Machine Learning for Flood Disaster Management in Africa

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1 Introduction

Natural disasters such as earthquakes, floods, tsunamis, and even extreme weather have caused serious problems to human society. Governments of different countries have been working to reduce the casualties and economic losses due to these natural disasters.

In Africa, drought and flood are the two main natural disasters. however, in the last decade, the flood has become the biggest problem. In the last decades, due to climate change, and the expansion of the population to the flood-prone area, there have been flooding events that have caused serious loss, especially in west Africa. Between 2008 and 2020, West Africa experienced unprecedented flooding which devastated agriculture, livestock, freshwater supplies, infrastructure, and homes. A report by the United Nations Office for the Coordination of Humanitarian Affairs [1] found that, in 2021 alone, flooding affected over 1.2 million people in 13 West and Central African countries.

In this report, we first present the basic concepts of disaster management and the application of machine learning in this field. After that, we discuss in detail the current flood management system in African countries and discuss the potential application of machine learning and ICT concepts in this domain. Finally, we conclude that, although there are many constraints in these developing countries such as data shortage, the application of machine learning and ICT concepts will surely improve the efficiency of flood risk management systems in Africa[2].

2 Disaster Management and Machine Learning Application

According to Ref[3], there are four stages of disaster management: prevention, preparedness, response, and recovery. ICT has been applied to each stage: disaster prediction, disaster rescue, and so on. The applications include several aspects such as information collection, post-disaster image collection, and damage assessment.

Of all of the applications, remote sensing, social media data process, and geographic information system are the most investigated. Before and during the flood, timely information collection is vital for disaster prediction and decision-making for disaster relief. Remote sensing technology, mainly satellite image

sensing, is widely applied in this scenario. Based on these data, a geographic information system is usually built to show detailed visualization and to contribute to the decision-making process. In addition, recently, due to the development of social media, users will create plenty of information before and during the disaster, which will surely help decision making. However, due to the agitation of the social media data, and the misinformation on the social media, these social media data should be carefully processed and presented[4].

The machine learning technique is part of artificial intelligent technology, which has been widely applied to different domains in the last decade. Recently, machine learning technology has also been applied in disaster management such as tracking and mapping, geospatial analysis, remote sensing techniques, robotics, drone technology, smart city urban planning, and transportation planning[5]. One of the successful applications is the application of machine learning in disaster response: it helps the decision-makers to understand the situation and make a better decision.

3 Flood Risk Management in Africa

Due to the weather diversity in Africa, different countries face different disasters. Of them, the most problematic natural disasters are drought, flood, and landslides. In terms of the flood, serious flood disasters have happened in the last few years: In 2019, at least 1200 lives were lost in countries in East Africa due to flooding in eastern Africa. In 2020, at least 1.6 million Somalian, Sudanese, and Ethiopian people were forced to evacuate their homes due to intense flooding[6]. In August of 2021, it was reported that flooding in the Gambia had killed at least 12, while over 100,000 were significantly affected by food insecurity. Nigeria, another West African country, saw at least 158,000 individuals from over 400 villages impacted by heavy floods. Over 60 people died from being unable to escape the rushing floodwaters or due to building debris from collapsed structures[7].

Currently, there are many governmental and non-governmental organizations, river basin authorities, and universities working on research projects about flood prediction and early warning in Africa[8]. For example, the Volta Basin project entitled Integrating Flood and Drought Management and Early Warning for Climate Change Adaptation in the Volta Basin' has the ambition to provide the first large-scale and transboundary implementation of Integrated Flood and Drought Management[2]. Of all the research works, different models and theories are utilized, such as the hydrological model and statistical model[9]. In addition, the main data source is radar data, satellite, or rainfall data.

4 Potential Machine Learning Application in Flood Risk Management in Africa

Based on the current status of flood prediction and early warning research in Africa, there are surely many aspects that we can improve with our ICT methodology and machine learning techniques: Some of the current methods from the

academic field don't take into account the constraints due to the low resource in Africa country. Also, due to the development of machine learning in recent years, it has been improved that machine learning can surely improve the accuracy of flood prediction[5].

There are several challenges to be solved to improve current methods: The biggest problem is the data. To apply machine learning, data is the essential problem. For example, to predict the flood, we need data related to rainfall, slope, elevation data, flow accumulation, soil, land use, and geology data from the remote sensing technique. However, in most of the developing in Africa, there is usually no systematic data collection.

In addition, to warn the residents about the coming flood, our system needs to interact with them. In this scenario, human-computer interaction becomes an important issue. In the African countries, especially in rural areas, people have limited access to a smartphone, instead, they only have simple phones. In some cases, many people even don't have access to their phones. In addition, the low literacy rate is one of the problems that we need to solve

To achieve the above goals, by combing the methodology of ICT and machine learning, we can create a geographic information system. To create a minimal viable product (MVP), the initial design for this system has three basic functions: flood and flood zoning prediction[10], flood warning, and visualization.

For flood and flood zone prediction, data related to rainfall, slope, elevation data, and flow accumulation might be limited. However, we have access to satellite images from the international organization. These data will serve as the data source for the first version of the system. In the meantime, the data collection process for the other data will begin in parallel.

If a flood and flood zone is predicted, the flood warning module will be triggered. The voice-based warning system is selected to help our system to interact with the residents due limit of smartphones. In the alarming calls. information about the flooding zone, and where to go are shown. In addition, the residents are also urged to alarm their neighbor who has no phones.

5 Conclusion

In this paper, we first review the definition of disaster management and the application of machine learning in disaster management. In addition, the same topics in the context of African counties are presented.

Taking account of limitations in developing countries, we proposed a GI system to predict flood, flood zone, and warning residences. With the help of machine learning techniques and ICT methodologies, the casualty and economic loss will be surely reduced.

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