ST.GALLEN SYMPOSIUM

Global Essay Competition 2024

Title: Mapping the Future of Global Health: Leveraging GeoAI to Optimise Resources in Climate -Resilient Healthcare Systems

Essay:

Do you know that between 2030 and 2050, the World Health Organisation projects that climate change will result in an additional 250,000 deaths per year from heat stress, malaria, diarrhoea, and malnourishment?[1] Inaction on climate change has weakened global health resilience to infectious illnesses, heat-related injuries, malnutrition, and mental health issues.[2] Additionally, as climate-sensitive health risks have increased, it has widened global inequalities, disproportionately affecting vulnerable and disadvantaged people already facing protracted armed conflicts, shortages of food and water, and poverty.[1,2]

According to Paul Farmer's 'Socialisation for Scarcity' theory, global health resources are scarce, thus doing more with less typically limits options and leads to unsatisfactory outcomes.[3] In deciding whether to strive for more or thrive with less, climate change requires us to confront the conventional mindset of scarcity based solely on social-economical or ethical considerations in pursuit of justice and fairness.[4] Our mindset needs to shift from perpetual shortage to innovative resourcefulness.

I believe Geospatial Artificial Intelligence (GeoAI) technology offers an innovative and transformative solution to climate-induced healthcare scarcity. This approach optimises healthcare resource usage and redefines our response to emerging health crises, balancing efficient resource utilisation with climate change-related resource constraints.

Healthcare Scarcity Amidst Climate Change

Global healthcare systems are faced with unprecedented challenges as global warming persists. Healthcare facilities are struggling to cope with the surging demand for medical services, supplies, personnel, and infrastructure due to climate change-related extreme weather events.[5] According to the Intergovernmental Panel on Climate Change's (IPCC) Sixth Assessment Report, climate change poses several health risks.[6] These included increased mortality and morbidity from extreme heat events, climate-related food-borne and water-borne diseases, vector-borne and emerging zoonotic diseases, and mental health issues linked to severe climate events and the resulting displacement of communities.

For instance, climate change has exacerbated healthcare scarcity and inequities in indigenous communities. This can even be seen in developed areas such as Northern Territory of Australia, as healthcare personnel relocated due to extreme heat waves, causing shortages in healthcare staffs and reduces community access to quality healthcare, thus worsening health risks of those who are already experiencing lower life expectancies and poorer health outcomes.[7]

By 2061, the effects of climate change are expected to have significant adverse effects on global health, promoting novel approaches such as GeoAI. Firstly, a 2°C rise in global temperature could lead to 370% more heat-related deaths.[2(p2347)] Furthermore, climate change is also projected to cause moderate-to-severe food insecurity for more than half a billion people.[2(p2347)] The incidence of life-threatening infectious diseases is likely to rise,[2(p2366)] and

the extreme temperatures will compromise the safety and storage of medications, increasing health risks of those with comorbidities.[5] These complex climate-induced healthcare challenges highlight the need for innovative solutions such as GeoAI, especially in developing nations with limited technology and financial resources.

Addressing Healthcare Scarcity with GeoAI

GeoAI uses artificial intelligence and large geospatial datasets to enhance healthcare resource allocation. GeoAI utilises diverse data sources, including satellite imagery, electronic health information, and social media content to create innovative public health strategies.[8] Policymakers and researchers can gain valuable data-driven insights by merging spatial science, machine learning, deep learning, and data mining technologies. As compared to standard Geographic Information Systems (GIS) research and statistical methodologies, GeoAI allows for data-driven discovery, high computational performance, and reduced overfitting and noise in training labels.[9] GeoAI's strengths have made it possible to be utilised in environmental health, epidemiology, genetics, social and behavioural sciences, and the study of infectious diseases.[10]

The availability of spatial big data aided in the prediction of disease transmission, healthcare resource allocation, and informed policy decision-making by modelling population health impacts.[11] This is due to the collection and utilisation of geo-tagged big data, especially from lifestyle devices like smartphones and social media platforms, to meaningfully explore massive amounts of spatial relations in real time.[12,13] GeoAI can predict healthcare demands or outbreak trends using geospatial data analysis, which helps simulate extreme weather events for community risk assessment and preparedness planning to optimise resource utilisation and effective healthcare delivery.[14] Thus, creating opportunities for health humanitarians to design, deploy, monitor, and evaluate resource-efficient responses to climate change, especially within vulnerable populations.

