

Information Systems Research for Climate Health: An Agenda to Tackle the Imminent Global Health Crisis

Sune Dueholm Müller
University of Oslo
sunedm@ifi.uio.no

Jørgen Andresen Osberg
University of Oslo
jorgenao@ifi.uio.no

Herman Tretteteig
University of Oslo
hermat@ifi.uio.no

Johan Ivar Sæbø
University of Oslo
johansa@ifi.uio.no

Geir Kjetil Ferkingstad Sandve
University of Oslo
geirksa@ifi.uio.no

Abstract

Climate change constitutes an imminent global health crisis threatening human health directly through extreme weather events and indirectly via altered disease patterns and food insecurity. This paper identifies climate health as an emerging field, emphasizing the critical role of Health Management Information Systems (HMIS) in mitigating the negative health impact. By leveraging Early Warning Systems (EWS) and integrating climate data, HMIS can provide decision-makers with actionable information. The study employs a Retrieval-Augmented Generation (RAG) chatbot to review a large corpus of interdisciplinary literature, highlighting the need for Information Systems (IS) research on EWS design and integration, climate health information systems in practice, resilient health systems, capacity building for climate health action, and institutional impact of digital innovation. The findings underscore the importance of developing robust, adaptive IS to support climate health actions and outline a comprehensive IS research agenda to address the multifaceted challenges climate change poses to public health.

Keywords: Climate health, Retrieval-Augmented Generation, Early Warning Systems, Health Management Information Systems.

1. Introduction

Climate change is one of the major challenges facing humanity in the twenty-first century. It constitutes an imminent global health crisis through significant alterations in weather patterns, leading to an increase in fatalities and exacerbating existing health inequalities. The World Health Organization (WHO) “estimates that climate change will cause 250 000 extra deaths per year due to hunger, malaria, diarrhea, and heat stress” between 2030 and 2050 (Sijm-Eeken et al.,

2022, p. 2083). Given the dramatic consequences of climate change and its effect on multiple aspects of human societies, ‘climate action’ has been identified as the 13th Sustainable Development Goal by the UN (<https://www.un.org/sustainabledevelopment/climate-action>).

Human health is inextricably linked to the climate, and climate change impacts human health directly and indirectly. It has a direct impact by increasing the frequency of extreme weather events like heatwaves, storms, floods, and wildfires, resulting in injuries, illnesses, and deaths. It also has an indirect impact through, for example, changes in temperature and precipitation, which increases the prevalence of vector- and waterborne diseases. Additionally, climate change affects food security, respiratory and cardiovascular diseases, and mental health (T. T. Chen et al., 2021; Shao & Zhang, 2024).

Globally, some healthcare systems are better poised to mitigate the adverse effects of climate change, while numerous others face considerable obstacles and may lack sufficient resources to respond effectively (Mosadeghrad et al., 2023; Sellers & Ebi, 2018).

Preparing for the future requires planning and estimating healthcare needs, necessitating decision support through forecasts and predictions. In essence, decision-makers need actionable information to mitigate, if not prevent, the negative impact of climate change on human health (Shao & Zhang, 2024). In turn, actionable information depends on analyzing and presenting valid and reliable data through Health Management Information Systems (HMIS), sometimes integrated with Early Warning Systems (EWS). We dub these systems climate health information systems. EWS provide timely information on environmental indicators impacting health outcomes and healthcare services (Mosadeghrad et al., 2023). These systems are essential for monitoring and identifying changing climate conditions and anticipating environmental risks and

emergencies, such as extreme temperatures or precipitation events. They may also support epidemiological surveillance by monitoring changes in disease incidence over time, particularly for vector- and waterborne diseases, along with the decline in certain health conditions due to implemented mitigation strategies. Such systems are critical in quickly alerting stakeholders at both local and national levels about potential environmental hazards, allowing for improved preparedness and response to prevent adverse health effects (Mosadeghrad et al., 2023; Sellers & Ebi, 2018).

