

Information communication technology and climate change adaptation in Somalia: Empirical evidence on awareness, preparedness, agriculture and risk responses

 Aweis Ahmed Hussein Jarras^{1*},  Ali Mohamed Hussein²

¹Faculty of Computer Science and information technology at capital university of Somalia, Mogadishu-Somalia; aweisjarras23@gmail.com (A.A.H.J.).

²Department of Public Health at capital university of Somalia, Mogadishu Somalia; Alilaki2017@gmail.com (A.M.H.).

Abstract: Information and communication technology (ICT) has the theoretical potential to enhance climate resilience; however, its effectiveness in fragile states such as Somalia remains underexplored. This study investigated the relationship between ICT utilization and four climate adaptation dimensions: awareness, disaster preparedness, agricultural decision-making, and risk response. Using a quantitative descriptive design, data were collected from 353 randomly selected ICT users in Somalia through a structured online survey. The predominantly rural, livelihood-based sample showed high mobile phone access (75.6%) but limited smartphone Internet access (40.2%) and significant educational gaps (27.8% with no formal education). Results revealed moderate and uneven ICT contributions: while over half of respondents reported increased climate awareness, trust in digital information was low (mean 2.91/5). Disaster preparedness via ICT was poor, with limited access to early warnings. Agricultural ICT support, particularly for drought-resistant practices, was minimal. However, ICT proved to be more effective for climate risk response, especially through mobile money and voice communication. The study concludes that the current ICT integration in Somalia is insufficient for robust climate adaptation. It recommends locally based, low-tech, accessible solutions prioritizing radio, voice calls, and mobile money, alongside hybrid models that combine digital alerts with traditional sources such as community elders to build trust and resilience in vulnerable, resource-constrained settings.

Keywords: Agriculture, Awareness, Climate change adaptation, Information communication technology (ICT), Preparedness, Risk responses, Somalia.

1. Introduction

Information and communication technology (ICT) has become a potent facilitator of climate resilience, providing new communication, data sharing, and decision-making support tools. While the most acute problems of the 21st century, which disproportionately impact developing and fragile states, are climate change, it has a bigger effect on weak and developing countries like Somalia. The country often experiences extreme weather events, such as long droughts, unpredictable rain, and flooding. These events significantly impact water availability, food security, and people's ability to make a living, especially in rural and pastoral areas. Climate variability has affected human livelihoods, but recently, it has intensified owing to heightened greenhouse gas emissions [1]. Climate change awareness has evolved, and international agreements and frameworks aim to mitigate and adapt to climate change. However, technological advancements, especially in ICT, have only recently been incorporated into climate response strategies. Environmental issues, including droughts and floods, have been part of Somali society for decades, severely impacting both pastoral and agricultural populations. The country has had low levels of technological development due to extended conflict and institutional instability.

Consequently, conventional coping mechanisms have prevailed, with little incorporation of contemporary ICTs in climate adaptation practices.

Globally, ICT has gained prominence in climate change adaptation processes generally. Satellite monitoring technologies, mobile applications, geographic information systems (GIS), and early warning systems are common technologies used to monitor climatic patterns and spread timely information. These instruments allow governments and communities to make better decisions and act in advance of climate risks. International bodies such as the United Nations and the World Bank stress the need to incorporate ICT in climate action plans. ICT aids in the realization of sustainable development goals (SDGs), especially those connected with climate action, food security, and disaster resilience. Consequently, it is becoming a key powerhouse in promoting sustainable development in the developed and developing worlds [2].

Regionally, climate change is a major problem in East Africa because of the region's reliance on rain-fed agriculture and susceptibility to extreme weather events. In Kenya, Ethiopia, and Rwanda, among others, there has been significant development of information and communication technology (ICT) in climate adaptation initiatives, such as mobile-based weather forecasts and digital agricultural advice services. Despite these developments, there are still differences within the region. Weak states like Somalia are still struggling to embrace ICT-based solutions due to a lack of infrastructure, governance, and scarcity of resources. This developmental imbalance highlights the necessity of implementing specific measures to enhance the use of ICT for climate adaptation in the area [3].

Somalia is one of the most weather-sensitive nations in the world, with frequent occurrences of droughts, floods, and desertification. Agriculture and livestock are very important to the country's economy; hence, the country is highly sensitive to climate variability. These environmental issues are intensified by continued political instability and inadequate institutional capacity. Over the past few years, Somalia has experienced a high rate of mobile phone penetration and telecommunications. Nevertheless, ICT is rarely used in climate change adaptation. The barriers include poor infrastructure, inadequate digital literacy, and failure to integrate policies to effectively utilize ICT in dealing with climate-related challenges [4].

The conceptual framework underlying this study is the relationship between information and communication technology (ICT) as an independent variable and climate change adaptation as a dependent variable. ICT refers to the use of mobile phones, Internet services, and digital platforms that support the exchange of information and communication. Climate change adaptation is gauged by four dimensions: community awareness, disaster preparedness, better agricultural decisions, and climate risk response. The framework presupposes that the greater the access to and use of ICT, the better these dimensions are, and consequently, the greater the adaptive capacity and resilience of communities [5].

This study is based on several theoretical views that articulate the potential of technology in the development of society. The diffusion of innovation theory is a theory about the adoption and spread of new technologies, including information and communication technologies (ICT), within communities. It focuses on aspects such as awareness, accessibility, and perceived usefulness in shaping adoption. In addition, the adaptive capacity theory focuses on the capacity of individuals and communities to adapt to the effects of climate using available resources, such as technology. The success model of information systems also aids the study by focusing on how effective ICT systems are in providing relevant and timely information for decision-making [6].

Ideally, information and communication technology (ICT) should be at the center of improving climate change adaptation through timely information, enhanced preparedness, and facilitation of decision-making processes. The successful application of ICT can help communities predict and act on climate risks, leading to less vulnerability and greater resilience. However, the potential of ICT is not fully utilized in Somalia due to infrastructural constraints, policy insensitivity, and a low level of awareness. This leaves a disparity between how ICT should be used and the existing realities. The effects are vulnerability, ineffective responses to disasters, and ineffective agricultural activities. This

study seeks to fill this gap through an analysis of the effectiveness of ICT in enhancing climate adaptation outcomes [7].

This research is unique in its focus on Somalia, a weak state, with limited studies on ICT and climate adaptation. It provides a holistic understanding of how ICT can enhance resilience by integrating various adaptation aspects into a single framework. The study is significant because it can inform policymakers, development organizations, and stakeholders. It offers insights on how ICT can be effectively used to address climate challenges, promoting sustainable development and resilience in high-risk environments [8]. The present research has several valuable contributions to knowledge and practice. Theoretically, it builds upon existing frameworks by extrapolating them to a fragile-state setting, providing new insights into how ICT can be adapted to climate change. It also constructs an abstract model of how ICT correlates with certain outcomes of adaptation. This study offers evidence-based information on how ICT affects climate adaptation in Somalia. In practical terms, it provides advice to policymakers and practitioners to help develop ICT-based interventions to aid resilience and support sustainable development efforts [9].

The overall purpose of this study was to explore how information and communication technology (ICT) can be used to improve climate change adaptation in Somalia. Specifically, it explores how ICT contributes to improving community awareness, disaster preparedness, agricultural decision-making, and climate risk response. It sets out to offer an overall insight into how digital technologies can be used to aid resilience-building initiatives within vulnerable communities. The targeted goals involve exploring how ICT can be used to enhance community awareness, how it can be utilized to enhance disaster preparedness, how it can be utilized to enhance better agricultural decision-making, and how it can be used to enhance climate risk responses. These objectives direct the research to fill the identified gaps towards the overall aim of the research.

2. Literature Review

The literature review offers a critical synthesis of the available knowledge on the role of information and communication technology (ICT) in climate change adaptation. It reviews theoretical views, empirical evidence, and theoretical relationships that justify how ICT can help build resilience. This part of the research places the study in the context of international, regional, and Somali literature and determines the main debates and gaps in knowledge [10]. The current literature indicates the increased significance of ICT in curbing climate-based problems, especially in the developing world. Mobile communication, early warning systems, and digital agricultural platforms have been extensively researched to support awareness, preparedness, and adaptive decision-making. The available literature concentrates mainly on stable and well-institutionalized settings, and fragile states like Somalia have not been explored well. Thus, the current review aims to fill this gap by dwelling on the specifics of the sociopolitical and environmental settings of Somalia. It combines a theoretical approach with practical knowledge to create a solid research base. This section also determines the relevance of the research objectives and how the study will contribute to academic knowledge and policy development [11].