GeoAI also enables health economists to mitigate and adapt to climate change's health effects, ensuring healthcare sustainability and efficient allocation of resources.[15] GIS-based spatial analytics helps to evaluate the uneven distribution of healthcare resources and providers and seeks to determine the optimal placement of facilities and healthcare workers in vulnerable areas to improve efficiency and access for vulnerable groups.[16,17] It can greatly improve healthcare resource availability and optimisation. Using large datasets, predictive analytics can be used to better allocate resources, prevent shortages and opportunity costs due to healthcare overuse, and maximise the impact of healthcare interventions in under-resourced climate-change-affected areas.[15]

GeoAI Case Studies and Application

GeoAI has shown potential for establishing climate-resilient health systems through disease surveillance and resource allocation after natural disasters. For example, in tropical climates, machine learning techniques such as Bayes Network and Support Vector Machine are used to construct dengue early warning systems by utilising epidemiological and meteorological data.[18] Similarly, the real-time geotagged data analysis performed by GeoAI during natural disasters such as floods, tropical storms, and heat waves facilitates the mapping of impacted regions for the effective allocation of medical resources and manpower.[10,19] Post-disaster accessibility modelling greatly improved the ability of healthcare systems and humanitarian

personnel to respond to catastrophes, such as Cyclones Idai and Kenneth in Mozambique,[20] hence increasing preparedness and lowering health risks in the face of climate disaster.

Looking forward, GeoAI has great potential to solve climate-related health challenges causing scarcity. GeoAI can aid in the planning of long-term healthcare services to mitigate climate impacts, similar to how the geospatial approach has been used to assess the accessibility and availability of primary healthcare professionals and services in Ethiopia and to monitor air pollution.[8,21] This involves active environmental monitoring, disease surveillance, and adequate resource allocation in health emergencies. GeoAI's diverse applications help adapt healthcare systems to climate challenges by offering innovative strategies to strengthen its ability to be climate resilient.

Geospatial Health Resource Optimisation Framework (G-HROF)

Although geospatial analysis has been utilised to address the health impact of climate change, a framework for integrating GeoAI technology into the healthcare system remains underdeveloped. I proposed a GeoAI Health Resource Optimisation Framework (G-HROF) to help countries manage climate-induced healthcare scarcity. This comprehensive framework aims to integrate GeoAI into a climate-resistant healthcare system to optimise limited medical resources more effectively during climate-related health events.

By adapting the Health Information System Geo-Enabling Framework[22] and the Health Technology Assessment (HTA) process[23], G-HROF hopes to help the health system "anticipate, respond, cope, recover, and adapt"[24(p8)] to climate-related shock and stress-induced health resource scarcity. To integrate GeoAI into health systems, the framework consists of five essential components (Figure 1).
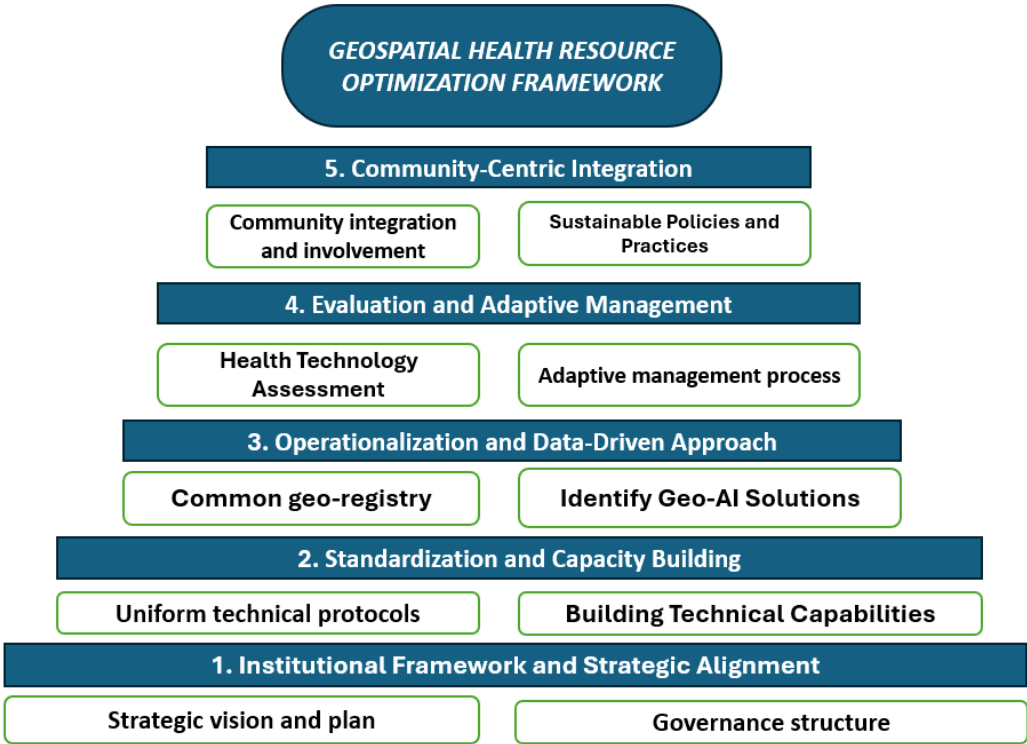

Figure 1: GeoAI Health Resource Optimisation Framework (G-HROF) Elements

1. *Institutional Framework and Strategic Alignment*

Firstly, the G-HROF is built upon an institutional framework that places emphasis on the effective and sustainable utilisation of scarce healthcare resources. To achieve this, the G-HROF formulates a clear vision and strategy for integrating GeoAI into healthcare systems, aiming to address health vulnerability resulting from both short-term climate variability and long-term climate change.[24] Once a framework is established, a robust governance structure may be established to ensure the ethical implementation of GeoAI technology, compliance with privacy policies and data protection standards, and facilitate prompt decision-making crucial during climate-related health crises. Healthcare systems will be able to efficiently allocate resources and deliver timely interventions thanks to the strategic alignment that G-HROF is offering.