Climate health is an emerging field of study investigating the impact of climate change on human health, including how various climate-related factors such as extreme weather events, heat stress, air quality, and changes in ecosystems affect health outcomes. It also explores mitigation and adaptation responses to the health impact, aiming to support health systems in managing and reducing the adverse effects of climate change on public health (Pizzulli et al., 2021). Impact studies dominate the existing literature on climate health (Berrang-Ford et al., 2021), whereas Information Systems (IS) research within this field is almost non-existent. In our review of the literature on the subject, we identified very few IS papers on climate and health (e.g., Parker et al., 2019). Of the 1915 papers identified in a Scopus search, only one article is in a journal on the Senior Scholars' List of Premier Journals that is tangentially related to the field (Chang, 2014). Our review shows that this is not because the subject is irrelevant to IS researchers. If anything, it is evidence of climate health being an emerging field of study, which nonetheless represents a greenfield area in IS research.

The aim of our review is to synthesize state-of-the-art knowledge on climate health from an IS perspective. We explore how future research can enhance the usefulness of climate health data for policymakers and healthcare providers by facilitating actionable information through HMIS. We highlight how HMIS can support informed decision-making and enable proactive measures, such as planning healthcare services in anticipation of predicted changes in disease patterns due to climate change. Based on the review, we propose a future IS research agenda on climate and health.

2. Method

To stimulate discussion on the IS research agenda regarding climate health, we have conducted a literature review using a Retrieval-Augmented Generation (RAG) app, which we will refer to as the RAG chatbot henceforth. Figure 1 shows the Graphical User Interface (GUI) of the chatbot.

Ask GPT about your documents

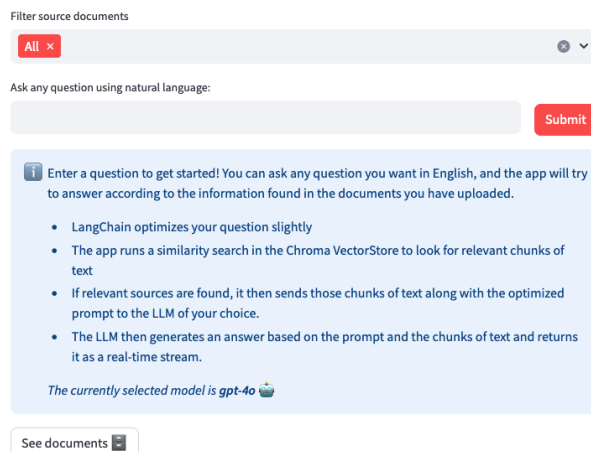


Figure 1. RAG chatbot GUI.

Climate health is a nascent, interdisciplinary research topic without a well-established IS literature foundation. It is a subject that has garnered attention from numerous other disciplines, such as climatology, meteorology, health, and computer science, to name a few. Therefore, to comprehend how IS can contribute to the climate health agenda, we need to examine the literature from all these different fields to understand the requirement for a sociotechnical understanding of information needs, strategies for managing this information, and support for decision-making through the development, implementation, and utilization of IS.

However, such a review is not feasible using existing techniques for a comprehensive literature review because they are often designed for reviews within a single discipline (Paré et al., 2015). Interdisciplinary research spans multiple fields with diverse methodologies, theories, and terminology, making it challenging to synthesize the literature using traditional approaches (Snyder, 2019). The sheer volume and variety of literature in interdisciplinary research can be overwhelming for techniques like meta-analysis (Kraus et al., 2022). We are, therefore, using a self-developed RAG chatbot to conduct an argumentative review (Triwicaksana & Oktavia, 2023). We first describe the chatbot, followed by an account of using it to review the literature.

2.1. Retrieval-Augmented Generation chatbot

The RAG chatbot is an app that leverages the power of Large Language Models (LLMs) to generate accurate answers to user-specified questions. It addresses the limitations of off-the-shelf generative AI chatbots like ChatGPT and Claude, such as a limited context window, low accuracy, and hallucination, by using provided data to inform its responses. In this case, the data are peer-

reviewed research papers retrieved through established literature review procedures.

The chatbot uses three key components to provide intelligent responses: LangChain, the OpenAI API, and ChromaDB. LangChain handles user questions, document retrieval, and response formatting. The OpenAI API, utilizing the GPT-4o model, creates answers based on the user's query and context. ChromaDB, a vector database, stores and quickly retrieves document information. When a question is asked, LangChain processes it, ChromaDB finds relevant documents, and the OpenAI API generates a context-aware response. This system ensures accurate, context-aware answers.

