

Facilities for addressing disaster challenges and promoting economic development in Africa

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Abstract: The effective location and efficient delivery service in emergency facilities are critical within industrial optimization, especially in developing nations. African countries faced significant challenges in managing public services due to a combination of low economic development and complex historical, cultural, and social factors. Between 2000 and 2025, the continent experienced an increase in natural disasters, including droughts, floods, and cyclones, which intensified the need for effective emergency response systems.

There is therefore a need for strategic locations in Africa to utilise emergency facilities effectively during this period. For example, countries such as Somalia and Ethiopia in the Horn of Africa experience severe droughts, which have resulted in food shortages affecting millions of people. Populations have also been displaced in Mozambique and Nigeria due to floods, which have also caused extensive damage to infrastructure. The well-located emergency services address the vulnerability of communities and thus improve responses.

During emergencies, the accessibility of vital services, such as ambulances and fire stations, is crucial to the communities. However, budget limitations in many developing countries mean that a limited number of facilities must serve larger populations, complicating service delivery and response times. A strategic approach to facility location is needed to address the need due to natural disasters effectively. The optimal location of these facilities is crucial for responding to emergencies due to natural disasters. For example, locating or relocating ambulance services closer to flood-prone areas or disaster response centres in drought-affected areas can directly reduce response times and reduce casualties.

In this study, we discuss the emergency response to disasters in developing countries. The location of facilities is also discussed, and we present the characteristics of the models that can be used to locate facilities to increase accessibility and outline their importance. We discuss the natural disasters in Mozambique and Nigeria and illustrate them with some quantitative examples from the Natural Disaster data obtained from EMDAT (2000 to 2025). The analysis shows the number of people who were affected during that period. The Chi-Square test to check the relationship between year and country reveals a significant result, indicating that the country and the year of the disaster are dependent.

Keywords: *Facilities, Natural Disaster, Economic Development, Africa*

1. INTRODUCTION

Facility location decisions (FLDs) are important in addressing the challenges due to natural disasters. In developing countries, the impact of these events can be devastating (Zorn, 2017). The location of emergency facilities, such as ambulance stations, at the emergency response centres is necessary for minimising the effect of disasters, thus improving community resilience. FLD is crucially needed where there are limited resources. However, there is always uncertainty about natural disasters, which makes it challenging to locate emergency facilities to address them (Gan, 2024). This is to enhance stability and improvement of cost and standard of living in those areas, and this may, in effect, lead to effective development in the future (Akram et al., 2022; Naoaj, 2023).

Ambulances and fire stations are vital for the timely and effective response to disasters (Boutilier and Chan, 2020; Paintya, 2018). The average response time of these emergency facilities directly or indirectly affects the safety and well-being of the people in the affected communities. The effectiveness and efficiency of locating and allocating resources in the affected communities are important for effective delivery. Reducing casualties and saving lives are the main objectives of locating emergency facilities for effective emergency medical services. The economic implications of such facilities and services are critical for the development of the area. Locating these emergency facilities properly will enhance and reduce the burden on the health system and will thus improve economic development (Chen and Lai, 2022).

Developing countries, with difficult budget positions and the requirements for providing other health and social services, face significant challenges in locating enough emergency facilities and services (Cevik and Huang, 2018; Suresh et al., 2024). The demands on the affected communities are restricted, and they adopt several innovative measures to address the problems. For example, because of poor road infrastructure, communities use alternative means of transport such as motorboats, bicycles, and animal-drawn carts to address emergency response problems in the event of disasters or any other emergencies. These modes of transporting the affected people in the event of emergencies have shown that it is an effective alternative to improving patient outcomes (Schmid et al, 2001; Shehu, 1997; Arreola-Risa, 2000; Razzak, 2002; Alaofe et al., 2020; Masaba and Manusi-Phetoe, 2023; Eisner et al., 2024; Chauke, 2025).