2.1. Theoretical Foundation

The theoretical basis of the study is interdisciplinary, considering the interaction between technology, society, and environmental adjustment. The theories offer a framework for how information and communication technologies (ICT) can promote adaptive capacity and resilience in vulnerable communities. They also provide insights into how technology can influence behavior, decision-making, and institutional responses [12]. Theoretical frameworks for climate change adaptation emphasize the importance of access to information, dissemination of knowledge, and adoption of innovations. ICT is a key facilitator in this process, enabling communication and helping to bridge information gaps. Information systems and development studies theories highlight the transformative potential of ICT in improving socioeconomic outcomes. The research demonstrates analytical rigor and conceptual clarity by grounding the study in existing theories. The theoretical basis not only aids in formulating research

hypotheses and interpreting empirical results but also provides an organized framework to analyze the contribution of ICT to climate adaptation in Somalia.

2.1.1. Diffusion of Innovation Theory

The diffusion of innovation theory describes how new technologies and ideas diffuse within a society. This highlights that awareness, perceived usefulness, compatibility, and accessibility are some of the factors that affect the adoption of innovations. This theory can be used to understand how communities embrace digital devices to access climate-related information and decision-making, as seen in the context of ICT. In developing nations, socioeconomic conditions, infrastructure availability, and cultural factors tend to affect the adoption of ICT [13]. The theory emphasizes the importance of communication channels and social networks in promoting the dissemination of innovations. Early adopters are very important in influencing others, hence speeding up the diffusion process. In Somalia, opportunities and constraints influence the diffusion of ICT. Although mobile phone penetration has risen considerably, barriers to mobile phone adoption exist in the form of low digital literacy and the absence of infrastructure. This theory can be applied to learn how the introduction and scaling of ICT-based solutions to climate adaptation can be effective among Somali communities [14].

2.1.2. Adaptive Capacity Theory

Adaptive Capacity Theory concerns how individuals, communities, and systems adapt to the effects of climate change. It emphasizes the importance of resources, knowledge, institutions, and technology in enhancing resilience. ICT is regarded as one of the most vital resources that enable access to information and facilitate adaptive decision-making. The theory highlights that greater adaptive capacity reduces vulnerability to climate risks [15]. Access to timely and accurate information allows communities to better anticipate and respond to environmental changes. ICT tools, including weather forecasting systems and mobile advisory services, are crucial for improving adaptive capacity. Factors such as poverty, inadequate infrastructure, and weak institutions limit adaptive capacity in the Somali context. However, ICT offers solutions to some of these challenges by providing accessible and scalable options. This theory provides a framework for studying the role of ICT in resilience-building within vulnerable societies [16].

2.1.3. Information Systems Success Model.

The Information Systems Success Model measures the effectiveness of ICT systems in providing value to users. It focuses on system, information, and service quality, user satisfaction, and net benefits. This model can be applied to evaluate the role of ICT systems in climate adaptation. Quality information systems deliver accurate, timely, and relevant information, which is vital for making effective decisions. Preparedness, risk reduction, and improved response strategies can be improved using reliable information in the context of climate change. ICT tools also require user satisfaction and system usability to ensure their long-term use. The effectiveness of ICT-based climate adaptation initiatives in Somalia is determined by the quality and availability of information systems. System performance can be influenced by challenges such as network reliability and data availability. This model can be used to determine the success of ICT interventions in attaining the desired outcomes regarding adaptation [17].

2.1.4. Sustainable Livelihoods Framework

The sustainable livelihoods framework emphasizes the role of assets, which may be human, social, natural, physical, or financial capital, in sustaining livelihoods. ICT is considered part of physical and social capital that enhances access to information and resources. This framework is commonly used in development research to analyze vulnerability and resilience. It highlights the impacts of external shocks, such as climate change, on livelihoods and how people respond to these shocks with available resources. ICT can enhance access to markets, weather, and agricultural knowledge, thus improving

livelihood strategies [18]. This promotes risk management and diversification. ICT can be instrumental in improving resilience in Somalia, where livelihoods largely depend on agriculture and livestock. ICT helps in better decision-making and reduces vulnerability by providing timely information and improving connectivity. This framework aids in connecting ICT use to livelihood outcomes and climate adaptation [19].

2.1.5. Technology Acceptance Model (TAM)

The Technology Acceptance Model explains how users accept and utilize new technologies. It focuses on two important aspects: perceived usefulness and perceived ease of use. These aspects influence users' attitudes and intentions to adopt ICT tools. The model can be applied in the context of climate adaptation to understand why people adopt or do not adopt ICT-based solutions in climate adaptation [20]. Users embrace ICT tools when they find them useful and convenient. This is especially true in developing nations, where digital literacy levels vary. Education, accessibility, and trust in technology affect user acceptance of ICT in Somalia. It is crucial to understand these factors to design effective ICT interventions. The Technology Acceptance Model provides insights into how adoption barriers can be overcome to maximize the benefits of ICT in climate adaptation [21].

2.2. Specific Objectives

Certain objectives help steer the direction of the research and break down the research problem into quantifiable components. They ensure that the research is focused on and aligned with the overall purpose. The objectives of this study were tailored to investigate the role of ICT in various aspects of climate change adaptation. All the objectives deal with important aspects of adaptation, such as awareness, preparedness, agricultural decision-making, and risk response. These dimensions indicate both the theoretical and practical problems faced by communities in Somalia. The empirical analysis and hypothesis testing are based on these objectives. This study is more analytically clear and relevant by specifying precise goals. They can serve as an interface between theory and empirical research, ensuring that the research provides both knowledge and policy guidance. Goals also assist in determining where ICT interventions can have the greatest impact [21].

2.2.1. Objective One: To examine how ICT can enhance community awareness of climate change.

This is achieved through the spread of information on climate risks and adaptation strategies using digital tools. The initial step in building resilience is awareness. ICT platforms, including social media and mobile phones, can reach large numbers of people within a short period. These sites offer weather predictions, warnings, and other information. This assists communities in realizing the risks of climate change and taking proactive steps. Community awareness through ICT should be improved in Somalia due to the lack of access to traditional sources of information. This goal aims to determine how ICT can close information gaps and improve knowledge at the community level.

2.2.2. Objective Two: Evaluate the contribution of ICT to disaster preparedness.

This involves the observation of the support of ICT tools in emergency communication and early warning systems. Responses are necessary to mitigate the effects of climate-related disasters. ICT facilitates real-time communication and coordination in emergencies. Early warning mechanisms can inform communities about impending disasters, enabling them to take preventive measures. This minimizes the loss of life and property damage. In Somalia, infrastructural and institutional constraints tend to hinder disaster preparedness. ICT can enhance preparedness through the means of the enhancement of communication and information flow. This paper discusses the ways in which these tools can be used to enhance resilience.

2.2.3. Objective Three: To assess how ICT can enhance agricultural decision-making.

The third objective is: Climate variability is very sensitive to agriculture, which makes informed decision-making essential for the productivity and sustainability of agriculture. ICT tools will allow farmers to access weather predictions, markets, and farming guidance. This assists farmers in making improved decisions concerning planting, irrigation, and harvesting. Better decision-making leads to increased productivity and reduced risk. ICT can greatly enhance results in Somalia, where agriculture is the primary livelihood. This study aims to determine how digital technologies can help farmers adapt to climate change.

2.2.4. Objective Four: To Investigate the ICT application in climate risk response.

This will entail a look at ICT assisting in the monitoring, reporting, and response to events related to climate. Appropriate response systems play a crucial role in reducing these effects. ICT facilitates data collection and analysis, offering timely and informed actions. It also aids in the coordination of stakeholders, including government agencies and humanitarian organizations. In Somalia, responses to climate risks are usually limited due to a lack of resources and coordination issues. ICT may also be used to boost response efforts through information flow and decision-making. This study examines these contributions.

2.3. The Relationship between the ICT and Climate Change Adaptation

ICT is the independent variable in this study, whereas climate change adaptation is the dependent variable. The correlation between these variables is key to explaining the effect of technology on resilience outcomes. ICT is an enabler that stimulates adaptive capacity. The availability of ICT increases information availability, communication, and decision-making. This, in turn, fortifies different aspects of climate adaptation, such as awareness and preparedness. This relationship is both direct and indirect. Somalia has contextual factors (infrastructure and institutional capacity) that determine this relationship. This relationship can be understood to explain how ICT can be used to promote resilience and where interventions can be made to improve it [22].

2.4. Hypothesis Development

Hypotheses were formulated to investigate the correlation between ICT and climate adaptation. These were informed by theoretical understanding and observations of the study. The main hypothesis suggests that ICT has a significantly positive impact on climate change adaptation. Other hypotheses investigate how ICT has affected certain dimensions, including awareness, preparedness, and agricultural decisions. The empirical analysis and validation are based on these hypotheses: Through testing these hypotheses, the purpose of this study was to arrive at causal relationships and present evidence-based conclusions. This enhances the contribution of this study to both theory and practice.

2.5. Empirical Gap

The existing literature on ICT in Somalia has mainly focused on economic growth and digital inclusion. There is little research on its role in climate change adaptation. This poses a significant gap in the literature. Moreover, there is a lack of empirical studies associating ICT with certain adaptation outcomes. This restrains the realization of the potential for the effective application of technology in climate resiliency endeavors. This study fills these gaps by offering an empirical investigation of the role of ICT in climate adaptation in Somalia. This helps develop a more detailed knowledge of the subject.