LangChain is a comprehensive framework that simplifies the development of LLM-powered, context-aware apps (<https://www.langchain.com>). It handles input management by preprocessing user queries into a suitable format. It also orchestrates the retrieval of relevant documents from the ChromaDB vector database and passes them, along with the user query, to the OpenAI API. Finally, LangChain reads and formats the response stream generated by the OpenAI LLM.

The OpenAI API enables responses based on the context of the relevant documents retrieved from the ChromaDB database (<https://openai.com/api>). These documents are passed along with the user query as inputs to the language model (LLM). The default LLM used by the chatbot is GPT-4o, which was released on May 13, 2024. Two key adjustments ensure the model generates accurate answers without hallucination. First, the temperature setting controls the model's creativity by adjusting the probability distribution of the next word(s). A lower temperature reduces hallucination by keeping the model focused on the user query and context. Second, the prompt template combines the user query and retrieved documents to instruct the model to answer based solely on the context.

ChromaDB is an open-source vector database that handles persistent storage and efficient data retrieval (<https://docs.trychroma.com>). It stores document vectors in the browser's IndexedDB (client-side storage system built into web browsers that allows web applications to store and retrieve large amounts of structured data). It enables similarity searches on text documents using vector embeddings that are mathematical representations of data in a high-dimensional space (<https://javascript.info/indexeddb>). Documents are ingested, split into chunks, converted into vectors capturing the semantic value of the chunk, and stored in the database. ChromaDB also enables vector space retrieval, where user queries are converted into vectors, and the database searches for relevant documents with the highest vector similarity to the query. Due to the nature of embeddings, documents with

related concepts and keywords are closer to each other in vector space. Additionally, ChromaDB provides persistent storage, as its indices are stored locally on the user's machine and can be reused whenever the chatbot is running.

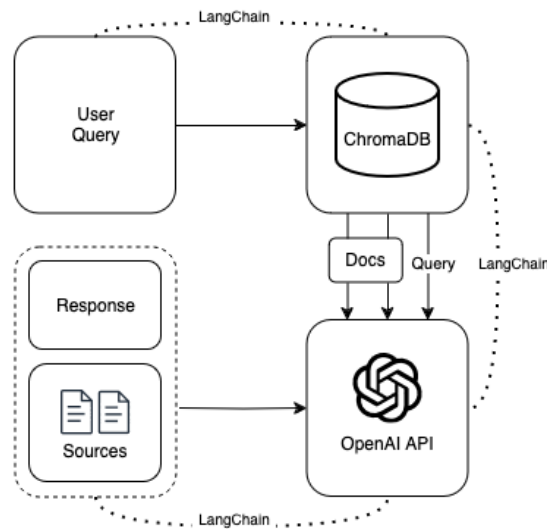


Figure 2. RAG chatbot components.

Figure 2 shows the chatbot's technical components and how they are linked. The chatbot works by first preprocessing the query, e.g., "How does climate change impact human health?" using LangChain to ensure it is in a suitable format. LangChain then converts the query into a vector representation that captures its semantic meaning. ChromaDB searches its database for documents with vectors most similar to the query vector, retrieving relevant research papers related to the impact of climate change on human health. The retrieved documents are fed into the OpenAI API as context. The API generates a response based on this context, using a prompt template instructing the model to answer the question using only the provided information.

The chatbot app is available on GitHub: <https://github.com/jorgenosberg/retrievAI>.

2.2. Literature search and analysis

We searched for academic literature using Scopus. We limited search results to journal articles and conference papers written in English. We wanted to include as many articles as possible that (1) focus on climate and health, (2) include a technology perspective, and (3) relate to the process of making decisions and gathering information to aid in decision-making. We applied the following string in a search within the papers' titles, abstracts, and keywords:

(climate AND health) **AND** (ICT OR “Information and Communications Technology” OR software OR “digital technolog*” OR “information technolog*” OR “information system*” OR “machine learning” OR “artificial intelligence”) **AND** (“decision-making” OR “decision making” OR surveil* OR monitor* OR “decision support” OR predict* OR forecast* OR “early warning” OR modeling OR modelling)

In this rendition of the search string, we have highlighted “AND” in bold to emphasize that it consists of three parts. The first part ensures that the retrieved articles relate to both climate and health. The second part stipulates that identified articles have a technology focus. The third part ensures that the articles deal with decision support in relation to “climate health.”