The assessment or evaluation of the impact of natural disasters on developing countries is important in determining where and how to locate emergency facilities. The appropriate heuristic or optimization models are needed to effectively study natural disasters and locate facilities to address the problems effectively (Sadeghi et al., 2021). The difficulties of applying heuristic or optimization models to determine a near-optimal location or an optimal location are necessary for effective service delivery, including evacuation. There is a need to preplan for the evacuation of affected people despite the unpredictability of the occurrence of natural disasters (de Veluz et al., 2023). For example, in African countries, where there are not enough experts, including decision-makers and policymakers, the problem becomes more pronounced. A study by Kamyabniya et al. (2024) in their review paper stated that they could not find any study on optimization models for disaster response operations in Africa. The study further stated that while the nature of natural disasters may vary from other regions, it is necessary to study the unique challenges in the African region. The lack of expertise and difficulties in properly locating facilities and allocating customers are complex. There are, however, studies applied to developing countries that offer strategies to address the location problem. For example, successful applications of optimization models have been demonstrated in vehicle routing in Senegal and food aid distribution in Angola. This study aims to address the gap in studies on Africa by researching Africa and using Mozambique and Nigeria as examples. The remainder of the paper is organised as follows. Section 2 discusses the emergency response and care in developing countries. The emergency facilities during emergencies are presented in Section 3, and the results and discussions are presented in Section 4. The conclusion of the paper is presented in Section 5.

2. THE MANY ASPECTS OF EMERGENCY RESPONSE AND CARE IN DEVELOPING

There is considerable evidence that the poor geographical location of facilities leads to poor accessibility of customers or patients (Rahman and Smith, 2000). There is also a demonstration of the use of mathematical models to solve location-allocation problems in developing countries (Rahman and Smith, 2000). The good location and allocation of facilities in the developing countries lead to regional development. For example, Serra and Marinov (1998), Caccetta and Dzator (2005), and Dzator and Dzator (2013), Murad et al. (2021), Chen and Lai (2022) use an optimization model to locate emergency facilities efficiently. It is important to note that there are no specific models for improving the overall provision of emergency medical care or facilities in developing countries. Facility location decisions are typically taken on political grounds in developing countries, which may sometimes lead to sub-optimal facility locations. In developing countries, factors that influence emergency care may include sub-optimal location and inadequate emergency facilities. Dzator and Dzator (2018) noted that emergency facilities that are located efficiently and effectively can reduce costs and improve utilization. Razzak and Kellermann (2002) specified the core components of emergency medical care system to include “community education on accessing the emergency care system and administering first aid; simple communication systems for notifying the emergency

care system of patients in need; transport, preferably motorized, for moving patients to the nearest health care facility; triage criteria to ensure efficient and timely utilization of existing resources at every level of the health care system; training of health centre personnel on the principles of emergency care; basic kits of instruments, supplies and medications enabling trained providers to give appropriate care at each level of the system". We focus on access only in this study. That is minimising distance and increasing access to facilities.

2.1. The Location of Emergency Facilities in Developing Countries

The location of emergency facilities, such as emergency or ambulance stations, in developing countries is an important element of healthcare infrastructure that significantly influences the efficiency and effectiveness of emergency response systems. Timely medical care is crucial during natural disasters, disease outbreaks, or violent conflicts, where every moment counts. Therefore, access to timely medical care is vital for adequate medical care (Shetab-Boushehri, 2022). A lack of emergency facilities, such as emergency or ambulance stations, is a significant challenge in many developing countries with high population density and geographic density. There are more hospitals and clinics in urban than rural regions, where there is a struggle with limited access to even basic healthcare services. This imbalance can lead to dangerous delays in receiving emergency care, which can ultimately worsen health outcomes (Chowdhury et al., 2022; Olugboja and Agbakwuru, 2024).

