
No formal education	20	5.0
Primary education	60	15.0
Secondary education	120	30.0
Tertiary education	200	50.0
Occupation:		
Farmer	140	35.0
Trader	80	20.0
Student	60	15.0
Civil Servant	40	10.0



Artisan	50	12.5
Unemployed	30	7.5
Income Level (GHC/Month):		
Less than GHS500	80	20
GHS500-1000	160	40
GHS1001-1500	100	25
GHS1501-2000	40	10
More than GHS2000	20	5

Source: Field Survey Data, (2024)



4.2 The level of access to mobile phone technology among residents in Tamale Metropolis

This section presents results and discussion on the level of access to mobile phone technology among residents in Tamale Metropolis.

4.2.1 Mobile Phone Access and Usage among Respondents

The findings on the access to and usage of mobile phones among residents of Tamale Metropolis reveal a relatively high penetration level and usage level, as can be evidenced elsewhere in Ghana and the broader sub-Saharan Africa. The 80% of respondents reporting to own a mobile phone, as indicated in Table 4.2, speaks to this. This rate is similar to the 79% national mobile phone ownership rate reported by Ghana Statistical Service (2021) Ghana Living Standards Survey, which reported higher rates of ownership for urban regions. Evidence from Work by Asampong et al. (2020) and Boateng (2019) confirms greater pervasiveness of mobile phones in rural and peri-urban Ghanaian society but with differences still prevailing depending on income and education.

Among the mobile phones found in Tamale, 56.2% indicated that they owned smartphones while 43.8% indicated that they owned feature phones. This agrees with a study done by Agyekum et al. (2021), which established that smartphone usage was most prevalent among the youth and the working class, simply because it was affordable and convenient to use. Similarly, Chavula (2014), in the case of mobile access in Malawi, found that although basic phones remain common among elderly and less educated groups, they are being gradually displaced by smartphones in which internet use and mobile applications are available. In line with this, the Tamale context reflects regional digital transformation sustained by socio-economic mobility and the affordability of technology.





The study also reveals that 62.5% of the respondents employ multiple SIMs, which is prevalent in most of sub-Saharan Africa. James and Versteeg (2007) indicated in their study that employing multiple SIMs is a strategic behavior to compensate for network unreliability as well as managing costs since customers might switch between networks for better deals or coverage. In Ghana, Nyarko and Quartey (2020) noted that competition between telecommunication operators and failure of universal coverage in rural areas tends to force the consumers to have multiple SIM cards to guarantee continuous service.

With respect to the frequency of usage of mobile phones, 56.2% used their phones multiple times per day, while a paltry 9.4% used their phones weekly or less. The foregoing reveals the same results as Dzandu and Dadzie (2012), who asserted that mobile phone usage in Ghana is founded on everyday habits, particularly for economic and communication purposes. In the same vein, research in Nigeria and Kenya (Aker & Mbiti, 2010; Etzo & Collender, 2010) evidences how extensive use of mobile phones enables communication effectiveness, service accessibility, and social relations. The extensive every-day use relative to the place could be an expression of such compulsion, as people in Tamale increasingly use mobile phones for enterprise, remittances, and information acquisition.

In relation to overall mobile phone applications, high usage is in most categories. Voice call (96.9%) and SMS (87.5%) are the leading utilities and are aligned with previous studies by Frempong et al. (2013) in Ghana and Jagun et al. (2008) in Nigeria, which established low-cost forms of communication remain the norm, particularly where internet connectivity is not as strong. But 62.5% of them employed the phones for internet access and 59.4% for social media access, indicating consistent integration of internet services into everyday usage. Agyekum and Yeboah-Banin (2016) also confirm this since they discovered that internet searching, WhatsApp

messaging, and Facebook interaction are increasingly being used by Kumasi users as part of everyday communication habits.

Additionally, 75% of the respondents to the survey reported using mobile money, a percentage that aligns with the rising financial inclusion reported by Osei-Assibey (2015), who noted that mobile money has emerged as a prevalent method of payment in Ghana's poor communities. Likewise, Mbiti and Weil (2011) from their Kenyan example noted the possibility of mobile financial services to transform access to banking for the poor. For Tamale, the use of mobile money indicates that citizens are adopting the usage of mobile platforms for information exchange as well as economic activities.

Lastly, mobile application usage, according to 56.2% of the participants, is a testament to the increasing utilization of digital media for purposes beyond traditional communications. This is consistent with findings by Alhassan and Adam (2022), which recorded an increase in the utilization of health- and agriculture-themed applications in Northern Ghana. The applications provide essential avenues through which timely and targeted information can be directed, particularly where there is a lack of access to conventional services.

Table 4.2: Mobile Phone Access and Usage among Respondents

Attributes	Frequency	Percentage
Mobile phone ownership:		
Yes	320	80.0
No	80	20.0
Types of Mobile phone own:		
Basic feature phone	140	43.8

Smartphone	180	56.2
Frequency of mobile phone usage:		
Several times a day	180	56.2
Once a day	60	18.8
Several times a week	50	15.6
Once a week or less	30	9.4
Functions used on mobile phones (Multiple responses):		
Voice calls	310	96.9
SMS/Text messaging	280	87.5
Internet browsing	200	62.5
Social media (WhatsApp, Facebook, etc.)	190	59.4
Mobile money services	240	75.0
Mobile applications (apps)	180	56.2

Source: Field Survey Data, (2024)





4.2.1 Overall Levels of Mobile Phone Access and Usage among Respondents

The examination of mobile phone accessibility and utilization among the residents of Tamale Metropolis brings to fore significant heterogeneity in active usage and technological reach. Based on 400 respondents, 40% indicated high usage and access according to the level of smartphone possession, daily frequent utilization, and access to a minimum of four functions of mobile phones such as internet browsing, message applications, voice calls, and media. Yet another 30% demonstrated moderate access and use, typically having either a smartphone or feature phone, and using them every day or a few times a week, with two or three feature phone uses. The last 30% demonstrated low access and use, occasionally basic phone ownership or not at all, and infrequent use limited to voice calls and SMS.

These results are consistent with the pattern at the regional level reported in comparable African contexts. Asongu et al.'s (2018) study of mobile phone penetration in sub-Saharan Africa concluded that higher smartphone penetration is seen in urban areas, although usage tends to be biased by socio-economic inequality and that high-frequency as well as multifunctional usage tends to be limited to the middle and upper-income groups. Consequently, Aker and Mbiti (2010) observed that mobile phone use in African cities not only encompasses ownership but also digital literacy and the ability to afford data services that constrain meaningful utilization in lower socio-economic segments.