The search yielded 1915 papers. 901 articles could be downloaded from our university library in bulk using EndNote 21. The remaining papers were unavailable or required manual downloading for several reasons, such as the absence of DOIs and metadata, as well as limitations due to institutional access and database restrictions. After downloading the papers, we trained the RAG chatbot on the literature corpus and began generating responses to pre-defined and emergent questions. We validated the responses by carefully reading the relevant sections of the cited papers and challenged the chatbot to elaborate, exemplify, and provide counterevidence when answers were unsatisfactory. Figure 3 shows an example prompt.

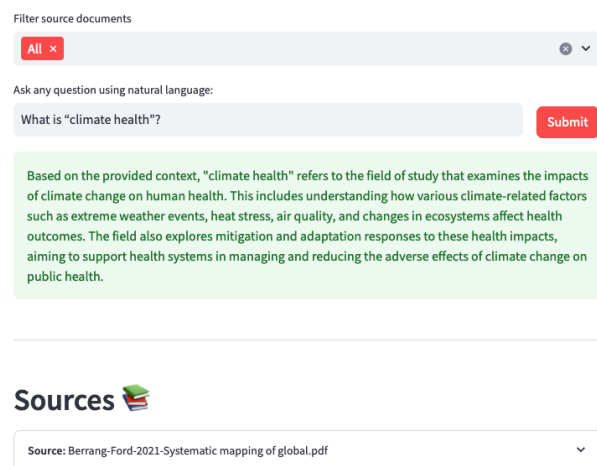


Figure 3. Example prompt.

NB: The screenshot shows only the first reference (“Sources”) due to space constraints.

A challenge with a literature review of this size is that we can neither include all papers on the list of

references nor cite all the papers referred to in each response to our prompts. For the sake of transparency and traceability of our research process, we are sharing the EndNote file with all the references from our Scopus search (<http://u.pc.cd/Krlrtalk>) and a PDF document containing our prompts (<http://u.pc.cd/D517>). In the text, we include selected citations from the chatbot’s responses based on our reading of the presented text passages.

Research in progress shows Retrieval-Augmented Generation (RAG) as a reliable technology for conducting literature reviews because it combines accurate, up-to-date information retrieval with coherent text generation, ensuring contextual relevance and factual accuracy (see, e.g., Cao et al., 2024; Huang & Huang, 2024). The RAG chatbot was utilized for literature analysis, while other generative artificial intelligence tools, specifically Grammarly and ChatGPT, were used for proofreading and copyediting the text. The RAG chatbot was used as an analytical tool throughout the article process. We used it as a virtual sparring partner in framing the article (introduction), conducting the actual review (state-of-the-art), and identifying knowledge gaps (research agenda). The article was, so to speak, created through an extended conversation with the chatbot, which we directed through well-planned “prompts” and follow-up questions.

3. State-of-the-art: IS and climate health

IS can help healthcare systems cope with climate change as an imminent global health crisis. They play a crucial role in predicting, preventing, and alleviating the negative impact of climate change on human health. HMIS are used to collect, analyze, and share data to support decision-making by different stakeholders confronted with the potential and real impact of climate change. At an abstract level, HMIS inform these stakeholders about potential vulnerabilities of the healthcare system to climate risks and support adaptations in response to anticipated and experienced climate change effects (Mosadeghrad et al., 2023). Specifically, these systems may support communication with the public and awareness-building efforts targeting vulnerable populations (Sheehan & Fox, 2020). Some HMIS integrate early warning and risk monitoring mechanisms that provide timely and accurate information on context-relevant environmental indicators. Such indicators vary as different regions confront varying climate-related health risks (Jancloes et al., 2015). Some early warning and risk monitoring mechanisms may be AI-based and create threat alerts that can be visualized on, for example, maps to identify high-risk areas and communities in the face of disasters

such as floods, earthquakes, and storms (Valle-Cruz et al., 2019). Such systems contribute to public health emergency preparedness and resilience by supporting policymakers and other stakeholders in allocating resources effectively. This includes simulating future climate change scenarios and estimating their impact on health outcomes to evaluate and plan mitigation strategies (Mousavi et al., 2020).