The strategic location of emergency facilities is essential for effective response and treatment. Key considerations include proximity to high-risk areas prone to disasters, population distribution, and existing transportation networks. Emergency facilities should also be designed with resilience in mind, incorporating features that can withstand local hazards such as floods, earthquakes, or civil unrest. For example, studies have shown that purpose-built, disaster-resistant structures significantly improve operational continuity after crises (Boutilier and Chan, 2020). Effective collaboration with local health authorities, local government authorities, NGOs, and community leaders in developing countries is critical for timely responses to health emergencies. This collaboration is to ensure that facilities function effectively in those countries. Another aspect is to train local healthcare providers who form rapid response teams that can enhance the effectiveness of emergency services (Kwang et al., 2025; World Health Organization, 2021).

Telemedicine and mobile health units, when integrated and incorporated into emergency health delivery, can enhance health service delivery. Studies have shown that technology innovations facilitate quicker responses and improve communication among healthcare providers, especially in remote areas (Kaawaase and Simon, 2021). For instance, a study highlighted the successful implementation of mobile health units in rural Tanzania, which significantly reduced response times to medical emergencies (Budde, 2021). Strategically, the placement of emergency facilities in developing countries is important to minimise the response time. This strategic placement will enhance the response rate, leading to more effective emergency service delivery for patients. There will also be equity in the delivery of services when technology is included in all areas, regardless of geographical location. Practical and comprehensive planning, along with the inclusion of technology innovations in emergency delivery, can result in effective and efficient healthcare systems.

3. EMERGENCY FACILITIES IN COMMUNITY DURING EMERGENCY SITUATIONS

There are emergencies in the communities due to causes such as natural disasters, public health crises, and socioeconomic challenges. During these crises, emergency facilities (temporary or permanent) are required to address the safety and well-being of the people in the communities. The facilities will also act as a safeguard mechanism for the communities.

Natural disasters such as floods and droughts can result to several people being affected in the community which will require temporary or permanent emergency facilities to be located in the communities. For example, Cyclone Idai in Mozambique which caused significant damages in the communities require emergency facilities to be located in the communities (Hope, 2019; Charrua et al. 2021). Public Health crises such as COVID and Ebola situations in countries such as Liberia, Sierra Leone, and Congo require emergency medical facilities to be located in those countries (Dzinamarira et al., 2020; Bwire et al, 2022; Buseh et al., 2015). These emergency facilities will provide isolation to prevent further spread of diseases (Buseh et al. 2015). Extreme poverty due to drought or health crises such as COVID where there are disruptions of several economic activities will result in emergency facilities such as food distribution centres to be located (Wilhite, (2000). There are other situations such as social unrest and environmental catastrophe where emergency facilities are required to safeguard people in the communities (Wilhite, 2000; Thomas et al. 2020; Marais et al.2024). The location of these facilities in response to tackle various emergency crises is crucial for protecting the communities. Optimising the geographic location to improve proximity and accessibility to disaster-prone areas is necessary for effective disaster management (Tang et al., 2023; Hassanain and Albugami, 2024).

3.1. The Characteristics of the type of for Improved Accessibility

The characteristics of the type of model to minimise travel distances and improve accessibility during emergencies such as natural disasters are presented below as follows:

- It should focus on minimising the distance between the customers or patients and the facilities, which is critical in emergency service delivery (Tadic et al., 2023)
- The disadvantages of delivery within communities should be minimised as equity issues are addressed (Kong et al. 2023).
- It should be applicable to real-world situations in emergencies (Bernabe-Loranca et al., 2019).
- The travel cost due to the minimisation of the total weighted distance should be achieved (Dzator and Dzator, 2018).
- It should be simple and straightforward to apply to optimisation problems (Romero-Montoya and Barrera-Camara, 2020).

3.2. Natural Disasters in Mozambique and Nigeria

Mozambique and Nigeria are countries in Southeastern Africa and West Africa, respectively. Mozambique is located in southeastern Africa and is bordered by the Indian Ocean to the east, and is also bordered by countries such as Tanzania, Malawi, Zambia, Zimbabwe, and South Africa. The population of Mozambique is approximately 32 million, with Maputo as the capital city. Nigeria is located in West Africa and is bordered by Benin, Niger, Chad, and Cameroon with the Atlantic Ocean to the south. Nigeria is the most populous country in Africa, with a population of 220 million. The total population of these two countries is 250 million.