2.6. Concept of Information and Communication Technology (ICT).

Information and Communication Technology (ICT) used in this analysis incorporates the use of mobile phones, Internet services, and digital platforms. Such technologies make communication and information sharing easier. ICT is important for obtaining climate-related information. It helps communities make decisions based on information and react to environmental changes. Considering

ICT as an independent variable assists in explaining its effect on the outcome of adaptation. This provides a foundation for examining its effects [23].

2.7. Concept of Climate Change Adaptation

Climate change adaptation is the capacity of communities to adapt to the effects of climate change. It encompasses awareness, preparedness, and risk response dimensions. Access to information, resources, and technology affects adaptation. ICT increases these factors and, therefore, resilience. In Somalia, adaptation is essential because of the high level of vulnerability. This variable reflects the outcomes of ICT interventions [24].

2.8. Conceptual Framework

The conceptual framework in Figure 1 shows the connection between ICT and climate adaptation. This demonstrates the impact of ICT on different aspects of adaptation. The framework combines theoretical ideas, research goals, and hypotheses. It provides a pictorial display of the study format. This framework can be used to understand the contributions of ICT to resilience in Somalia. It determines how the results are analyzed and interpreted.

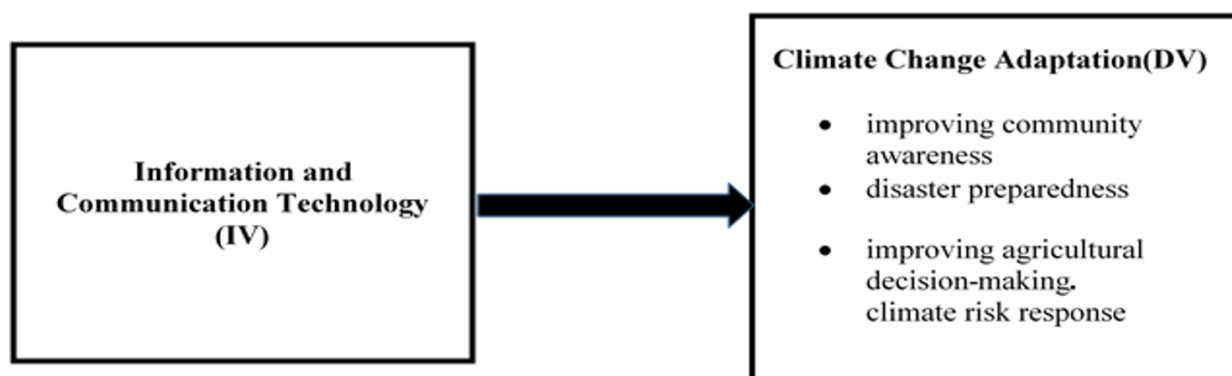


Figure 1.
Conceptual Framework.

3. Research Methodology

This section describes the research methodology used to examine the role of information and communication technology (ICT) in climate change adaptation in Somalia. It provides a clear description of the research design, field of study, population, sampling methods, and data collection procedures. The methodology was geared toward ensuring the study met its goals in a systematic and scientifically rigorous way. This chapter also explains how the data were gathered, analyzed, and interpreted to answer the research questions. It highlights the use of quantitative methods and descriptive analysis to examine the relationship between ICT and climate adaptation. This section also describes the procedures employed to ensure the validity and reliability of the study. Moreover, the ethical considerations, limitations, and scope of the study are addressed to achieve transparency and credibility. These methodological parts are clearly defined and form the basis of the empirical analysis in subsequent sections. The research was conducted in Somalia, a country in the Horn of Africa, which is highly vulnerable to the effects of climate change, including droughts, floods, and environmental degradation. The socioeconomic setup of Somalia is largely reliant on agriculture and livestock, making it highly susceptible to climatic changes. The rising application of ICT, particularly mobile technology, provides a relevant background for analyzing its role in climate adaptation.

The population was divided into individuals and communities directly or indirectly impacted by climate change, and those who use ICT tools. This involved farmers, pastoralists, and urban dwellers

dependent on digital platforms to obtain information related to climatic conditions. These groups play a crucial role in understanding how ICT can help create awareness, preparedness, and decisions. The choice of Somalia as a study area was also based on its high vulnerability and the lack of research on ICT use in climate adaptation. The population represented various socioeconomic backgrounds, providing an opportunity to analyze ICT use in detail and its effects on adaptation strategies.

This study used a descriptive research design with a quantitative methodology. The descriptive design suits the investigation of the current situation in ICT use and its contribution to climate change adaptation without controlling any variables. This enables methodical gathering and examination of data to outline patterns and associations. A quantitative approach was used to be objective and analyze data statistically. Numerical data to be analyzed with descriptive statistics were collected using structured questionnaires. This approach enables researchers to effectively summarize and interpret the data. Findings on demographic characteristics and research objectives were presented using descriptive analysis. This approach provides a clear picture of the effects of ICT on various issues of climate adaptation. It is also helpful in generalizing the results in the study context.

This study will focus on 3,000 people affected by climate change in Somalia who use ICT. The sample size will cover both rural and urban populations, guaranteeing the presence of various socioeconomic groups. A large population size offers a wide sampling area. This population was selected based on its relevance to the objectives of the study. Those who actively use ICT tools will have a higher chance of providing an insight into the effects of the technologies on climate adaptation. This will ensure that the data obtained are significant and relevant to the research topic. This study will have a clearly defined target population, which will make the sampling process structured and representative. This increases the reliability and validity of the results, which can be used to draw more precise conclusions regarding the role of ICT in climate adaptation.

A total of 353 respondents were selected from the target population of 3,000 people. This is a sufficient sample that can be analyzed quantitatively and provides a sufficient amount of accuracy and confidence in the findings. This enables a meaningful interpretation of the statistics, but it is manageable to collect data. Standard sampling methods were used to determine the sample size to make it representative of the population. Having a large enough sample decreases the sampling error and makes the findings more reliable. This also allows for better generalization of the results. The 353 respondents will facilitate the capture of different perspectives, given the differences in ICT usage and climate adaptation practices. This improves the quality of the data and facilitates effective analysis.

The research frame is a set of criteria applied to select study participants. This ensures that the sample is pertinent to the research aims and is representative of the target population. Individuals who use and have access to ICT tools in their lives are included in the frame. A research framework is necessary to ensure consistency and focus in data collection. This assists in excluding people who do not fit the study conditions, thus enhancing the validity of the results. The frame also enables the study to be in line with its objectives. The research framework ensures minimal bias, thereby increasing the validity of the findings. It offers a methodical way of choosing participants and guarantees that the data collected is reliable and pertinent.

The following were the inclusion criteria for this study: participants needed to be residents of Somalia and have access to information and communication technology (ICT) tools, such as mobile phones or the Internet. The participants should also possess some degree of awareness or experience regarding the effects of climate change. This guaranteed that the respondents provided pertinent information. Furthermore, the participants should be free to volunteer to participate in the research. This is relevant on ethical grounds and ensures that the data collected is based on informed consent. To ensure that different views were considered, people with various socioeconomic statuses were included. These criteria were used to make the sample representative of ICT users impacted by climate change. This improved the relevance and quality of the collected data and aided in achieving the objectives of the study.

The inclusion criteria were as follows: use of ICT tools or non-exposure to climate-related problems. These participants might fail to provide valuable information on the study variables. The omission of these factors aids in keeping the research on track. Participants who were not willing to participate or had no capability to fill in the questionnaire were also excluded. This guarantees the completeness and reliability of the data collected. It minimizes the chances of biased or inaccurate responses. The study enhanced the quality and consistency of the data by using exclusion criteria. This ensures that only pertinent participants are involved, increasing the validity of the results.

This study used a simple random sampling method to sample respondents within the target population. This approach can guarantee everyone an equal opportunity to be selected and, hence, less sampling bias. This enhances the representativeness of our sample. Quantitative studies can be conducted using random sampling because it aids in statistical analysis and generalizing results. This made the sample representative of the population. This helped improve the accuracy of the findings. In this technique, the study was fair and objective in selecting the participants. This enhances the validity of the research results.

An online questionnaire was used to collect data for this study. The technique is effective, economical, and appropriate when a large population of respondents is required. It also enables easy management and analysis of the data. The questionnaire was structured with closed-ended questions that would help collect information pertaining to ICT use and climate adaptation. It contained demographic questions as well as those regarding the study goals. This guarantees thorough data collection. Online data collection is especially appropriate in the Somali context because of the use of mobile technology. This enables the involvement of various places and improves response rates.