In Ghana proper, Osei-Akoto and Frempong (2017) established that while the cities such as Accra, a large percentage of the populace still use basic phones and minimal mobile functionality because of income limitations and unstable coverage. This is in line with 30% of Tamale participants in this research categorizing under low access and usage, indicating persisting infrastructural and economic limitations to technological integration.

Contrarily, research in Accra and Kumasi like that of Boateng et al. (2020) has shown higher mobile phone functionality among working people and youth, with smartphones used to access mobile apps, social media, and mobile money being the norm. But even there, usage is also segmented on the basis of education and wealth, confirming the observation in Tamale that there is a very high percentage of people who have only very limited access to mobile technology.

The comparatively high percentage (40%) of Tamale respondents with high access and usage can be explained by the urbanization trend of the city, the availability of tertiary institutions, and increasing youth exposure to digital technologies. The fact that 30% of the respondents continue to have low access, however, highlights the importance of targeted interventions to close the digital divide. This could involve infrastructural expansion, subsidized schemes for smartphones, and digital literacy training with special attention given to covering the needs of marginalized groups.

Table 4.3: Overall Levels of Mobile Phone Access and Usage among Respondents

Level of Access & Usage	Criteria Summary	Estimated No. of Respondents	Percentage
High Access & High Usage	Own smartphone, use multiple times/day, and access ≥ 4 phone functions	160	40.0
Moderate Access & Usage	Own smartphone or basic phone, use daily or several times/week, and use 2–3 basic functions	120	30.0

Low Access & Low Usage	Own no phone or basic phone only, use once a week or less, and use only calls/SMS	120	30.0
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Source: Field Survey Data, (2024)



4.3 How mobile phones are being used to access and disseminate climate change information in the metropolis

This section presents results and discussion on how mobile phones are being used to access and disseminate climate change information in the metropolis.

4.3.1 Access and Dissemination of Climate Change Information via Mobile Phones

According to the results depicted in Table 4.4, the research revealed wide-ranging results on the access and dissemination of information on climate change by residents of the Tamale Metropolis using mobile phones. Of the 400 interviewed respondents, 55 percent asserted to have obtained information related to weather or climate using mobile phones, while 45 percent asserted otherwise. This access, which is moderate, conforms to previous research conducted in rural and peri-urban Ghanaian settings, for instance, Nyantakyi-Frimpong and Bezner-Kerr (2015), who indicated that despite the high penetration of mobile phones, the adoption of such technology for climate-related messaging is uneven. In the same vein, a research by Okello, Okumu, and Egeru (2020) in Uganda concluded that fewer than half of the rural populace had accessed climate-related and agriculture mobile-based messages as a result of predominantly technological and infrastructure limitations.

Among those who had ever been reached with information on climate change (n = 220), through which the information was received was reported. The most common channels were SMS messages (68.2 percent), voice calls (54.5 percent), word of mouth from family and friends (59.1 percent), and social media platforms (50 percent). Mobile apps (40.9 percent) and mobile-based community radio (45.5 percent) were also mentioned. These results sustain the contention of Aker and Mbiti (2010), who illustrated that voice and text platforms remain indispensable for the provision of information in sub-Saharan Africa, especially among the illiterate. Dzidonu (2010)



posits, however, that the use of informal and voice-based transmission can erode the timing and correctness of information exchanged, especially where technical information is lost in the process of translation.

The rate of receiving climate information varied significantly among respondents. Approximately 27.3 percent had messages every day, 31.8 percent every week, 22.7 percent every month, and 18.2 percent seldom. This trend shows that although access exists, it is neither regular nor consistent for a majority of the population. These same trends were noted in Ouedraogo et al. (2018) research in Burkina Faso, with farmers predominantly getting weather information at unperiodic intervals, hence remaining of little value for adaptive response planning in a timely manner. Danso-Abbeam and Baiyegunhi (2017) also noted in the case of Ghana that even with the prospects from Information and Communication Technology tools, irregular information flow remains a challenge to households' effective adaptation planning.

Additionally, in the study, it was found that a significant percentage (72.7 percent) of those who had received climate information indeed shared it with other people. This shows the contribution of the community member to information sharing. It was shared mainly through voice calls (68.8 percent), SMS (62.5 percent), and social media (50 percent). These findings buttress the social dimension of information diffusion, where social networks and trust take center stage, as per the study of Tambo and Abdoulaye (2012) who emphasized the role of social capital in Nigerian agricultural innovation adoption. Similarly, Jalloh et al. (2013) noted that common practice patterns for sharing information in Sierra Leone heightened awareness of agricultural risk, especially where there was poor formal communication system.



Interestingly, social media and mobile app-based information access and sharing are a new phenomenon in peri-urban and urban Ghana's digital communication environment. Nevertheless, their generally lower usage compared to that of SMS and voice indicates that digital divides continue to exist. Ahiataku-Togobo and Owusu (2021) indicate that this digital divide is observed to adhere to literacy, income, and network availability, influencing the access and response to climate information.

Table 4.4: Access and Dissemination of Climate Change Information via Mobile Phones

Attributes	Frequency	Percentage
Receiving climate change/ weather info on phone:		
Yes	220	55.0
No	180	45.0
Frequency of receiving climate info:		
Daily	60	27.3
Weekly	70	31.8
Monthly	50	22.7
Rarely	40	18.2
Channels used to receive climate info (Multiple responses):		
SMS alerts	150	68.2
Voice calls	120	54.5



Social media platforms	110	50.0
Mobile apps	90	40.9
Community radio via mobile phone	100	45.5
Informal sharing from family/friends	130	59.1
Do you share climate information via mobile phone (<i>n</i> = 220):		
Yes	160	72.7
No	60	27.3
How information is share? (Multiple responses):		
SMS/Text messaging	100	62.5
Voice calls	110	68.8
Social media platforms	80	50.0
Mobile apps	60	37.5

Source: Field Survey Data, (2024)





4.3.2 Types of Climate-Related Information Received via Mobile Phones

Based on information presented in Table 4.5, 71.0% of the respondents in the Tamale Metropolis indicated receiving everyday and weekly weather forecasts through mobile phones, and it was the most utilized form of climate-related information. This result is parallel with Tetteh et al. (2021), who wrote that weather forecasting is the most applied climate service via mobile phones in most peri-urban settlements in northern Ghana. Ayanlade et al. (2019) also, in a Southwestern Nigeria study, demonstrated that the application of mobile weather forecasts was quite frequent when planning agricultural activities at more than 68%. These analyses indicate that weather information is highly pertinent and regularly updated, which would render them more useful to target users like farmers and merchants.