These two countries have a history of experiencing natural disasters. The recent incident in Mozambique happened in 2019. They have experienced distinct natural disasters in recent times. There is therefore a need to address these challenges. Mozambique experienced a tropical cyclone in 2019 (Charrua et al. 2021). There has been widespread damage in several cities. Several people were affected by the disaster, with damage to infrastructure, and it disrupted livelihood. Nigeria has floods in various areas as well as droughts in some areas. Heavy rains were leading to flooding in several cities and towns (Louw et al. 2019, Eke and Ogba 2021). This has impacted agriculture and livestock in some areas (Abbas et al. 2018, Jega et al. 2022)

4. RESULTS AND DISCUSSION

Table 1 The average number of affected people in Mozambique (MOZ) and Nigeria (NGA) at the top two locations

Year	Average number of people affected - MOZ	Average number of people affected - NGA	Chi-Square p-value
2000 - 2005	366626	22817	< 0.001
2016 - 2020	97198	645	

The table above shows the number of people affected at the two top locations in Mozambique and Nigeria, categorized by the number of individuals impacted by natural disasters from 2000 to 2005 and 2016 to 2020. The results show that the average number of people affected by the natural disasters differs between the two countries. Further analysis is needed to determine if the likelihood of being affected by a natural disaster is dependent on the country where it occurs and when it occurs. The chi-squared test with a p-value of less than 0.001 revealed that the number of people affected by the natural disaster is dependent on the country. That is, there is a significant relationship between the country and the year in which the natural disaster occurred.

Figures 1 and 2 shows people affected by natural disasters (Biological and Hydrological) from the Emergency Events Database (EMDAT). The results show that for Mozambique, the mean values vary with a minimum for Biological Disaster occurring from 2011 to 2015, while the maximum is from 2021 to 2025 with 17659 per year. The high mean value might be due to the COVID-19 cases. For Nigeria, the highest mean value also occurs from 2021 to 2025, with the minimum mean value occurring from 2000 to 2005. The Hydrological Disaster shows that several people (645852 per year) were affected by floods in Mozambique from 2000 to 2005, which is the highest value and lowest occurring between 2021 and 2025, with 59591 affected. For Nigeria, the highest number of people affected (1031958 per year) occurred from 2011 to 2015.

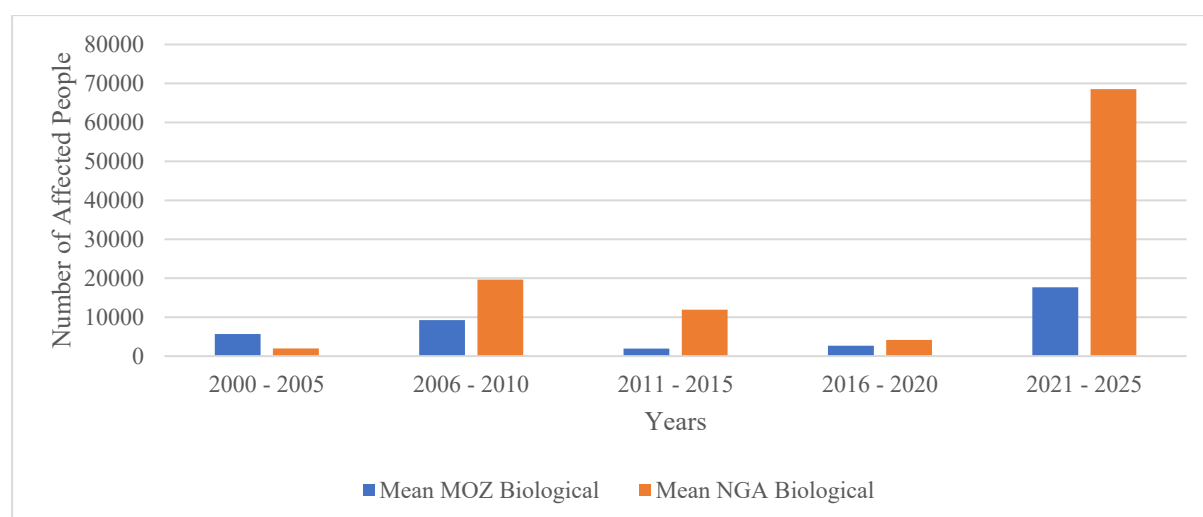


Figure 1 Natural Disaster for 2000-2005 (, 2006-2010 , 2011-2015 , 2016-2020 and 2021-2025