Extant research shows that the digital technology components of climate health information systems, such as eHealth and telemedicine, are critical in monitoring, predicting, preventing, and controlling climate-sensitive diseases (Stewart-Ibarra et al., 2019). Understanding the sociotechnical context is important when designing and implementing such IS. It is a prerequisite for successfully integrating climate data into HMIS to support planning for and responding to extreme weather events. This involves identifying climate-related information that is relevant and useful for health-related decision-making, understanding the interactions among healthcare providers, climate services, public health authorities, and local communities, and recognizing the need to base decisions and interventions on near real-time climate and health data. A nuanced understanding of the sociotechnical context increases the likelihood that the information provided is actionable and effective in mitigating the health risks associated with extreme weather events (Janclous et al., 2015). At the data use level, it necessitates community engagement to elicit the specific information needs of communities involved in health interventions, ensuring that marginalized or vulnerable populations are served. Community engagement is critical to understanding the nuances of climate health information needs. Engaging with communities helps grasp the viewpoints of local stakeholders and the vulnerabilities various populations face. This engagement is key to establishing trust and ensuring the information provided is relevant and useful (Hoy et al., 2014). At the policy level, interests must be aligned across global, regional, and community levels to ensure a coherent and holistic approach to climate health.

Alignment of interests necessitates cross-sectoral collaboration and coordination to prevent effort duplication and optimize resource use. Aligning actions with national priorities and fostering local leadership and ownership are fundamental for long-term impact and success (Hoy et al., 2014; Mosadeghrad et al., 2023). Assuming that the information needs are understood and interests are aligned, climate health information systems should be developed based on assessments of vulnerability, capacity, and adaptation (VCAs). “VCAs measure potential hazards associated with climate change, as well as the capacity of systems to respond to these challenges. When applied to health,

VCAs examine staffing in particular specialties, service quality, physical health infrastructure, and health worker training capabilities, allowing policymakers to understand the vulnerabilities and gaps in capacity that may result from climate and development shocks” (Sellers & Ebi, 2018, p. 8). Looking beyond the development and implementation of such systems, effective use requires capacity building, which includes developing analytical capabilities and designing user-friendly data analysis tools (Stewart-Ibarra et al., 2019).

Extant research has explored the specific questions that healthcare decision-makers encounter when coping with the impact of climate change. These questions include how to strengthen the capacity of the healthcare system to be able to respond to the impact of climate change on health outcomes (Mosadeghrad et al., 2023), what the key components of a resilient healthcare system against climate change are (Mousavi et al., 2020), and what the training needs of healthcare professionals are regarding locally relevant environmental health topics (Sellers & Ebi, 2018). Figure 4 lists the IS-related climate health questions explored by extant research.

Extant research has explored several specific questions that healthcare decision-makers face in addressing climate change, including:

1. How to strengthen the capacity of the health system to respond to the health effects of climate change?
2. How to reduce the healthcare sector's contribution to greenhouse gas emissions and its carbon footprint?
3. How to manage the environmental determinants of health and create climate-informed health programs?
4. How to develop robust emergency preparedness and management processes?
5. How to track environmental information and the prevalence of diseases related to climate change?
6. How to model and predict the health effects of climate change?
7. How to identify locations and populations at risk?
8. How to develop and implement preparedness and response plans for extreme climate events?
9. How to provide counseling services to the public and local health sectors?
10. How to ensure the workforce is prepared to respond to health threats posed by climate change?
11. How to conduct applied research and translate findings into practice through evidence-based decision-making?
12. How to design and evaluate effective adaptation and protective measures, including public and environmental health ones?
13. How to improve health care and emergency services during times of crises?
14. How to provide health staff with training on locally relevant environmental health topics and risk communication?
15. How to allocate resources for specialist training based on projections about changes in disease patterns?

These questions reflect the multifaceted challenges that healthcare decision-makers must address to mitigate and adapt to the impacts of climate change on health systems and public health.

Figure 4. Climate health questions explored by extant research.