Mobile phone dissemination of severe weather alerts, by contrast, was reported by just 49.5% of the sample population. Although important, this rate represents a gap in emergency communication that has been noted by Antwi-Agyei et al. (2020) as well, where they established that a large percentage of the exposed population in northern Ghana had no idea of the weather extremes approaching because of poor dissemination systems. Likewise, Malawian research by Mutsvangwa et al. (2018) indicates that mobile severe weather warnings are delayed or poorly targeted, losing their impact. It suggests that there should be improvement in early warning systems, for example, more timely and targeted mobile messaging.

Receipt of wider climate change news and information was experienced by 53.0% of respondents. This relatively moderate access is congruent with findings by Owusu and Waylen (2013), who stated that although increased general awareness concerning climate change exists in Ghana, frequent and regular information access is not even. Nhamo and Muchuru (2019) also recognized the same pattern in Zimbabwe, where mobile phones were being used increasingly in the

dissemination of environmental news but were constrained by literacy levels and network coverage in rural settings. The findings point to the use of mobile phones as transformational technologies for public engagement with climate discourse, yet there remain issues with content suitability and technical capability.

Information on air quality was the least exploited category of data, as stated by only 26.5% of the respondents. Limited application could be due to the relative newness and low ranking of air quality as a matter of public interest in most areas of Ghana. Boateng et al. (2022) argued that public concern about air pollution is less likely to be addressed as similarly severely as weather variability. In addition, a survey carried out by Amegah and Agyei-Mensah (2017) indicated that although air quality issues emerged while being in Accra, mobile platforms are behind in providing health-related information related to it. That indicates a latent potential to merge environmental health warnings into patterns of mobile communication, especially in urban settings with growing levels of air pollution.

Local climate action, i.e., e.g., tree planting and clean-up activities, information was received by 36.0% of the respondents. This shows moderate mobile platform action with climate action at the local level. Climate action at the community level is triggered, as shown by a study by Yaro and Hesselberg (2016), by NGOs and local leaders and not by direct mobile communication, which can account for the relatively lower rates. Yet, Owusu-Daaku and Agyeman (2021) cite the growing use of WhatsApp and SMS channels in mobilizing women and youth in urban areas in Ghana for local environmental activism. This is a shift towards socially embedded communication, but whose reach is still restricted by digital capacity and device ownership.



Table 4.5: Types of Climate-Related Information Received via Mobile Phones

Type of Information Received	Number of Respondents	Percentage
Weather forecasts (daily, weekly)	284	71.0
Severe weather alerts (e.g., heavy rains)	198	49.5
Climate change news and updates	212	53.0
Air quality index updates	106	26.5
Local climate events (e.g., clean-ups)	144	36.0

Source: Field Survey Data, (2024)



4.4 The infrastructural and socioeconomic factors affecting the effective use of mobile phones for climate change communication

This section presents results and discussion on the infrastructural and socioeconomic factors affecting the effective use of mobile phones for climate change communication.

The logistic regression model in Table 4.6 provides a structured examination of the determinants of the infrastructural and socioeconomic variables that affect the effective utilization of mobile phones in climate change communication in the Tamale Metropolis. The research, with 400 observations, has a Nagelkerke R^2 of 0.296, which is a moderate explanatory power.

Through the analysis, it is revealed that respondents who indicated having good network coverage were 2.8 times likely to use mobile phones efficiently in acquiring climate change information (OR = 2.816, $p < 0.001$). This is in agreement with Asenso-Okyere and Mekonnen (2012), who discovered that network quality not only affects access but also frequency of use of mobile services for farm extension and climate information. In Ghana, in which more than 85 percent of the population is located in places technically reached by mobile networks, there is weak and inconsistent quality, especially in peri-urban and rural areas (Nyantakyi-Frimpong & Bezner Kerr, 2015). Likewise, Jalloh et al. (2013) documented in their West African regional report that weak network coverage interrupts the delivery of timely weather forecasts and seasonal warnings, especially in northern Ghana and Burkina Faso. These interferences are likely to result in lost adaptation opportunities, thereby placing significance on network connectivity and signal strength. Conversely, based on their research on the use of ICT among cocoa farmers in Ghana's Western Region, Okello and Addai (2020) discovered that even where networks existed, low digital literacy and sharing of telephones among consumers muted the effectiveness of mobile-based services. This implies that although network coverage constitutes a building block, social and human factors



also mediate its efficacy. Thus, in Tamale, where youth and literate societies prevail, the infrastructural advantage can be maximized in climate communication.

Access to electricity also came out strongly as a determinant of climate information usage of mobile phones with an odds ratio of 2.396 ($p = 0.001$). Where power supply is inconsistent, usage of mobile phones is typically constrained by the fact that one cannot charge gear in time. Drawing from their investigation of off-grid solar-powered community centers in Northern Ghana, Agyekumhene et al. (2019) observed that information and service access were significantly enhanced by off-grid solar power through ensuring regular recharging of mobile phones. Likewise, Matinga et al. (2014) recorded the catalytic functions of decentralized solar systems to drive energy access expansion in rural Malawi, complementing access to radio, TV, and mobile-based information platforms. Yet, in comparison, Essandoh-Yeddu and Osei (2017) noted that although solar power is renewable, the use thereof is normally limited by the initial cost and maintenance issue, more so in remote Ghanaian villages. That is, while the availability of electricity complements the use of mobiles, one must consider the source as well as the reliability of the electricity when seeking to facilitate long-term communication interventions.

Mobile phone services affordability emerged as a statistically significant predictor of the effective use of mobile phones for climate information, with an odds ratio (OR) of 1.857 ($p = 0.016$). It indicates that users who find mobile phone services affordable are almost twice more likely to effectively use mobile phones for obtaining climate information. This result parallels the result of Agyekumhene et al. (2019), which noted that most residents in Northern Ghana limit airtime and mobile data by cost, impacting their frequency of use of climate forecasts. Antwi-Agyei et al. (2021) also noted that smallholder farmers, especially women, are not frequently in a position to purchase call credits or data bundles and hence are subjected to limited use of mobile climate





services. Nonetheless, in contrast to Mtega et al. 's (2014) Tanzanian study that reported that subsidized SMS notification raised poor farmers' adoption of climate information, existing evidence points out that affordability is still a hindrance despite increases in mobile penetration. The two studies together suggest that even if there is universal ownership of phones, cost of use still holds full interaction with climate communication platforms at bay.