This research is based on primary data obtained through direct responses. Primary data provide first-hand information that is unique to the research objectives. This is precise and pertinent. The ability to control the data collection process enables researchers to collect primary data. This enhances the quality and reliability of the information collected. It also facilitates the study of particular research questions. Using primary data, this study creates new knowledge on the role of ICT in climate adaptation. This study contributes to the existing body of knowledge. A pilot test was conducted to determine the effectiveness of the questionnaire. This consisted of the questionnaire being given to a limited number of respondents before the actual data collection. This was done to detect any clarity and structure problems. A pilot test was used to fine-tune the questionnaire, refine the wording, and reduce ambiguity. This made the questions easy for the respondents to comprehend. This increases the validity of the data. A pilot test is critical for assuring the quality of the research instrument. This minimizes mistakes and enhances the general validity of the research.

Descriptive statistics were used to analyze the data. It involves frequencies, percentages, and tables in the summary of the data. These techniques provide a clear understanding of the findings. Both demographic data and study objectives were subjected to descriptive analysis. This helps identify patterns and trends in ICT usage and climate adaptation. This will help in the interpretation and discussion of the results. The descriptive analysis was in line with the research design and purpose. This offers an easy and efficient method for presenting the findings. Validity is the degree to which a study measures what it is supposed to measure. Validity in this study was achieved by designing the questionnaire in line with the research objectives. Other sources of validity include expert reviews and pilot testing. Reliability refers to the consistency of the measurement. Standardized questions and uniformity of data collection procedures were used to ensure reliability. This minimized error and enhanced the quality of the data. The validity and reliability of this study can be improved by ensuring that it is credible. This was done to ascertain that the results were true and reliable.

Research involving human participants is very important in terms of ethics. In this study, participation was voluntary, and informed consent was obtained. The rights and purpose of the study were explained to the respondents. Privacy and anonymity in the research were upheld. No personal details are revealed, and the data are not used against the participants. This safeguards the participants' privacy. Another aspect of the study was ethics to promote integrity and transparency. This enhances

the trustworthiness of the research. Nevertheless, this study has several limitations that may impact the results. Among the limitations is the use of online questionnaires that can exclude those who do not have Internet access. This may have influenced the representativeness of the sample. The other limitation was the descriptive analysis, which failed to prove causality. Although it offers important information, it might not be sufficient to explain the dependency between variables, and as such, it limits the analysis further. This restriction limits the analysis. Nonetheless, these limitations notwithstanding, the study offers valuable information on the role of ICT in climate adaptation. These limitations can be overcome in the future by incorporating mixed methods and larger sampling methods.

4. Results and Discussion

The table below summarizes the findings of the descriptive statistical analysis of the data obtained from 353 respondents in Somalia. The results are presented based on the study's objectives. Five Likert-scale questions and one frequency table were examined to analyze each objective. Percentages are rounded to one decimal place. The findings are discussed within the framework of the Somali climate adaptation landscape and the literature. 4.1 Demographic Profile of Respondents.

4.1. Demographic Characteristics of Respondents

Table 1.
Demographic Characteristics of Respondents.

Characteristic	Category	Frequency (n)	Percentage (%)
Gender	Male	201	56.9
	Female	152	43.1
Age Group	18-25	68	19.3
	26-35	112	31.7
	36-45	95	26.9
	46-60	58	16.4
	60+	20	5.7
Primary Livelihood	Farmer	124	35.1
	Pastoralist	98	27.8
	Agro-pastoralist	76	21.5
	Urban worker/business	55	15.6
Location	Urban	148	41.9
	Rural	205	58.1
Access to ICT	Mobile phone	267	75.6
	Internet/smartphone	142	40.2 (multiple)
	Radio	189	53.5
	No access	31	8.8
Education	No formal	98	27.8
	Primary	127	36.0
	Secondary	89	25.2
	University+	39	11.0

The demographic characteristics of the 353 respondents empirically confirm many of the most important claims of the literature review regarding the weaknesses of Somalia and the conceptual limitations of ICT-driven climate adaptation. Consistent with the literature's theme that Somalia's economy heavily depends on rain-fed agriculture and livestock, the results show that 84.4% of respondents rely on climate-dependent livelihoods (35.1% farmers, 27.8% pastoralists, and 21.5% agro-pastoralists), and 58.1% are rural inhabitants. This distribution aligns with the Adaptive Capacity Theory discussed in Section 2.1.2, which states that communities dependent on resources are at greater risk from climate variability. The gender balance (56.9% male, 43.1% female) reflects traditional roles noted in the literature, where men are more involved in external information collection, a critical factor for developing inclusive ICT interventions. Additionally, the age structure within the economically

active groups (31.7% aged 26–35, 26.9% aged 36–45) can be explained by the Diffusion of Innovation Theory, as these groups are more receptive to adopting new technologies when the benefits are clear.

In relation to ICT access and education, the central barriers identified in the empirical data present a dual narrative of opportunity and constraint. The mobile phone penetration rate of 75.6% confirms findings in the literature regarding Somalia's high level of telecommunication development. However, smartphone Internet adoption at 40.2% remains a significant obstacle, directly explaining why advanced digital platforms are not being utilized to address climate change. Radio remains widely accessible (53.5%), and the high usage frequency (68.6% daily/weekly) supports the literature's indication that traditional coping mechanisms dominate. Notably, 27.8% lack formal education, and only 11.0% have university-level education, which directly relates to the Technology Acceptance Model, where perceived ease of use and perceived usefulness are critical for adoption. Digital literacy is essential for adopting new ICT tools. The 8.8% who have no ICT access of any kind highlights the digital divide that still exists, especially in far rural settings, which supports the conclusion of the literature that infrastructural factors, poor digital literacy, and policy fragmentation are all contributors to a lack of successful ICT use in the face of climate change in Somalia.

4.2. Objective One: Role of ICT in Improving Community Awareness of Climate Change

Table 2.
Community Awareness.

Item	Statement	SD (1) %	D (2) %	N (3) %	A (4) %	SA (5) %	Mean
Q1	Receive timely climate info via mobile phone	12.5	18.7	24.1	31.2	13.5	3.15
Q2	ICT improved my understanding of climate change	8.5	15.3	22.1	36.8	17.3	3.39
Q3	ICT helps learn new adaptation strategies	10.2	17.8	25.5	32.9	13.6	3.22
Q4	Trust climate info from digital channels	15.6	22.4	28.9	22.1	11.0	2.91
Q5	ICT more effective than traditional methods	13.3	19.5	26.1	27.8	13.3	3.08

The results on community awareness indicate that ICT can only play a small yet not a full role in knowledge sharing on climate change in Somalia. This is a direct result of the observation in the literature where traditional coping methods are at the forefront, and modern inventions of ICT are still under-exploited. The respondents who obtained timely information about climate through mobile phones were the lowest (Q1, mean=3.15; 44.7 percent), and the awareness of climate change through ICT was also the lowest (Q2, mean=3.39; 54.1 percent)—values that were lower than the measure of majority adoption. These data can also be attributed to the Diffusion of Innovation Theory, according to which awareness propagation occurs when technologies are seen as valuable and available to the public. The considerable level of neutral responses (22–28% average on items) suggests that the diffusion process was in its initial phase. Importantly, the level of trust in digital climate information is threatening: 33.1% of the participants strongly agreed that they trust ICT-based climate messages (Q4, mean=2.91, lowest of five items), and 38.0% did not trust them. This result is a direct contradiction of the Information Systems Success Model, which signifies that system effectiveness is preconditioned by information quality and user satisfaction. Here, the identification of barriers, poor infrastructure, low digital literacy (27.8% have no formal education), and inadequate policy integration, described in the literature is empirically confirmed since the unreliability of network connections and the use of culturally alien information sources compromise credibility.

In addition, only 41.1% of the respondents agreed with the perception that ICT is more effective than traditional methods, which raises awareness of climate (Q5, mean=3.08), and supports the position in the literature that adaptive capacity (Adaptive Capacity Theory) depends on available, reliable resources. In Somalia, people view digital information with mistrust, particularly when community elders are in charge of determining coping strategies and when the information is based on experience and provided by an unknown source. This unwillingness to do so is explained in the Technology Acceptance Model, where perceived usefulness is low, as users have already experienced delays,

irrelevant, or inaccurate messages. The empirical gap identified in Section 2.5, which highlights the lack of research on the lifts of a particular outcome, is addressed here. It demonstrates that awareness alone is insufficient; trust-building processes are necessary. To increase community awareness, the findings suggest that ICT interventions should not substitute but enhance traditional media (radio at 68.6% daily/weekly, community meetings at 56.7%), validate computerized information using local leaders, and make the network reliable. Without this integration, ICT still faces the risk of not performing to its theoretical capacity, and Somali communities will remain with incomplete climate knowledge and be vulnerable.

4.3. Frequency of Use of Information Sources

Table 3.

Sources of Climate Awareness Information.