2. *Standardisation and Capacity Building*

Secondly, G-HROF also includes the standardisation of the technical specifications, formats, and protocols used for geospatial data. This ensures the availability and quality of the data across the data lifecycle.[22] Furthermore, G-HROF emphasised the necessity of having sufficient technical capability for the proper management and usage of geospatial data to maximise the potential in predicting and responding to changing demands arising from climate events. It also entails equipping practitioners to be proficient in GeoAI so that they can leverage the technology to optimise the distribution of resources in times of scarcity.

3. *Operationalization and Data-Driven Approach*

Thirdly, G-HROF requires practitioners to find cost-effective GeoAI solutions that can apply comprehensive data analytics to dynamically allocate resources. First, a common geo-registry of the master lists for essential geographic objects, including administrative and reporting divisions and health facilities, as well as the hierarchies and geospatial data related to them, must be created, and made accessible with a mechanism in place for regular updates.[22] To enable practitioners to allocate resources pre-emptively and efficiently, G-HROF must ensure that the technology is capable of predictively identifying climate-related health hazards in settings with limited resources. This data-driven approach is essential for optimising resource utilisation, ensuring targeted and effective medical interventions, and enabling the healthcare system to proactively identify geographical areas with climate-related health risks.

4. *Evaluation and Adaptive Management*

As is the case with other health technologies, GeoAI HTA is a significant component of G-HROF, evaluating the technology's usefulness for resource optimisation and healthcare delivery. This process involves conducting research and evaluating scientific evidence by either collecting original data or synthesising secondary data through the creation of sandboxing pilots in smaller geographical regions. A committee of experts or policymakers then receives the research findings and recommendations and decides on the implementation of the recommendations for the larger population.[23] This evaluation process will include an adaptive management process with an iterative feedback loop to continuously review the impact of the recommendations on the larger population and enable adjustments and modifications to be made to better improve resource allocation and optimisation.[22]

5. Community-Centric Integration

Finally, G-HROF will emphasise the necessity of community integration and involvement. Through collaboration with the government, clinicians, domain experts, and civil society, the framework assures the public that GeoAI applications do not just depend on data but also a comprehensive understanding of local risks and vulnerabilities that may be impacted by climate change.[24] Conversely, by adopting sustainable policies and practices, healthcare infrastructure can be strengthened against climate-induced disruptions, ensuring the uninterrupted availability of essential health services, even in the aftermath of extreme climate events.

Key Challenges

G-HROF must overcome several key challenges to realise its full potential. Firstly, addressing ethical issues such as data privacy and the fair allocation of healthcare resources is crucial to building practitioner trust in GeoAI technology. Large health data is complex and prone to data misuse and privacy infringement after collection, storage, and analysis.[10] Additionally, using AI as a decision-making tool may also lead to bias, as the choice about how to allocate scarce medical resources favours utilitarian efficiency in saving lives over individual human needs.[4,25] This means that it will be difficult to determine who should be held responsible and accountable for the just distribution of resources while upholding the dignity and choices of those affected by climate-related health disasters. As mentioned, an effective ethical governance framework is necessary to assess the risks to data privacy, safeguard individual rights, and evaluate G-HROF's impact on the just allocation of resources.[4] Such an ethical framework would allow clinicians, practitioners, and decision-makers to build consensus on G-HROF's best normative standards.

Secondly, GeoAI's supervised learning algorithms may be less accurate due to the lack of labelled training data,[10] which is essential for accurate geospatial feature identification from input data. Additionally, instead of allowing AI to become a hype with unrealistic expectations and promises,[25] G-HROF may need to develop well-designed research to validate findings needed for governments to adopt by countries.[10] With so much big data available, domain expertise remains critical to avoid false findings and properly comprehend the modelled relationship.[10] Therefore, G-HROF integration into health systems must address ethical considerations, incorporate expert knowledge and opinions, and design reliable research to validate GeoAI technology before it can be widely used.

Steering Global Health into a Resilient Future

In conclusion, GeoAI helps solve climate change-related healthcare resource scarcity. It can improve communicable disease prediction as well as allocation of healthcare manpower and resources, particularly following climate-induced health crises. In a world where resources are limited and humans are challenged by climate change, integrating GeoAI can better enable healthcare systems to effectively address and manage healthcare scarcity.

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