Literacy, with an OR of 3.077 ($p < 0.001$), was the strongest predictor of good use of mobile phones in this study. Interviewees who were literate were three times better at using mobile platforms to access climate information. This supports the contention by Tambo and Abdoulaye (2012) that comprehension and interpretation of technical information are pertinent in response to weather warnings and adaptation measures received through mobile technology. Likewise, Awuor et al. (2020) observed that low literacy among Kenya's rural communities undermined their self-esteem and capacity to read SMS-based extension messages. These are still greater for marginalized social groups, including elderly farmers and illiterate women, who will need to have intermediaries to interpret messages. However, there is counter evidence through Owusu et al. (2022) in Eastern Ghana, which has shown that voice services and radio interfaces have brought an end to literacy barriers in certain environments, offering the contribution of types of adapted communication to the local capacities. The present finding again asserts the pivotal role of core literacy in filling the information access-action gap in climate adaptation.

At the income level, while the odds ratio of 1.651 signifies a positive relationship between income and proper mobile phone use, the relationship was not statistically significant ($p = 0.072$). This implies that even additional income might be enabling purchase of device and mobile services but that factors like literacy and awareness might be playing an even stronger role on the actual usage. Previous research by Nyantakyi-Frimpong and Bezner-Kerr (2015) in Northern Ghana revealed



that richer households had better opportunities for investing in farm technologies such as mobile-based CIS. Similarly, Sawadogo et al. (2018) in Burkina Faso revealed that income inequality influences digital sources of information, particularly during unfavorable weather conditions. However, the result of this study supports the contention by Dossou and Glehouenou-Dossou (2007) that income will never lead to useful use in the absence of the capacity to comprehend and faith in received information. Furthermore, power relations within households, as argued by Arku and Arku (2010), influence the extent to which income leads to the experience of access to mobile technology, particularly in instances where communication device expenditure is controlled by men.

Education is also a statistically significant predictor of the effective use of mobile phones with an odds ratio of 1.093 ($p = 0.048$). This shows that for every extra year of education, the tendency to use mobile phones in an effective way to obtain climate-related information is rising. This concurs with Nyantakyi-Frimpong and Bezner Kerr (2015) finding, who established that increased educational levels improve farmers' capacity to understand and use weather advisory services in Northern Ghana. Asenso-Okyere and Mekonnen (2012) also established that education raises digital literacy resulting in improved use of mobile-based information systems by African farmers. The result is also in line with a wider pattern across sub-Saharan Africa, which has been recorded by Mtega et al. (2013), where they found that higher levels of education feed positively into both access and knowledge of ICT content, especially in climate risk and agriculture. Nevertheless, these findings are contrary to those of Antwi-Agyei et al. (2018), who confirmed that while education has eased access to information, it is not necessarily put into practice unless coupled with local extension and training assistance.

Age, while not being statistically relevant ($OR = 0.707$, $p = 0.081$), demonstrates a negative trend with the successful use of the mobile phone, indicating that older people might be less willing or capable to utilize mobile phones in an attempt to seek climate change information. This is echoed by Boateng and Thomas (2021), whereby they discovered that older farmers in Northern Ghana were less at ease with the utilization of mobile apps and favored direct contact via extension agents. Similarly, Mutunga and Deen-Swarray (2020) indicated that younger generations of individuals in Kenya and Tanzania were more literate with regards to mobile technology because they were accustomed to and exposed to working with digital tools on a regular basis. Conversely, though, Sulemana et al. (2019) conducted a study in Ghana's Upper West Region and indicated that age didn't meaningfully constrain the usage of the mobile phone where there are training and support mechanisms in the community. What this means is that although age can impose initial constraints, support systems in society are able to turn its effects around.

Gender-wise, the model does not reveal any statistically significant impact on productive mobile phone use ($OR = 1.170$, $p = 0.430$). This observation is against the findings that highlight gender differences in ICT use. For example, Aker and Ksoll (2016) established that women in rural West Africa experienced higher barriers to mobile phone purchase and usage primarily because of social norms and economic subordination. Likewise, Alhassan and Abu (2020) likewise found that, in Northern Ghana, men dominated the household appliances, limiting women's autonomy to use digital information independently. Contrarily, the non-significance of gender effect in this study may be an indicator of rising parity in mobile phone possession among urban places such as Tamale, where public campaigns and access to markets have enhanced women's autonomy. This is affirmed by evidence from Dzanku and Sarpong (2019), whose study in peri-urban Ghana documented gender gaps closing in mobile use for accessing climate and agriculture services.

Table 4.6: Logistic Regression Results: Factors Influencing Effective Use of Mobile Phones for Climate Change Communication

Predictor	Coefficient (β)	Std. Error	Wald square	Chi- p-value	Odds Ratio (Exp(β))	95% CI for OR
Intercept	-2.152	0.483	19.86	<0.001	0.116	0.054 – 0.249
Network Coverage (Good=1)	1.035	0.247	17.54	<0.001	2.816	1.781 – 4.454
Electricity Availability	0.874	0.273	10.25	0.001	2.396	1.430 – 4.013
Affordability (Yes=1)	0.619	0.258	5.76	0.016	1.857	1.118 – 3.085
Literacy (Literate=1)	1.124	0.312	12.97	<0.001	3.077	1.667 – 5.682
Income (High vs Low)	0.501	0.278	3.24	0.072	1.651	0.958 – 2.845
Education Level (Years)	0.089	0.045	3.92	0.048	1.093	1.001 – 1.194
Age Group (Older=1)	-0.346	0.198	3.05	0.081	0.707	0.481 – 1.039
Gender (Male=1)	0.157	0.199	0.62	0.430	1.170	0.781 – 1.754



Log-Likelihood:	-198.21
Pseudo R ² (Nagelkerke):	0.296
N (Observations)	400

Source: Field Survey Data, (2024)





4.5 The effectiveness of existing mobile-based communication strategies in promoting awareness and adaptive responses to climate change in Tamale Metropolis

This section presents results and discussion on the effectiveness of existing mobile-based communication strategies in promoting awareness and adaptive responses to climate change in Tamale Metropolis.

4.5.1 Respondents' Perceptions of Mobile-Based Climate Change Communication Strategies

The information in Table 5.7 indicates the way the respondents in the Tamale Metropolis view mobile-phone-mediated communication strategies towards climate change awareness and adaptation. It is evident from the results that the mobile phones are performing moderately to allow climate communication, although there are some challenges involved.

The majority (65%) of the respondents, in overwhelming agreement, concurred or strongly concurred that the climate change information they received through mobile phones is understandable. This concurs with Owusu et al. (2021), who in studies conducted among rural communities in Ghana indicated that mobile phone messages, specifically voice and local language SMS, improved environmental and agriculture advisories' understanding. However, this finding is a bit more positive than that of Muleke et al. (2020) for Kenya, where technical jargon and language used to disrupt accurate understanding of mobile alerts.