Previous studies have focused on understanding how healthcare professionals perceive climate change (Stewart-Ibarra et al., 2019) and have emphasized the critical need for evidence-based decision-making to develop effective policies and plans (Mosadeghrad et al., 2023). Extant research also shows that key decision-makers, like healthcare professionals, encounter various

challenges when making informed decisions in response to the anticipated disease increases due to climate change. These challenges arise because of (1) data fragmentation, (2) information overload, and (3) disparate healthcare models. First, data collection efforts frequently suffer from fragmentation and a lack of coordination, which impairs the capacity to anticipate and effectively address the expected health consequences of climate change (Turner et al., 2013). Second, despite having more data and computational models than ever, decision-makers are overloaded with information, making it difficult to navigate and make timely and educated decisions (Armentano & Kun, 2016). Third, differences in healthcare models within and across countries challenge the development and deployment of integrated HMIS. “Disparate healthcare models, even within single countries or regions, as well as international differences make it difficult to build integrated, seamless systems, and to transfer successful solutions” (Kuhn et al., 2007, p. 502). This, in turn, may lead to the first point regarding data fragmentation.

The literature reports several challenges in developing, implementing, and using climate health information systems. For one, a lack of resources and expertise across the climate and health sectors hinders the development and implementation of EWS. Secondly, there is a need to increase analytical capabilities and develop user-friendly data analysis tools that combine health and climate information for routine reporting activities. Enabling climate-informed healthcare decisions and actions requires “enhancing the workforce’s ability to detect and treat diseases, monitor and predict spatio-temporal patterns and implement intervention and control strategies in a timely and cost-effective manner through the use of tools and analysis informed by climate data” (Connor et al., 2006, p. 29). Thirdly, efforts to strengthen capabilities and systems for climate-sensitive disease surveillance and response should take a system-thinking approach to ensure sustainability and effectiveness. Despite these insights, the literature on the development, implementation, and use of these systems is lacking. Much of the existing literature revolves around developing data models, including predictive and computational models. However, our understanding of how to effectively implement these systems in practice is surprisingly limited. This naturally leads us to propose a future research agenda.

4. IS climate health research agenda

We have established that climate health is a new and emerging field of study in response to climate change as an imminent global health crisis. Through our

review, we have shown that IS are central to current and future efforts to predict, prevent, and alleviate the negative impact of climate change on human health. We have emphasized the importance of understanding the sociotechnical context of systems use and what that entails when working at the intersection of climate and health. We have highlighted the key issues and information needs such systems must support. We have also underscored the challenges stakeholders face in making informed decisions and those involved in developing, implementing, and using the decision support systems referred to as climate health information systems. It is evident that there are more unanswered questions than answers within this field. A 2021 study revealed that there are “15 963 studies in the field of climate and health published between 2013 and 2019. Climate health literature is dominated by impact studies, with mitigation and adaptation responses and their co-benefits and co-risks remaining niche topics” (Berrang-Ford et al., 2021, p. e514). IS studies are, however, lacking. Therefore, climate health constitutes a greenfield IS research area. Through a series of prompts to the RAG chatbot, aimed at uncovering gaps in climate health knowledge and the need for a greater understanding of how technology, particularly in the context of IS, can contribute new insights, we are able to propose a future research agenda. Future research should focus on at least five areas:

- EWS design and integration
- Climate health information systems in practice
- Resilient health systems
- Capacity building for climate health action
- Institutional impact of digital innovation

EWS design and integration. To support climate-sensitive healthcare responsiveness, IS research should be directed toward developing and seamlessly integrating EWS. This necessitates investigating the underlying information infrastructures, work routines and structures, and decision-making processes to ensure effective EWS alignment and deployment. Many studies have focused on predictive models without adequately addressing the underlying information infrastructure they are part of and rely on to function in practice (Merkord et al., 2017). It is also critical to assess the cost-effectiveness of EWS – for example, by studying how to optimally design them and integrate them with other systems, such as HMIS, and by investigating the efficiency of the responses they trigger (Aron, 2006). Future studies should focus on:

- Translating predictive models into actionable practices, enhancing evidence-based decision-making.

- Developing architectures and frameworks for effectively integrating EWS into existing HMIS.
- Designing EWS to enable stakeholders to cope with false positives and negatives (false positives and false negatives are incorrect alerts when a prediction is wrongly made, with false positives leading to unnecessary responses and false negatives causing missed intervention opportunities.).
- Establishing best practices for monitoring and communicating climate-health vulnerabilities.