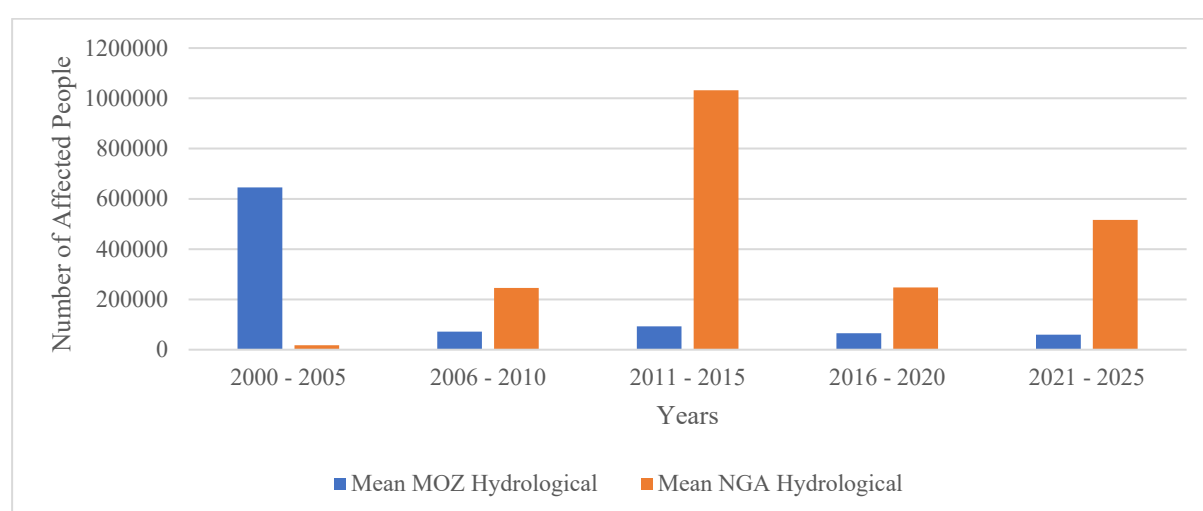


Figure 2 Natural Disaster for 2000-2005 , 2006-2010 , 2011-2015 , 2016-2020 and 2021-2025

5. CONCLUSION

The study discusses emergency facilities and natural disasters. We discussed the importance of accessibility during emergencies. The characteristics of models that improve accessibility are presented, and the natural disasters concerning developing countries and Africa in particular are also discussed. Data from EMDAT were used for two African countries, Mozambique and Nigeria. The analysis shows the number of people who were affected by natural disasters. In recent times, the hydrological disasters have increased. For example, Cyclone Itai, which occurred in 2019, devastated Mozambique, resulting in significant property damage and affecting many people, confirming the consequences of the hydrological disaster.

Addressing the challenges of natural disasters will help promote sustainable economic development. Improvements in government and stakeholder emergency preparedness will enhance a more stable economic environment. The stable economic environment will stimulate job creation and economic activities, leading to improved and sustained economic development.

Policymakers and stakeholders can utilise the information gathered from the literature and analysis of the natural disasters to enhance future preparedness and resilience. For instance, this preparedness will ensure that emergency services can reach affected populations quickly. For future research, we will conduct detailed case studies on the optimisation of facilities in these two African countries and other relevant African countries. These case studies will help address the problem of climate change and changing demographics by carefully incorporating these constraints into the proposed optimisation model. Exploring additional factors for optimising natural disaster locations to facilitate effective response, delivery, and management will be achieved through an extensive review of the literature and addressing gaps for future research.

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