With regard to adaptation, 63% of the respondents replied that cell phone messages have enabled them to know how to adapt to weather change. This corroborates Danso-Abbeam et al. (2018), who argued that northern Ghanaian smallholder farmers who had access to agricultural advice through mobile platforms were in a better position to implement early planting and drought-resistant seeds. Along the same lines, Ouedraogo and Dembele (2019) discovered in Burkina Faso



that mobile climate services resulted in higher uptake of adaptive agriculture practices. These works highlight the potential for transformation by mobile communication when locally informed and relevant.

Trust was equally half given by the respondents (50%) to the mobile-based sources of climate change information. Antwi-Agyei and Stringer (2021) also observe this, since although the mobile phone was a required communication device employed during the 2020 Accra floods, the recipients challenged the credibility as well as the source of the messages. Nhamo and Muchuru (2015) also found in Zimbabwe that non-trust in non-traditional information channels, i.e., mobile alerts, reduced their impacts on decision-making. The results put emphasis on institution building and agents behind mobile messaging as a trusted source of information, perhaps through community mobilization or association with local opinion leaders.

Along with the ability of mobile communication to facilitate change of behavior, 58% of the interviewed respondents indicated that it made them behave in order to adapt to climate change. This agrees with Yaro et al. (2020), which showed that SMS campaigns on bushfire prevention in the Upper East Region have achieved quantifiable changes in household fire management. Nevertheless, the report also shows that 25% of the respondents were either neutral or disagreed, which is the awareness-action gap. Agyekumhene et al. (2020) mentioned that gaps in such aspects typically result from socioeconomic constraints rather than a lack of communication per se, such as inadequate access to tools of adaptation.

Timeliness of warnings was also a point to improve. Although 57% of the respondents agreed that they got timely climate warnings through mobile phones, 27% disagreed or strongly disagreed. This is consistent with Apata et al. (2016) in Nigeria who concluded that frequent network



coverage and late release truncated the efficacy of mobile-based early warning systems. In addition, Dery et al. (2019) further observed in Ghana's Northern Region that technological factors, e.g., unguaranteed electricity supply for clients to charge devices, affected receiving timely messages.

Respondents were reasonably positive about the applicability of mobile climate information to their local context, with 56% agreeing or strongly agreeing. This supports the contention of Tambo and Wünscher (2017) of being keen to see targeted location-based content being brought into climate information services. But a majority were neutral or disagreed, supporting the conclusion reached by Acheampong et al. (2020) that top-down content creation in mobiles is likely to overlook local environmental conditions.

Sharing of information is another crucial element. Sixty percent of the respondents reported having exchanged climate information through mobiles with other individuals within the community. This result is consistent with Yeboah et al. (2021), who highlighted social diffusion of agricultural and environmental knowledge on WhatsApp groups and peer networks within Ghana. Nonetheless, Mugambiwa (2018) in South Africa discovered that although young people were more inclined to provide such information, the older generations were less involved because of a lack of digital skills, indicating that age-specific methods need to be employed.

Lastly, mobile communication is discovered to have a positive impact on knowledge levels. An overwhelming majority of 68% of the respondents concurred that mobile phones made them more knowledgeable about climate threats in Tamale. This supports research by Codjoe et al. (2014) and Amadu et al. (2020), which established that climate education campaigns in urban Ghana based on mobile made individuals more knowledgeable about flooding, drought, and health

climate threats. However, part of the population is not engaged, suggesting potential hindrances such as restriction to access mobile phones or depletion of content.



Table 5.7: Respondents' Perceptions of Mobile-Based Climate Change Communication Strategies

Statement	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
The climate change information I receive on my mobile phone is easy to understand.	24 (6.0%)	40 (10.0%)	76 (19.0%)	132 (33.0%)	128 (32.0%)
Mobile phone messages have helped me learn how to adapt to changes in weather patterns.	36 (9.0%)	48 (12.0%)	64 (16.0%)	120 (30.0%)	132 (33.0%)
I trust the sources of climate change information communicated through mobile phones.	52 (13.0%)	68 (17.0%)	80 (20.0%)	104 (26.0%)	96 (24.0%)
Mobile-based communication encourages me to take specific actions to cope with climate change	44 (11.0%)	56 (14.0%)	68 (17.0%)	120 (30.0%)	112 (28.0%)
I receive climate alerts on time via my mobile phone to help me prepare adequately	60 (15.0%)	48 (12.0%)	64 (16.0%)	116 (29.0%)	112 (28.0%)



The mobile climate information I receive is relevant to my local environment and needs	48 (12.0%)	60 (15.0%)	68 (17.0%)	116 (29.0%)	108 (27.0%)
I have shared climate change information received via mobile phone with others in my community	40 (10.0%)	52 (13.0%)	76 (19.0%)	120 (30.0%)	112 (28.0%)
Mobile phones have improved my awareness about climate change risks in Tamale Metropolis	28 (7.0%)	36 (9.0%)	64 (16.0%)	132 (33.0%)	140 (35.0%)

Source: Field Survey Data, (2024)





4.5.2: Adaptation action used by respondents to adapt to climate change in Tamale Metropolis

The results in Table 4.8 show attitudes regarding adaptive measures undertaken by the inhabitants of Tamale Metropolis following climate change and how these actions reflect on the impacts of mobile-based communication. Among the six highest ranked adaptive measures, adaptation of farming practices was the most utilized approach with a mean rank value of 2.16, followed by measures to conserve water (mean rank = 2.41). The least used method was the application of climate-resilient crop varieties, which recorded the highest mean rank of 5.18. The level of overall respondent agreement, as calculated by Kendall's Coefficient of Concordance ($W = 0.0912$), was low and revealed that there existed heterogeneity in adaptation options defined by personal contexts, availability of resources, and differences in exposure to climate change communication.

The need for farm practices to adapt is in line with research by Antwi-Agyei et al. (2018), which emphasized how Ghanaian farmers traditionally adjust planting date and crop type due to climatic change. Likewise, Jalloh et al. (2013) confirmed that in West Africa, adjusting planting and harvest times was one of the easiest and most straightforward coping mechanisms utilized by rural farmers. Such strategies are normally just communicated through mobile platforms, which offer timely updates on pest infestations, weather predictions, and best planting times. Although Antwi-Agyei et al. observe that such information availability is not equal, particularly to poor or less literate farmers, this present study argues that mobile phones have started bridging such an information gap in Tamale.

Water-saving behaviors came second, illustrating a modest but increasing interest in water resource conservation. Tambo and Wünscher (2015) in their northern Ghana research proposed mobile phones helped share water-saving tips, especially with communities that were susceptible



to unpredictable rains. The same is argued by Mungai et al. (2017) in Kenya, where farmers' water usage behavior was notably shaped through text-based agricultural extension messaging. But all the seeming advantages notwithstanding, adoption is limited by the lack of contact with irrigation technology and technical knowledge on how to use such techniques effectively. So while efficient as mobile phones are in transmitting information, their effectiveness is tempered by the existence of enabling physical and institutional factors.