Information Source	Daily (%)	Weekly (%)	Monthly (%)	Rarely (%)	Never (%)
Mobile Phone (SMS/calls)	34.8	28.3	15.6	12.5	8.8
Internet/Social Media	18.4	22.1	20.4	21.0	18.1
Radio	41.1	27.5	14.2	10.5	6.8
Community meetings/elders	25.5	31.2	22.4	14.2	6.8
Government/NGO announcements	12.2	19.3	24.6	26.9	17.0

The statistics on the use of information sources indicate that there is a hybrid information environment in Somalia, where modern ICT is implemented alongside but has not yet substituted the traditional and mass media systems, directly confirming the claims in the literature that traditional coping strategies prevail. The most common source of information was the radio, with 68.6% of respondents listening to it on a daily or weekly basis, closely followed by mobile phones (63.1% daily/weekly) and community meetings/elders (56.7% daily/weekly). This trend is empirical evidence of the Diffusion of Innovation Theory (Section 2.1.1), which theorizes that changes are propagated by credible social networks and opinion leaders. In Somalia, community elders are regarded as opinion leaders who disseminate climate information. The fact that mobile phones are almost as popular as radio phones (63.1% vs. 68.6% usage) refers to the literature finding that mobile telecommunications are rapidly gaining strength in Somalia, but the fact that 25.5% of people use their mobile phones daily illustrates that face-to-face interaction is critical to establishing trust and putting climate information services into a context that digital technology cannot currently perform. The least exploited sources are government and NGO announcements (only 31.5% daily/weekly, 43.9% rarely/never use them), which validates the fact that weak institutional capacity and poor coordination between official authorities and local communities are indeed a problem stated in the literature.

Importantly, the use of the Internet and social media is minimal (40.5% daily/weekly, 39.1% rarely or never), which directly reflects the gap in the literature addressed by such empirical studies as in Section 2.5, which focused on economic growth and digital inclusiveness, but not on climate adaptation, and that such advanced ICT tools are underutilized. This trend can be attributed to the Technology Acceptance Model: the perceived ease of use is low because of high data costs, uneven network coverage, and low digital literacy (27.8% without formal education, as shown in Table 4.1). The Sustainable Livelihoods Framework further explains why radio and simple mobile phones (SMS/voice) dominate: they demand little financial and human resources, are not easily impacted by infrastructure shocks, and can be easily integrated into already existing livelihood strategies. The outcomes of the high daily/weekly utilization of community meetings (56.7%): ICT interventions are also not expected to substitute the traditional systems, but add to them. In the case of climate alerts being sent through mobile phones, the elders of society would verify and strengthen their commitment during meetings. Otherwise, ICT potential has not yet been achieved because of infrastructural limitations, inertial policies, and lack of awareness, as the Somali communities receive disjointed and distrusted sources of information and remain vulnerable to climate shocks.

4.4. Objective Two: Role of ICT in Disaster Preparedness

Table 4.
Disaster Preparedness.

Item	Statement	SD (%)	D (%)	N (%)	A (%)	SA (%)	Mean
Q1	Receive early warning alerts on mobile	16.7	23.1	25.8	24.1	10.3	2.88
Q2	ICT helps community coordinate preparedness	11.9	20.4	27.5	28.9	11.3	3.07
Q3	Can contact emergency services/family quickly	14.2	21.8	24.9	26.6	12.5	3.02
Q4	ICT enables preventive actions before disaster	13.0	19.4	26.1	29.7	11.8	3.08
Q5	Current early warning systems effective	19.1	26.4	28.3	18.1	8.1	2.70

The disaster preparedness results reveal an urgent mismatch between the potential of ICT due to its theory and its practical application in Somalia, with low rates of effective early warning and coordination. It is not until question 1 that less than 34.4 percent of those surveyed agree or strongly agree that they are alerted to disasters before they strike (e.g., flash floods or drought) on their mobile phones, and therefore view current ICT-based early warning systems as effective and reliable (only 26.2 percent). The results are direct assumptions of the Adaptive Capacity Theory, which postulates that communities require information in time and at the correct place for anticipation and response to environmental changes; otherwise, vulnerability will only increase. The high neutral response rate (24-28 percent across items) suggests that a significant portion of respondents are unsure whether ICT is a key contributing factor to preparedness, indicating poor system functioning, as reported in the Information Systems Success Model, where user satisfaction depends on system quality (network reliability, coverage) and information quality (accuracy, timeliness). Additionally, as stated in the literature, disaster preparedness in Somalia is limited due to infrastructure deficiencies, weak institutions, and reliance on traditional warning systems (e.g., cloud patterns, animal behavior). These traditional methods are empirically validated here, as communities depend on indigenous warning systems when digital systems malfunction.

Despite these weaknesses, small positive indicators were observed: 40.2% of the respondents concurred that ICT could be important in helping communities to plan preparedness measures (Q2, mean=3.07), and 41.5% testified that ICT could also be relevant in supporting preventive measures such as food or livestock relocation to disaster-prone areas (Q4, mean=3.08). Although not a majority, these numbers are in agreement with the Diffusion of Innovation Theory (Section 2.1.1), which states that early adopters are starting to incorporate ICT into preparedness routines, but diffusion is not yet at a critical mass. This is especially applicable to the Technology Acceptance Model in terms of the perceived usefulness of ICT to preparedness; the scores are low since users have a feeling of inefficiency and reduced desirability due to false alarms or delayed messages, or even no responses at all, undermining trust and promoting disuse. An emergency service or family having a quick way to be in contact with them (Q3, mean=3.02) is of some use, although the lack of network reliability (addressed in the methodology section as an availability constraint of the network and data) limits its usefulness. To transition the relationship between the ideal work of the ICT and its present situation, a trajectory of this study suggests that Somalia needs to invest in interoperable early warning systems that integrate satellite systems with local telecom systems, with an emphasis on simple applications (voice calls and radio, as presented in Table 5). Communities will continue to be vulnerable to climate-related disasters until such investments are made; therefore, the cycle of poor responses and unnecessary losses reported in the literature continues.

4.5. Usefulness of ICT Tools for Disaster Preparedness

Table 5.
Perceived Usefulness of ICT Tools for Preparedness.

ICT Tool	Very Useful (%)	Useful (%)	Neutral (%)	Not Very Useful (%)	Not Useful at All (%)
SMS text alerts for early warning	23.5	31.2	22.4	13.3	9.6
Voice calls from leaders/NGOs	28.6	33.7	19.8	10.5	7.4
Social media (WhatsApp groups)	18.4	25.5	26.1	17.8	12.2
Radio broadcasts	35.4	34.1	16.4	8.5	5.6
Mobile apps for weather tracking	12.7	19.2	27.2	22.1	18.8

The perceived usefulness data demonstrate a clear hierarchy of disaster preparedness tool usage in Somalia, directly related to infrastructural realities and user abilities outlined in the literature. Radio broadcasts are the most accessible resource, with 69.5% of respondents identifying them as very useful or useful, followed by voice calls with leaders/NGOs (62.3%) and SMS text alerts of early warning (54.7%). This trend empirically confirms the Sustainable Livelihoods Framework, which asserts that successful information services should build on existing physical and social capital—radio does not require literacy, data plans, or a consistent electricity supply, and can be provided even in the most resource-challenged, remote areas. The high rating of voice calls leverages the 75.6% mobile phone penetration, as indicated in Table 1, and does not require smartphones or internet connectivity; thus, it can operate even on 2G networks where there is no coverage. This hierarchy aligns with the Technology Acceptance Model: perceived ease of use and perceived usefulness are highest for tools that require minimal digital literacy and are reliably used under challenging conditions in Somalia. On the other hand, weather-tracking mobile applications were considered the least helpful, with only 31.9% of them rated as very useful or useful, and 40.9% rated as not useful at all. This is a direct result of low smartphone penetration (40.2%), high data prices, and the 27.8% no formal education level that was reported in Table 1. The endorsement level of social media (44.9% very useful/useful, yet 30.0% not useful) and the relatively lower accent of SMS text alerts as opposed to voice calls (54.7 percent vs. 62.3) have huge policy implications that directly apply the Diffusion of Innovation Theory. Innovation is easily adopted when innovations are compatible with the current values, infrastructure, and social practices; in Somalia, the aspect of reliability is preferred over sophistication. The neutrality rates are high with social media (26.1) and mobile apps (27.2), suggesting a lack of confidence; some respondents have either not used these tools enough to determine their usefulness or have shown unsatisfactory outcomes because of network breakdowns. The Information Systems Success Model explains that perceived usefulness can be directly related to system quality (network coverage, battery life, success in delivering messages). Voice communication works well even with low-end (2G) phones, but apps require a steady 3G/4G or smartphone. Here, the warning in the literature that it is hampered by infrastructural constraints, policy insensitivity, and low awareness of using ICT is empirically proven. To boost its disaster preparedness, Somalia ought to focus on radio-based early warning, community voice call networks, and SMS alerts that can best be delivered via feature phones, instead of investing in app-based solutions, which it should only invest in places where infrastructure has proven to be sufficient. Without paying heed to this hierarchy of preferences, there is a risk of squandering resources on technologies that are not adopted by communities, or not at all, and this gap between the potential of ICT and underutilization recorded in the course of this study will persist.