Such studies necessitate a systems-thinking approach to conceptualize EWS as part of a broader health information infrastructure. A hypothetical example of such a study is to examine how to integrate EWS for climate-related health risks into existing HMIS. This research would involve developing and testing infrastructure-aligned solutions that enable real-time climate data to inform clinical decision-making. The study could evaluate the solutions' impact on health system preparedness and response to climate-driven health emergencies.

Climate health information systems in practice.

Practice studies are needed to implement and evaluate climate health information systems that provide localized, actionable data for health-related decision-making. Healthcare sectors worldwide face the challenge of developing appropriate responses to the information provided by EWS and HMIS more broadly. "It is relatively easy to establish a system which can collect large volumes of public health surveillance data with very little delay. It is much more difficult to determine, on a continuous basis, whether that data contains information which demands public health action, or more likely, warrants further investigation" (Muscatello et al., 2005, p. 11) Applied research into the local conditions and practices is necessary to facilitate the development and adaptation of generic technological solutions that support decision-makers and healthcare professionals in acting upon the provided information. "Applied research should be conducted and their findings should be translated to practice through evidence-based decision-making" (Mosadeghrad et al., 2023, p. 9). This will involve case studies focused on integrating and using near-real-time health and weather data. Further exploration should be directed toward:

- Tailoring climate services to meet the specific needs of healthcare decision-makers.
- Understanding the data sharing and trust-building requirements for building effective IS, and garnering support from stakeholders across climate and health.

There is a "need for localised responses to the effects of climate change on health" (Berrang-Ford et al., 2021, p. e523). There is a specific need for "case studies or demonstration projects to generate local evidence on climate-health linkages" (Stewart-Ibarra et al., 2019, p. 16). Furthermore, it is highlighted that "a collaborative research process with investigators from the climate and health sectors would facilitate data sharing, build trust, and foment a culture of research on climate and health" (Stewart-Ibarra et al., 2019, p. 16). Researchers could conduct embedded multiple-case studies of climate health IS implementation across several healthcare facilities in regions prone to extreme weather events. Such studies may examine how stakeholders utilize these systems for decision-making and identify best practices for tailoring them to local needs. The results could include a process framework for localizing climate health information systems.

Resilient health systems. Research is needed into the operational challenges of healthcare systems that utilize EWS and how they cope with, e.g., fluctuations in the demand for healthcare services. The aim of this research is to understand and enhance the resilience of health services in the face of climate-induced health challenges. Public health services face challenges in developing appropriate responses to information about the predicted health impact of climate events. Near real-time information requires near real-time responses, necessitating studies on organizing and managing such responses (Muscatello et al., 2005). Prospective research should prioritize:

- Examining strategies for developing near-real-time response capacities in public health systems.
- Investigating how resilient health systems can mitigate the effects of, and respond effectively to, climate health crises.
- Studying healthcare systems' ability to adapt and respond (resilience) to the changing needs and pressures of climate change.

There is a need to "tailor the climate services so as they become more relevant and useful in specific health related decision-making" (Jancloues et al., 2015, p. 2898). This, in turn, necessitates research into the information needs and how to cater to them to ensure that systems are both robust and adaptive in the face of changing imperatives. It follows that studies should investigate how to "combine near real time health and weather data to get feedback on effectiveness of

prevention and response interventions” (Jancloes et al., 2015, p. 2899) to build resilient systems that are both robust and adaptive. Studies could, for example, investigate how healthcare systems in malaria-prone regions build resilience to malaria surges, focusing on the role of IS. By analyzing strategies such as enhanced vector control, improved diagnostics and treatment, and increased outbreak response capacity, the research should examine how IS help build healthcare resilience to malaria by supporting reliable data collection, real-time tracking, and effective communication in managing malaria outbreaks.

Capacity building for climate health action. The future success of climate health action requires studies that explore the needed capacities within and across institutions to effectively utilize EWS and HMIS in predicting, preventing, and alleviating the negative impact of climate change on human health. “The climate and health sectors do not feel ready to develop and implement an EWS or other adaptation measures due to limited institutional capacity” (Stewart-Ibarra et al., 2019, p. 19). Consequently, there is a need to study the required institutional capacity for EWS and HMIS implementation and use, including but not limited to the needed analytical capabilities and required user-friendly data analysis tools. Scholars should turn their attention to:

- Determining varying institutional capabilities required for EWS implementation and climate health interventions.
- Designing user-friendly tools and frameworks for data analysis to support climate health decision-making.
- Investigating ways to empower local communities and healthcare professionals by building their capacity to act on climate health.