The middle-of-the-pack ranking for the installation of rainwater harvesting systems (mean rank = 3.02) also warrants mention. Although this practice has worked well in augmenting local water security during droughts (Kwakye et al., 2020), it is hardly in use, likely because of the installation cost and an absence of technical knowledge. In South Africa, rural society would not embrace harvesting systems without state or NGO-program intervention, Mutekwa (2009) determined. For Tamale, promotion of awareness through mobile-based communication will be appropriate, but without reinforcement in practice, implementation is limited.

Joining community awareness programs achieved an average score of 3.95, indicating respondents' values assigned to construction of knowledge in a shared platform. This result is in agreement with Adiku et al. (2022), who were of the view that mobile phones have led to increased participation in climate fora, particularly women and young people in Ghana. Yet, as promising as it may seem, Asare-Nuamah and Botchway (2019) noted that access to such initiatives in Ghana remains heavily dependent on social networks and transportation, which cannot be addressed through mobile communication.

Lower-order indicators, such as adoption of conservation agriculture techniques and climate-resilient crop varieties, indicate underlying system issues. For example, Asare-Nuamah et al.

(2020) discovered that northern Ghanaian farmers may not be aware of or have access to enhanced seed varieties despite mobile campaign marketing for them. Likewise, Mutsvangwa and Dube (2017) verified that though conservation agriculture was pushed by mobile platforms in Zimbabwe, adoption was constrained by insecure tenure and poor training.

Table 4.8: Adaptation action used by respondents to adapt to climate change in Tamale Metropolis

Adaptation action	Mean rank
Altering farming practices	2.16
Using water-saving techniques	2.41
Installing rainwater harvesting	3.02
Participating in community awareness	3.95
Implementing soil conservation	4.66
Utilizing climate-resilient crops	5.18
Number of Respondents (n)	400
Number of Items Ranked (m)	6
Sum of Squared Deviations (S)	54,320
Kendall's W	0.0912

Source: Field Survey Data, (2024)



CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.0 Introduction

This chapter presents the summary and synthesis of the principal findings of the study of mobile phone penetration and its contribution to deepening climate change communication within Tamale Metropolis. Drawing from the critical research objectives, the chapter summarizes the socio-demographic profile of the respondents, the level of access to mobile phone technology, and how mobile phones are being used to receive and disseminate climate information. It also analyzes the infrastructural and socioeconomic determinants affecting the efficient utilization of mobile phones in this regard and assesses the perceived efficiency of existing mobile-based communication interventions in promoting awareness and adapting behaviour.

5.2.0 Summary of findings

The study assesses the level of penetration of mobile phones and analyses its role in promoting climate change communication among citizens of Tamale Metropolis. A descriptive study design based on quantitative research method was employed in data gathering in the research. A questionnaire was employed to gather the study data. The sample size of 400 were collected from sampled populations. Frequency, percentage, logistic regression and Kendall's concordance analysis were all employed for this study.

5.2.1 Socio-demographic characteristics of respondents

The majority of the participants (77%) were aged 25 to 34 years, indicating a youthful and economically productive population in Tamale Metropolis. Females had a slightly larger proportion (58%) of the sample than males (42%). Education was generally high, with 50% of the



participants having tertiary education and 30% having secondary education, only 5% of whom had no formal education. Occupationally, the majority of the respondents were farmers (35%), followed by traders (20%), students (15%), artisans (12.5%), civil servants (10%), and the unemployed (7.5%). The respondents' income levels indicated that 40% had incomes ranging from GHS500 to GHS1000, 20% earned less than GHS500, and only 5% earned more than GHS2000.

5.2.2 The level of access to mobile phone technology among residents in Tamale Metropolis

The research reveals that there is very high mobile phone penetration of the population in Tamale Metropolis as 80% of the interviewees claimed to own a mobile phone. Among them, 56.2% of them owned smartphones, and 43.8% of them owned basic feature phones. Almost 62.5% of the interviewees used more than one SIM card, mostly as a means of managing network dependability and cost. On frequency of use, 56.2% said they used their phones several times a day, while only 9.4% used them once or less weekly. Mobile phone services were also extensively used: 96.9% of them used voice call, 87.5% used SMS, 62.5% used mobile internet browsing, and 59.4% used social media sites. Use of mobile money was prevalent at 75%, indicating its increasing application in financial transactions. Furthermore, 56.2% of the respondents interviewed used mobile applications, namely health and agriculture information. The research divided mobile phone usage and access into three levels: 40% of the interviewees had high use and access (smartphone intensive usage and several functions), 30% had moderate access (limited to basic smartphone usage with two or three functions), while the other 30% had low access (basic telephone or no phone usage, limited to calls and SMS).

5.2.3 How mobile phones are being used to access and disseminate climate change information in the metropolis

The research revealed that 55% of the respondents had received weather or climate messages on their cellular phones, which is a sign of moderate access. Of these, the channels of communication most used were SMS (68.2%), voice call (54.5%), word of mouth through relatives and friends (59.1%), social media (50%), mobile apps (40.9%), and phone radio (45.5%).

With respect to frequency of receipt of information, 27.3% received daily messages, 31.8% weekly messages, 22.7% monthly messages, and 18.2% rarely. Most (72.7%) of the recipients of the climate information also shared the information with others—largely in voice calls (68.8%), SMS (62.5%), and social media (50%). Weather forecasts (71.0%) were the most widely used type of climate-related information, followed by general climate change news (53.0%) and severe weather warnings (49.5%). Reports on community activities (36.0%) and air quality information (26.5%) were received less often.

5.2.4 The infrastructural and socioeconomic factors affecting the effective use of mobile phones for climate change communication

Logistic regression also indicated that good network coverage highly enhances the probability of mobile phone utility for climate information by almost three times (OR = 2.816, $p < 0.001$). Being well-electrified doubled the probability of mobile phone utility (OR = 2.396, $p = 0.001$), also indicating the significance of power supply in using devices. Affordability of telephone services was also another significant factor, and those study participants who thought the prices were within reach were nearly twice as likely to make efficient use of mobile phones (OR = 1.857, $p = 0.016$). The literacy predictor was strongest, increasing the chances of successful use by three (OR = 3.077, $p < 0.001$), highlighting the importance of reading and comprehension abilities in retrieving

climate information. Education had a positive impact also, with each extra year of education increasing the chances by approximately 9% (OR = 1.093, $p = 0.048$). Income level was positively, but not statistically, associated (OR = 1.651, $p = 0.072$) to indicate that other factors than income affect use. Age was inversely associated with the use of mobile phones (OR = 0.707, $p = 0.081$), with older people using mobile phones less effectively, although this was not statistically significant. Gender was not a strong predictor of mobile phone use (OR = 1.170, $p = 0.430$), indicating comparatively equal access and use by men and women in the study area.