4.6. Objective Three: Role of ICT in Improving Agricultural Decision-Making

Table 6.

Agricultural Decision-Making.

Item	Statement	SD (%)	D (%)	N (%)	A (%)	SA (%)	Mean
Q1	Use mobile for weather forecasts before planting/harvest	14.5	21.9	24.1	27.5	12.0	3.00
Q2	ICT provides market price information	16.1	23.4	25.8	23.5	11.2	2.91
Q3	Receive digital agricultural advice (SMS/apps)	18.7	25.5	24.6	20.4	10.8	2.79
Q4	ICT reduced crop/livestock losses due to climate	13.3	20.4	28.3	25.8	12.2	3.03
Q5	ICT improved farm productivity and income stability	15.9	22.1	26.9	24.4	10.7	2.92

The agricultural decision-making results indicate that ICT has a fringe and insignificant role in assisting Somali farmers and pastoralists in managing climate variability, which vindicates the finding visible in the literature that ICT applications in climate change adaptation use are still negligible despite the increase in mobile phones. A mere 39.5% of the respondents agreed or strongly agreed with such claims as they looked at mobile phones to get weather forecasts in advance (before planting or harvesting) (Q1, mean=3.00), and only 31.2% received digital agricultural information (via SMS or apps) on issues related to irrigation, pest management, or drought-resistant seeds (Q3, mean=2). These statistics verify the empirical validity of the Adaptive Capacity Theory, which states that timely and precise information is a key resource for adaptation. These data indicate that too few farmers have access to reliable ICT-based climate information to make critical decisions. The large share of neutral answers (between 24 and 28 percent of answers in the items) reflects a state of large uncertainty regarding the perceived benefits of ICT, a symptom of undelivered, untimely, or locally inapplicable information. Moreover, only 40.1% of respondents agree or strongly agree that ICT provides useful market price information (Q2, mean=2.91), which is a disturbing result as market access is key to livelihood resilience in an agriculture-based economy, such as Somalia. The Technology Acceptance Model reflects this cynicism; perceived usefulness is low because farmers have had inaccurate forecasts, late data, or messages that do not fit local agro-ecological conditions.

Though these are weak, small positive signals can be found: 38.0 percent concur that ICT has contributed positively to lowering crop or livestock losses because of climate variability (Q4, mean=3.03), at 35.1 percent regarding farm productivity and income stability because of ICT (Q5, mean=2.92). Although these numbers in this case are not a majority, they are in line with the Diffusion of Innovation Theory, as they indicate that early adopters are starting to see tangible benefits, although diffusion has yet to extend to most farmers. According to the literature review, in Somalia, one of the main livelihoods, ICT has the potential to significantly increase outcomes, although limited digital literacy (27.8% have no formal education) and network access in rural regions and unprocessed locally focused content limit its effectiveness. According to the Information Systems Success Model, user satisfaction can best be achieved with the quality of information, that is, whether it is accurate, timely, relevant, etc. In Somalia, most weather forecasts lack the locality required to make individual village or pastoral area forecasts, being of national or regional scope; available market price information tends to be old-fashioned or obtained in remote markets. Therefore, interventions must invest in more local participatory gathering of data (e.g., community-based weather stations), deliver information via reliable channels (voice messages in Somali as well as radio), and train on how to interpret and apply digital advice to better agricultural decision-making. Without addressing these quality and accessibility gaps, ICT will also be underutilized, and farmers will still be dependent on traditional knowledge (although a rich resource) that is fast becoming inadequate due to the escalating climate change situation, and the agricultural communities are left in danger of making highly avoidable losses, as cited in the study introduction.

4.7. Impact of ICT on Specific Agricultural Decisions

Table 7.

Extent of Agreement that ICT Improves Specific Decisions.

Agricultural Decision	Strongly Agree (%)	Agree (%)	Neutral (%)	Disagree (%)	Strongly Disagree (%)
Choosing what crop to plant	10.5	25.2	29.5	20.4	14.4
Determining the best planting time	12.7	28.3	26.1	19.1	13.8
Deciding when to irrigate	9.6	22.4	28.9	24.1	15.0
Choosing when to sell livestock/produce	11.0	24.6	27.5	22.4	14.5
Selecting drought-resilient methods	8.5	20.1	30.2	25.5	15.7

The results of certain agricultural decisions demonstrate that the perceived role of ICT is weak and disproportionate to the key decisions farmers and pastoralists need to face the changes in climate. The greatest amount of consensus was on deciding the best time to plant, but only 41.0% said they agreed or strongly agreed that ICT helped them make this decision; this was followed by which crop to plant (35.7%) and when to sell livestock or produce (35.6%). These numbers, none over the majority, confirm the Adaptive Capacity Theory, which states that access to information on adaptive practices is critical to resilience construction. However, the actual information shows that ICT cannot provide trustworthy information to make basic decisions. The most concerning is the worst-ranked option: choosing drought-resilient farming practices, with only 28.6% agreement and 41.2% disagreement (strongly disagree/disagree). This empirically confirms the literature warning that barriers such as inadequate infrastructure, digital literacy, and lack of policy integration hinder the effective use of ICT in climate issues. The failure of ICT to communicate drought-resistant practices in a country like Somalia, where droughts are frequent, would be a major failure of adaptability capacity. The strong responses to the neutral option (26–30% in all decisions) suggest widespread uncertainty, which the Information Systems Success Model explains by the low quality of systems and inconsistent information. Farmers receive some generalized, untimely, or locally irrelevant information that cannot respond to their specific agro-ecological factors.

The trend of how people respond is a depiction of the Digital Divide and the Technology Acceptance Model. Decisions with real-time, local information, such as which irrigation to use (only 32.0% agreement) and which drought-resistant methods (28.6%), have the least ICT impact since they require high-quality and constantly available information streams that are currently unavailable in Somalia because of inadequate infrastructure. Conversely, decisions that are informed based on seasonal projections or overall market patterns (planting time, crop decision, time to sell) show moderately better but still insufficient agreement. The Sustainable Livelihoods Framework notes that ICT needs to be embedded among the already existing human capital (literacy, skills), social capital (trust networks), and physical capital (reliable phones, network coverage). Having no formal education and only 40.2% access to smartphone internet (Table 1), any text-based (or app-based) advisory service will be automatically out of reach for the majority. Moreover, the literature review states that societies relying on traditional coping mechanisms used indigenous knowledge passed on to elders through observation of the environment. The Diffusion of Innovation Theory assumes that the increased rate of adoption will only occur when farmers can see the obvious and sustained advantages of their peers (early adopters). The diminished levels of agreement, as shown in this study, reflect a lack of social evidence. To strengthen agricultural decision-making, interventions should be designed within a participatory framework, involving farmers to produce local, voice-based, radio-linked advisory messages and demonstrate actual outcomes (e.g., pilot groups of farmers with improvements in yields). Until such targeted endeavors are undertaken, ICT will be marginalized in the agricultural decision-making process, and farming communities in Somalia exposed to climate shocks will continue to incur losses that are preventable without exploiting ICT, as the author mentions in the introduction of the study that there are ineffective agricultural practices due to the underutilization of ICT.

4.8. Objective Four: Role of ICT in Climate Risk Response

Table 8.

Climate Risk Response.

Item	Statement	SD (%)	D (%)	N (%)	A (%)	SA (%)	Mean
Q1	Can quickly report hazards via ICT	13.6	20.9	25.5	27.2	12.8	3.05
Q2	ICT enables coordination with humanitarian organizations	15.0	22.4	26.9	24.4	11.3	2.95
Q3	Receive real-time updates on response efforts via mobile	17.8	24.1	27.2	21.0	9.9	2.81
Q4	ICT helped access relief resources more quickly	14.2	20.4	27.8	25.2	12.5	3.01
Q5	Overall, ICT is effective for risk response	12.2	18.7	28.9	27.5	12.7	3.10

The results of the climate risk response show a pragmatic yet optimistic view in that ICT has shown a real contribution in certain functions and failed in others, which is directly mirrored in the literature, where ICT potential is observed to be partially unmet because of infrastructural and coordination gaps. Notably, 40.0% of the participants responded affirmatively that they can promptly communicate (e.g., floods, crop failure) to the authorities (or NGOs) with the help of ICT (Q1, mean=3.05), with 37.7% of the participants reporting that ICT has made access to relief resources (cash transfers, etc.) much quicker (Q4). Although the figures are lower than the majority, it can be argued that it is one of the relatively higher means of all objectives. Thus, the aspect of ICT response, and more specifically, mobile money and reporting, may be considered more developed than either preparedness or agricultural decision-making. Adaptive Capacity Theory applies here: quick reporting and the possibility of accessing resources will directly decrease the level of vulnerability, but the statistics indicate that only two out of five people will have such advantages, and the rest will not. Nevertheless, there are still remarkable gaps: only 30.9% are really updated on response efforts by means of the mobile phone during the disaster (Q3, mean=2.81, which is the lowest of these goals), and only 35.7% say that ICT enhances communication with humanitarian agencies (Q2, mean=2.95). The high neutrality (2528) shows that a large proportion of respondents are either not using ICT-supported responses or that it is inconsistent. This disparity is described in the Information Systems Success Model: hazard reporting (Q1) and relief access (Q4) are based on comparatively simple, unidirectional transactions, while real-time updates and coordination are based on bidirectional information flows and interoperability between institutions, which Somalia cannot yet afford because of its fragmented government and unreliable networks.