In empowering local communities, “research agendas should consider particular communities of interest that may experience disproportionate health burdens related to climate change” (Sellers & Ebi, 2018, p. 8). Researchers could also help design and evaluate training programs to build climate health response capacity and competencies among healthcare professionals. These programs should focus on digital literacy, climate-related health impacts, and EWS support. Investigating local needs is a prerequisite for designing such IS-centered programs.

Institutional impact of digital innovation. EWS and HMIS are increasingly relying on AI and ML technologies in, for example, forecasting, and introducing new digital innovations to healthcare

institutions through these technologies will impact work and workers alike. Vulnerable groups are at risk of discrimination, exclusion, and inability to access or understand the new technologies, and research should focus on how to ensure equitable working conditions. “Systems to monitor and communicate information about vulnerability must be complemented by robust climate and health research agendas designed to expand and improve the quality of information provided as the effects of climate change vary over time” (Sellers & Ebi, 2018, p. 8). Studies on the impact should focus on “information systems as an enabling technology to support data access, model-based prediction, and continuous model evaluation and improvement. These systems must encompass not only computer software, but also networks of individuals and institutions that create a broader enabling environment to support the application of these tools” (Merkord et al., 2017, p. 12). Future scholarly work should focus on:

- Investigating the effects of digital innovation on employment conditions across different worker demographics, especially vulnerable groups.
- Assessing the readiness of health sector institutions to integrate digital tools, such as EWS, in climate health strategies and responses.
- Exploring the potential of digital technologies to strengthen climate health actions while avoiding exacerbating existing inequalities.

Extant research underscores “the importance of additional research to examine the impact of technological innovation on the employment conditions to which vulnerable workers are exposed. In particular, in-depth studies are needed to examine how the application of diverse digital technologies or AI/ML applications within the workplace may impact different groups of workers” (Jetha et al., 2021, p. 659). More broadly, studies could examine how introducing AI-powered EWS affects organizational structures and decision-making processes in the healthcare sector. This research should investigate changes in roles, processes, and power dynamics following the implementation of such systems. These studies could provide insights into managing the institutional impacts of digital innovation in climate health.

In summary, the preceding discussion underscores the significant demand for future IS studies. While the highlighted research areas and topics do not constitute an exhaustive list of possibilities, they are derived from our argumentative review of the existing literature. This list of research questions should, in the future, be

qualified and validated by global and local actors responsible for climate health initiatives. They should be able to nuance and supplement with concrete knowledge needs. The imperative is, however, clear: IS scholars must engage in climate health research. The potential to contribute through significant and influential studies is unmistakable. Let us begin.

5. Limitations

This paper has several limitations. First, the theoretical foundation is not fully developed. It could benefit from further elaboration and a more explicit engagement with both relevant IS theories and key climate health stakeholders, strengthening the basis for the proposed research agenda. The agenda would benefit from incorporating perspectives from various stakeholders, including healthcare providers, policymakers, and community members. Second, relying on an AI chatbot to review the literature raises methodological concerns about validity and reliability. Using an AI chatbot, even an RAG chatbot, for a literature review may introduce biases inherent in the AI's training data or algorithms. There is, therefore, a need for future validation of both the review approach and the findings. Third, while the research agenda covers a broad range of topics, the depth of analysis for each area is limited. In the future, this agenda should be expanded with detailed examples or hypothetical scenarios to illustrate how IS can support climate health actions. Ideally, these examples should be grounded in empirical investigations of stakeholder needs. Examples include, but are not limited to, investigations of potential barriers to implementing the proposed climate health IS in real-world settings.

6. Conclusion

This paper establishes climate health as a nascent yet critical field within IS research. By synthesizing interdisciplinary literature, it underscores the necessity of robust HMIS and EWS to mitigate the health impact of climate change and thereby respond to this imminent global health crisis. The proposed research agenda focuses on five key areas of IS research: EWS design and integration, climate health information systems in practice, resilient health systems, capacity building for climate health action, and institutional impact of digital innovation. This agenda aims to guide future IS research in developing adaptive, effective solutions for climate-related health challenges.

6. References

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