5.2.5 The effectiveness of existing mobile-based communication strategies in promoting awareness and adaptive responses to climate change in Tamale Metropolis

The research also established that mobile-phone communication approaches were fairly effective in arousing climate change awareness and adaptive responses in Tamale Metropolis. The information disseminated through mobile phones was straightforward and understandable to two-thirds of the participants (65%), and 63% reported that it informed them about coping with new climatic conditions. Just half of the participants viewed such sources as reliable. In addition, 58% supported that mobile communication motivated them to make changes, and 57% concurred on getting alerts in a timely manner, yet more than a quarter denied it. Approximately 56% considered the information contextually relevant, whereas 60% reported having shared climate information with other members of their community. Astonishingly, 68% stated that mobile phones made them more aware of climate dangers. The most common adaptation behaviour in mobile communication was shifting agricultural practice, with water-saving practices being the second most common. The other adaptations involved installation of rainwater harvesting systems and engaging in local awareness programs. The low Kendall's Coefficient of Concordance ($W = 0.0912$) signified varied

adaptation choices available in the population, driven by personal resource, information, and action capacity.

5.3 Conclusions on the study

Based on the study findings, the following conclusions were proposed;

5.3.1 The level of access to mobile phone technology among residents in Tamale Metropolis

In conclusion, the study established that mobile phone technology is highly accessible among the population of Tamale Metropolis. A predominant percentage of the population uses mobile phones with a corresponding division between smartphone and feature phone users. The population uses various coping measures like utilizing multiple SIM cards to compensate for network unreliability and maximize costs of communication. Usage frequency describes the extent of embeddedness of mobile phones in everyday life because most users engage with their phones several times a day. Mobile phones are utilized for instrumental function aside from communication. Voice call and short message service are the most used functions, but there is increasing use of internet browsing, social media, and mobile applications. Mobile money transactions are also common, which is a sign that residents' economic activities have undergone change. Mobile health and agricultural apps are also on the rise, which shows that there is a livelihood and well-being information need. Three tiers are employed by the study to segment levels of access and usage in a heterogeneous population with dissimilar abilities to exploit the potential of mobile technology. High access users utilize all kinds of functions a lot, whereas others stick to basic services like calls and messages.

5.3.2 How mobile phones are being used to access and disseminate climate change information in the metropolis

The study concluded that mobile phones are a major means of accessing and sharing climate change information by the residents of the Tamale Metropolis. Most of the population uses several



channels, such as text messages, voice calls, social media, and mobile applications, to gain climate messages, which indicate the various modes through which individuals access digital information. The rate at which this information is received is uneven, testifying to differential activity and perhaps differential access. Notably, the spread of information goes beyond single reception in that most receivers actively relay climate messages to their intended social networks, testifying to information sharing being social. Most sought-after material is still weather forecasts, and it testifies to a keen desire for up-to-date and practical information to inform daily choices. While, at the same time, lack of infrequent access to information on community matters and air quality indicates possible communications coverage deficits.

5.3.3 The infrastructural and socioeconomic factors affecting the effective use of mobile phones for climate change communication

Furthermore, the study concluded that effectiveness of mobile phone use in climate change communication in the research area largely relies on infrastructure and socioeconomic determinants. Secure access to electricity and good quality network coverage prove to be the basic necessities, allowing users to be able to adequately utilize mobile-based information. Affordability of mobile phone services is also key to facilitating usage, revealing that economic access plays a crucial part in how climate information is being used. Literacy is significant, operating on the basis of basic reading and comprehension ability as a prerequisite to grasping and applying climate information. Education generally plays a positive role in that continuous learning constitutes an empowerment keystone. Income level seems to play some role, not the only one, but there is a suggestion that contextual factors come into mobile phone use. Older citizens' reluctance not to use mobile phones as effectively captures intergenerational variation in a way that could be transcended by support or training for their use. Gender does not appear to restrict access or

application under these circumstances and represents a fairly stable opportunity for men and women to enjoy the benefits of mobile communication support.

5.3.4 The effectiveness of existing mobile-based communication strategies in promoting awareness and adaptive responses to climate change in Tamale Metropolis

Finally, the concluded that communication strategies using mobile phones are significant in increasing awareness and advocating adaptive measures to curb climate change in Tamale Metropolis. The information disseminated via mobile phones is likely to be easily accessible and useful in guiding people on how to react towards environmental changes. The trust level in the communications varies, though with a mandate to improve the validity and reliability of sources of information. While mobile communication entices others to adopt adaptive measures, prompt warnings and applicability of the information to the local environment are still areas for improvement. The sharing of climate information among communities underscores the social utility of such communication systems.

Mobile messaging-influenced adaptation behaviors vary widely, and residents implement a lot of behavior change, including agricultural practices and saving water. Other adaptive activities, including the installation of rainwater harvesting systems and sensitization at the community level, have moderate adoption, mirroring various capacities at the individual level and resource availability. The variability in adaptive decision demonstrates that mobile communication can empower but also relies on other socially, economically, and infrastructurally induced circumstances that open or restrict action.

5.4 Recommendations

Based on the study findings, the following recommendations are made for research and policy consideration.





Based on the study findings, the following conclusions were proposed;

1. This study recommends that telecommunication organizations, in conjunction with departments of the local government, give top priority to expansion and upgradation of network infrastructure within the Tamale Metropolis. Network reliability and coverage will expand to render the use of more than one SIM card unnecessary and bridge connectivity gaps currently dampening optimal utilization of the mobile phone. Through affordable and secure access, particularly to isolated communities, such players can enable more percentage of the population to tap into the rich potential of mobile technology. This will not only improve communication but also enable vital sectors like health, agriculture, and financial services, which overall lead to enhanced livelihood and social well-being for the people.
2. The study further recommends that local government officials in Tamale Metropolis should partner with telecommunications companies as well as community organizations to design and roll out a customized, multi-channel communication plan that addresses prevailing access gaps and content deficiencies. This strategy would give highest priority to reaching previously inaccessible groups, making messages accessible in accessible formats and local languages, and tailoring content to include weather forecasts as well as messages regarding community events and environmental conditions. Involving community leaders and voices of trust in the dissemination process can lead to greater trust building and allow greater sharing within social networks. It will ensure more participatory community involvement, continue to enhance timely availability of key climate information, and enable the people to make informed choices that advance their climate resilience.