The comparatively better results of hazard reporting and access to relief are empirical confirmations of the literature assertion that in Somalia, several concepts have intensely grown mobile phone penetration and telecommunication, in this case mostly mobile money platforms (e.g., EVC Plus), which are now highly embedded in our everyday life and the delivery of humanitarian logistics. The Technology Acceptance Model explains that perceived usefulness is strong due to the delivery of tangible, immediate payoffs (cash transfers) even when in risky or isolated places. In comparison, real-time updates (Q3) are affected by issues of network reliability and a lack of systems that relay timely, influential information back to the affected communities. The low coordination score (Q2) is due to institutional fragmentation that is observed in the literature: government agencies, non-governmental organizations, and community institutions tend to work in silos, and ICT has not yet been able to overcome those gaps. The highest score (Q5, mean=3.10) of the five items indicates reserved optimism, although the distance between reality and the ideal is huge. Investment decisions can be made to improve climate risk response by focusing on two-way communication systems (e.g., interactive voice response, community feedback loops), combining ICT with local response committees, and focusing on mobile network resilience in disaster-prone regions. ICT will only be useful as partial response tools unless these coordination and real-time information gaps are closed, creating communities vulnerable to crises, precisely the gap that this research will help to fill.

4.9. Effectiveness of ICT Methods for Climate Risk Response

Table 9.
Perceived Effectiveness of ICT Response Methods.

ICT Method	Very Effective (%)	Effective (%)	Neutral (%)	Ineffective (%)	Very Ineffective (%)
Mobile money (e.g., EVC Plus) for aid distribution	32.0	35.4	18.1	8.5	6.0
Two-way SMS for reporting needs	18.4	28.6	24.9	16.4	11.7
Mobile phone calls for coordinating help	28.3	33.1	20.7	11.3	6.6
Social media for mobilizing community support	14.2	22.9	26.6	20.4	15.9
Digital mapping (sharing safe routes via phone)	8.8	16.4	29.5	26.1	19.2

The perceived effectiveness data on ICT-based climate response approaches show a drastic order that is directly attributed to the infrastructural situations in Somalia, user capacities, and institutional conditions, much to the affirmation of the Sustainable Livelihoods Framework. Mobile money (e.g., EVC Plus) used for aid distribution is rated as the most effective, with 67.4 percent of respondents observing it to be very effective or effective, and only 14.5 percent observing it to be ineffective or very ineffective. This confirms the literature's observation that the perception of mobile telecommunications has surged dramatically in Somalia and that mobile money has become entrenched in everyday life and humanitarian activities. The Technology Acceptance Model explains this high rating: mobile money has high perceived usefulness (instant cash transfers in insecure locations) and perceived ease of use (via a simple phone, no literacy or internet needed). Voice calls for organizing assistance are next, with 61.4% viewing them as very or effectively used, supported by 75.4% mobile phone penetration (Table 1), which requires no smartphone or data plan. Both approaches are successful because they align with already established physical and social capital, can be reliably used within 2G networks, and are institutionalized by humanitarian actors.

In contrast, more technologically advanced techniques were poorly rated. The least effective was digit mapping (sharing safe routes through phone), with only 25.2% considering it very effective or effective, and 45.3% considering it ineffective or very ineffective. Mobilizing community support using social media was next, with low scores of 37.1% very effective or effective and 36.3% ineffective or very ineffective. The reporting needs using two-way SMS were in the middle, with 47.0% considering it very effective or effective, but 28.1% found it ineffective. The Information Systems Success Model is specifically supported or affirmed by this hierarchy: digital mapping requires a variety of GPS, stable 3G/4G, and current geospatial data conditions, which are uncommon in rural Somalia; information quality is often low due to obsolete or erroneous maps. The Diffusion of Innovation Theory states that innovations not aligned with infrastructure, literacy levels (27.8% have no educational background), and culture will be slow to adopt. Literature warns that infrastructural dependencies, poor digital literacy, and the absence of policy integration are barriers to successful ICT use, which this study affirms. Humanitarian and development actors aiming to improve climate risk responses should focus on mobile money and voice communications, emphasize simple two-way SMS communication, and avoid investing in digital mapping or social media interventions until basic infrastructure is improved. Ignoring this effectiveness hierarchy would waste resources on tools that vulnerable communities cannot utilize, perpetuating the disparity between ICT potential and underutilization recorded in this research.

4.10. Discussions

The combined presentation of the outcomes of the climate risk responses indicates hyperactive responses and instructive paradoxes characteristic of the role of ICT in Somalia: although individuals consider ICT to be moderate in general ($Q5$ mean=3.10), there are significant gaps among individual

response functionalities, which directly support the main thesis of the literature that the potential of ICT is not fully utilized through infrastructural, institutional, and literacy barriers. Mobile money (67.4% very effective/effective) proves to be the most effective, followed by voice calls (61.4%), digital mapping (25.2%), and social media (37.1%), which lag behind. The hierarchy empirically confirms the Sustainable Livelihoods Framework, which states that ICT interventions should be built on previously existing assets. Mobile money leverages the ubiquity of basic phones and agent networks, while digital mapping requires new assets, such as smartphones, data plans, and digital literacy, which vulnerable groups often lack.

The Adaptive Capacity Theory also applies: prompt, high-quality information and effective coordination are necessary for an effective response; mobile money makes concrete resources (cash) available under risky conditions, while the lack of tangible information (the inability to provide real-time updates) causes communities receiving aid to work with information asymmetry, which poses a risk to adaptive capacity.

A framework of performance differences by the Information Systems Success Model articulates these differences in terms of the quality of systems and information. Simple voice calls and payment remittances on 2G networks and feature phones work sufficiently well and have high levels of user satisfaction. Conversely, digital mapping requires GPS, stable 3G/4G, and up-to-date geospatial data, which are hardly available in rural Somalia, leading to low-quality information and dissatisfaction. The Technology Acceptance Model further explains that perceived usefulness is high when methods provide direct, low-effort benefits (mobile money, voice calls) and low when the methods are complex and require technical skills and costly infrastructure. The Diffusion of Innovation Theory also contends that innovations that cannot fit the existing infrastructure, literacy (27.8% have no formal education), and cultural practices (elders, mosque networks) will have difficulty spreading. Interestingly, the difference between hazard reporting (40.0% can report) and real-time updates (30.9% receive updates) indicates that feedback loop communities are sending information, but the receiver of the message (the community) does not respond, making the act of reporting pointless and ineffective. The demand for two-way communication systems (interactive Voice Response, radio connection, and callback services), which are present in the literature, is well supported. Finally, although ICT has the potential to respond to climate risk, especially the use of mobile money and voice-mediated responses, the fundamental flaw in the research argument is verified by the existing gaps in real-time information and the use of high-tech tools. Complete priority investments need to focus on voice-based and mobile money solutions, enhance bidirectional communication, and postpone complex digital interventions until basic infrastructure is enhanced. In the absence of this move, the climate response would continue to be reactive, disjointed, and unequal, as the most vulnerable populations in Somalia are subjected to frequent droughts and floods.

5. Conclusion

This study finds that although information and communication technology (ICT) has a profound theoretical potential to improve climate change adaptation in Somalia, its actual effect is limited, disparate, and fabricated by structural constraints. The empirical evidence among the 353 respondents indicates that ICT leads to a moderate effect on community awareness (54.1% of all respondents agreed that ICT enhanced understanding) and disaster preparedness (only 34.4% of all respondents received timely early warnings), agricultural decision-making (only 39.5% of all respondents used mobile weather forecasts), and climate risk response (40.0% of all respondents were able to report hazards). The penetration of mobile phones (75.6%) is high, but the lack of internet access in smartphones (40.2%) and 27.8% of the population lacking formal education constitute a digital divide, which the Technology Acceptance Model and Diffusion of Innovation Theory can explain clearly. There is an extremely low level of trust in digital climate information (mean 2.91/5), and the dominance of traditional sources, such as radio (68.6% daily/weekly) and community elders (56.7%), remains high and more credible. Mobile money and voice calls are the most efficient to use in response (67.4% and 61.4%, respectively),

while complex tools like digital mapping (25.2% effective) and social media (37.1%) are ineffective because of infrastructure and literacy issues. In this way, the main hypothesis concerning the great contribution of ICT to climate adaptation is partially confirmed; ICT conditions under the addition of pre-established resources (basic phones, radio, voice communication) and collapse when high rates of digital literacy, reliable internet, or complex coordination are demanded. There remains a significant gap between the idealized purpose and the actual state of ICT, as outlined in the literature gap, which keeps Somali communities extremely susceptible to frequent droughts, floods, and loss of agriculture.