3. In addition, this study recommends that the government in collaboration with the ministry of communication and digitalization should do more to enhance rural telecommunication networks and provide a stable supply of electricity to farming communities. The ministry of communication and digitalization should initiate specialized digital literacy schemes to extend to farmers, especially aging farmers, to enhance their capacity to receive and understand climate information from mobile. These applications need to be made accessible and presented to the particular needs and situations of a wide range of users.

4. Finally, this study recommends that local government institutions should work hand in hand with local leaders and credible local institutions to build more legitimate and locally grounded information sources. The collaboration should aim to co-create climate messages that not only are true but are also culturally appropriate and communicated in the local languages to enable them to build trust and generate greater acceptance. Further, coupling mobile communication activities with community support training programs, the availability of resources, and community outreach activities can erase socioeconomic boundaries that impede residents' capacity to act on information received. Promoting such participatory and inclusive practices can guarantee that climate communication via mobile media actually translates to substantive behavioral change, permitting people to adapt to climate conditions within their prevailing social and economic context.

5.5 Suggestions for future research

Future research should be conducted on the variance in the utilization of cellular phones, access to information, and climate change adaptation between rural and urban Ghana. This is due to the variance in infrastructure, education, and economic standing between the urban and rural

populations, where such studies would be able to pinpoint unique challenges and opportunities unique to each environment



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APPENDICES

APPENDIX 1

Questionnaire Mobile Phone Penetration and Climate Change Communication in Tamale Metropolis

Thank you for participating in this survey aimed at assessing mobile phone penetration and its role in enhancing climate change communication in Tamale Metropolis. Your insights will help us understand how residents utilize mobile technology to access climate-related information and adapt to changing environmental conditions. The findings will inform strategies to improve communication efforts and enhance community resilience to climate change. Your responses are confidential and will be used solely for research purposes. Thank you for your valuable contribution

Section A: Demographic Information

1. Age Group: 1= 18–24 [] 2 = 25–34 [] 3 = 35–44 [] 4 = 45–54 [] 5 = 55 and above []
2. Gender: 1= Male [] 2 = Female []
3. Highest Level of Education Completed: 1 = No formal education [] 2 = Primary education [] 3 = Secondary education [] 4 = Tertiary education (College/University) []
4. Occupation: 1= Farmer [] 2 = Trader [] 3 = Student [] 4 = Civil servant [] 5 = Artisan [] 6 = Unemployed []
5. Monthly Income (GHS): 1 = Less than 500 [] 2 = 500 – 1,000 [] 3 = 1,001 – 1,500 [] 4 = 1,501 – 2,000 [] 5 = More than 2,000 []

Section B: Mobile Phone Access and Usage

6. Do you own a mobile phone? 1= Yes [] 2 = No (If No, please skip to Question 12) []



7. What type of mobile phone do you own? 1 = Basic feature phone (calls & texts only) []
2 = Smartphone (can access internet & apps) []
8. Do you use multiple SIM cards in your phone(s)? 1= Yes [] 2 = No []
9. How often do you use your mobile phone? 1= Several times a day [] 2 = Once a day []
3= Several times a week [] 4 = Once a week or less []
10. What functions do you commonly use on your mobile phone? (Select all that apply)
- Voice calls []
 - SMS/Text messaging []
 - Internet browsing []
 - Social media (WhatsApp, Facebook, Twitter, etc.) []
 - Mobile money services []
 - Mobile applications (apps) []

Section C: Access and Dissemination of Climate Change Information via Mobile Phones

11. Have you ever received information related to climate change or weather forecasts on your mobile phone? 1= Yes [] 2 = No []
12. If yes, through which channels do you receive climate change information? (Select all that apply)
- SMS alerts []
 - Voice calls []
 - Social media platforms []
 - Mobile apps []
 - Community radio via mobile phone []
 - Informal sharing from family/friends []





13. How frequently do you receive climate-related information on your mobile phone? 1= Daily [] 2 = Weekly [] 3 = Monthly [] 4 = Rarely []
14. Do you use your mobile phone to share or disseminate climate change or weather information to others? 1= Yes [] 2 = No []
15. If yes, how do you share this information? (Select all that apply)
- SMS/Text messaging []
 - Voice calls []
 - Social media platforms []
 - Mobile apps []
16. **What types of information do you receive through your mobile phone?** (Select all that apply)
- Weather forecasts (daily, weekly) []
 - Severe weather alerts (rains) []
 - Climate change news and updates []
 - Air quality index updates []
 - Local climate events (e.g., community clean-ups) []

Section D: Infrastructural Factors Affecting Mobile Phone Use

17. How would you describe the mobile network coverage in your area? 1= Very poor [] 2= Very Good []
18. How reliable is your access to electricity for charging your mobile phone? 1= No access to electricity [] 2= Reliable and consistent electricity supply []
19. How affordable is it for you to buy airtime and data bundles to use your mobile phone regularly? 1= Not affordable at all [] 2 = Very affordable []



20. Do you find the cost of airtime and data affordable for your regular use? 1= Yes [] 2 = No []

21. Does your income level affect your ability to buy airtime or data for mobile phone use? 1= Yes [] 2 = No []

22. How confident are you in using mobile phone features beyond basic calls and SMS? 1= Very confident [] 2 = Not confident []

23. Have you received any training or education on how to use mobile phones for accessing climate or weather information? 1= Yes [] 2 = No []

24. If no, would you be interested in such training? 1= Yes [] 2 = No []

Section F: Perceptions of Mobile-Based Climate Change Communication Effectiveness

25. Please rate your level of agreement with the following statements on a scale from (1= Strongly Disagree, 2 = Disagree, 3= Neutral, 4 = Agree and 5 = Strongly Agree)

Statements	Level of agreement				
	1	2	3	4	5
The climate change information I receive on my mobile phone is easy to understand.					
Mobile phone messages have helped me learn how to adapt to changes in weather patterns					
I trust the sources of climate change information communicated through mobile phones					
Mobile-based communication encourages me to take specific actions to cope with climate change					



I receive climate alerts on time via my mobile phone to help me prepare adequately					
The mobile climate information I receive is relevant to my local environment and needs					
I have shared climate change information received via mobile phone with others in my community					
Mobile phones have improved my awareness about climate change risks in Tamale Metropolis					

26. Please rank the following actions you have taken to adapt to climate change in Tamale Metropolis, with 1 being the most important/effective/frequent and 6 being the least.

Adaptive Action	Rank
Altering farming practices	
Using water-saving techniques	
Installing rainwater harvesting systems	
Participating in community awareness programs	
Implementing soil conservation methods	
Utilizing climate-resilient crop varieties	

Thank you for your time and participation.