6. Recommendations

Based on the findings of this study, policymakers, humanitarian organizations, and development practitioners are advised as follows. First, it is important to focus on investing in radio-based early warning systems and voice-call networks, as these are the most credible, available, and useful in disaster preparedness and climate awareness (69.5% and 62.3% perceived usefulness, respectively). Second, increasing the use of mobile money platforms (e.g., EVC Plus) to respond to climate risks, which have been rated at a 67.4% level of efficacy, and combining them with a two-way SMS or interactive voice response to complete the feedback loop between communities and responders. Third, consider how digital information can be incorporated into existing information sources through the use of community elders to verify the accuracy of digital climate warnings during routine communication to ensure trust and higher uptake. Fourth, invest in localized, participatory data collection (community-based weather stations, market price reporting) and disseminate information via simple, voice-based, Somali-language messages via radio and plain mobile phones, not by apps, until smartphone coverage and digital literacy levels have soared. Fifth, consider the underlying obstacles of digital literacy (27.8% have no formal education) and network reliability by incorporating basic skills in digital literacy training into agricultural extension programs and network resilience in regions prone to disasters by focusing on mobile networks. Last but not least, establish a national ICT adaptation-to-climate approach that directly addresses the four dimensions (awareness, preparedness, agricultural decisions, risk response), devotes resources to hybrid (traditional + digital) communications, and establishes interoperable early notification devices that connect satellite surveillance to local telecommunications.

6.1. Contribution of the Study

This study has several innovations for knowledge and practice in ICT-enabled climate adaptation in fragile states. Theoretically, it applies four well-known models to the context-specific situation in Somalia, which is a weak state with a long history of conflict, institutional instability, and limited digital literacy: the Diffusion of Innovation Theory, Adaptive Capacity Theory, Information Systems Success Model, Sustainable Livelihoods Framework, and Technology Acceptance Model. This illustrates that these theories need to be modified to accommodate the dominance of old coping processes, the centrality of trust in digital information, the effectiveness of the tools, and infrastructure limitations. Empirically, this study addresses a large gap in the literature: existing studies on ICT in Somalia have focused on economic growth and digital porousness, yet this study is the first to present systematic quantitative evidence of ICT use to achieve desired climate-adaptive outcomes (awareness, preparedness, agricultural decisions, and risk response) in 353 respondents. It produces original data on the perceived usefulness of certain tools (radio and voice calls, SMS messages, mobile money, social media, and digital mapping), with clear preference hierarchies. In practice, the study provides practical recommendations to policymakers and humanitarian actors: emphasize radio and voice-based systems, scale mobile money responses, avoid preempting investments in multifaceted digital solutions, and interconnect ICT with conventional communication media. It also offers a validated conceptual framework and survey tool that can be applied in other weak and climate-sensitive environments.

6.2. Empirical Contribution

This research study has empirical value in that it presents primary quantitative data on the role of ICT in climate adaptation in a vulnerable state where no such evidence was previously observed. The study develops descriptive statistics regarding the four dimensions of adaptation using a sample of 353 respondents who represent livelihoods in Somalia that are sensitive to climate (84.4% farmers, pastoralists, or agro-pastoralists; 58.1% rural). Notable empirical results cover mobile phone penetration of 75.6%, smartphone internet of 40.2%, and trust in digital climate information, with a low mean of 2.91/5 (the lowest). The most used source was radio (68.6%, 63.1%/week, respectively). Such empirical tendencies set baseline parameters for future studies, confirm the hierarchy of tool effectiveness, and evaluate the gap between ICT possibilities and utilization. The paper also presents frequency tabulations, Likert-scale means, and a cross-tabulation that can be used to guide evidence-based policy and compare future longitudinal or intervention analyses.

6.3. Practical Contribution

The real impact of the present study is that it will provide evidence-based, context-linked guidelines to create and practice ICT interventions that will work in the challenging environment in Somalia. First, practitioners must shift resources from complex, application-based (with very low perceived usefulness) solutions to radio broadcasts (69.5% useful), voice calls (62.3%), and mobile money (67.4% effective) as the primary means of climate awareness, preparedness, and response. Second, the analysis reveals that bridging the trust gap (only 33.1% trust digital information) can be achieved by relying on hybrid models; that is, digital alerts should be validated by community elders in regular meetings and institutionalized. Third, humanitarian agencies must incorporate mobile money in disaster preparedness efforts because it is rapid, fungible aid even in high-insecurity regions and should be accompanied by plain two-way SMS or interactive voice response to ensure that vulnerable communities get real-time disaster response information (only 30.9% get a response today). Fourth, agricultural extension must offer localized weather and market messages through voice messages in Somali and radio programs, with some modest digital literacy capacity training, not SMS or applications that leave out 27.8% of the uneducated and 59.8% who lack smartphone access to the Internet. Fifth, feature-phone-compatible SMS and voice alerts should be prioritized by early warning systems, and redundancy through radio and network resilience must be invested in disaster-prone rural areas. These are immediately applicable practical recommendations based on the ratings of respondents and can be instantly implemented by government agencies, NGOs, and telecom operators engaged in the adaptation of the Somali climate.

6.4. Weaknesses of the Study

This study has several limitations. First, an Internet questionnaire, though fitting (and reaching) ICT users, inevitably leaves out individuals who do not have Internet access (only about 59.8% have no Internet on smartphones) and those in remote regions, with no connection, leaving the sample prone to bias towards urban, younger, more literate ICT users. Second, the descriptive research design and quantitative approach can reveal connections and trends between not causality, that is, ICT usage can result in climate adaptation outcomes; because the study indicates that the users of ICT are more aware, it cannot confirm that ICT led to their behavioral change, instead of self-selection or other variables. Third, the study population of 353 is statistically adequate, yet it might not adequately represent the Somali region and livelihood system diversity (e.g., Puntland, Somaliland, and South-Central) because of security and accessibility issues. Fourth, this research is based on self-reported perceptions and Likert responses, which are subject to social desirability bias, recall bias, and different interpretations of scales by different respondents who vary in their literacy levels. Fifth, the cross-sectional design measures one point in time (2026) and is not able to describe seasonal differences in climate information requirements or the rapidly changing mobile network coverage and digital literacy. Sixth, qualitative methods (such as focus groups and key informant interviews) were not used in the study, which may have provided

greater depth into how and why some ICT tools are being trusted or rebuffed and how the traditional and digital systems work together in reality.

6.5. Further Research Studies

Based on the results and constraints of this study, we provide some directions for future research. To validate the hypothesis based on causal relationships, longitudinal studies must first be implemented to monitor alterations in the outcomes of ICT adoption and climate adaptation over time, specifically as mobile network coverage increases and digital literacy enhances and enables causality inference via panel data. Second, the socio-cultural process underlying trust (or distrust) in digital climate information requires mixed-method studies involving quantitative survey techniques with qualitative methods such as interviews, focus group discussions, and participatory rural appraisals to elucidate how communities are adopting ICT in conjunction with indigenous knowledge systems. Third, the generalizability of the study findings and context-specific moderators would be determined through comparative research across various areas in Somalia (e.g., urban vs. rural, agro-pastoral vs. pastoral, conflict-affected vs. stable) and other delicate states (e.g., Yemen, South Sudan, Afghanistan). Fourth, the usefulness of certain hybrid models, such as radio + mobile money, voice alerts + elder verification, or interactive voice response feedback loops, should be tested in intervention-based research (randomized controlled trials or quasi-experimental designs) on a set of outcome measures (adaptation outcomes, e.g., yield improvement, livestock survival rates, disaster response times). Fifth, digital literacy program studies should include an assessment of the training modalities (community-based, radio-delivered, mobile-based) that are most effective in increasing the perceived ease of use and actual utilization of ICT tools in climate adaptation among populations with no formal education. Sixth, research is needed on the political economy of ICT to adapt to climate change, such as how telecom regulators, humanitarian funding systems, and issues of data privacy can construct equitable access. Lastly, cost-effectiveness comparisons between various ICT tools (radio vs. SMS vs. mobile money vs. apps) would assist resource-constrained policymakers in prioritizing resources for interventions with the highest resilience benefits per dollar invested in weak environments.

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Institutional Review Board Statement:

The Ethics Committee of the Center for Research and Development at the Capital University of Somalia reviewed and approved this study involving human participants. Approval was granted under reference number CUR&D0064/2025, ensuring that all research operations complied with the ethical standards with international guidelines outlined by the committee.

Transparency:

The authors confirm that the manuscript is an honest, accurate, and transparent account of the study; that no vital features of the study have been omitted; and that any discrepancies from the study as planned have been explained. This study followed all ethical practices during writing.

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