# Artificial Intelligence in Flood Disaster Early Warning: False Alarms and Missed Alarms-Formation Mechanisms and Governance Pathways

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***Abstract:*** *Given the problems existing in traditional emergency plans (slow response, false alarms and missed alarms) it's an inevitable trend that by combining new information technologies such as big data, artificial intelligence, the Internet of Things and cloud computing with monitoring and providing early warning on emergencies to assist managers to make correct decisions in time. On the basis of the full life-cycle risk governance theory and the Technology Enactment Framework, we analyze the formation mechanism of false alarms and missed alarms in artificial intelligence-based flood early warning from the perspective of public administration; find out the shortcoming of current governance (lack of full-process control, barrier to cross-departmental collaboration, unclear division of rights and responsibilities, and inadequate grassroots implementation capacity); build targeted governance pathways from institutional design, coordination mechanisms, the rights and responsibilities system, and capacity building to provide ideas for achieving efficient, scientific, and intelligent governance of emergencies.*

***Keywords:*** *artificial intelligence; flood disaster early warning; false alarms and missed alarms; collaborative governance*

## 1. Introduction

With the continuously deepened globalization and post-industrialization, the interaction and interdependency among different fields get closer; the causes and environment of various emergencies become more complex; major emergencies worldwide keep rising in terms of frequency and severity. Utilizing modern digital information technologies for emergency monitoring and early warning and supporting decision-makers' timely and scientific decisions has become an inevitable trend for the development of social governance.[1] With the effect of global climate change, the frequency and intensity of extreme weather continues to increase, posing a serious challenge to urban safety and economic development. Especially because of its features of suddenness, wide range of impact and difficulty of prevention, the issue of flood disasters has been attracting more and more attention in modern society. We must use advanced technological means (such as artificial intelligence) to analyze and give early warnings about urban flood disasters so that we can better prevent and respond to flood disasters. Despite the fact that existing studies have achieved a deep integration of artificial intelligence technology with flood disaster response and make great progress in the accuracy of early warning, response efficiency and scientific decision-making, it also faces problems like the difficulty of technology integration, high pressure on data security and privacy protection, lack of interdisciplinary talent. Strengthening the construction of cross-departmental coordination mechanism, improving the scenario adaptability of algorithm model, and promoting the large-scale and standard application of artificial intelligence technology in flood disaster response require further research efforts. In this paper, by utilizing the analysis tool of full life-cycle risk governance theory and the Technology Enactment Framework, the formation mechanisms of false alarms and missed alarms were analyzed from the perspective of public administration, and target governance paths were constructed, which gives some ideas for realizing efficient, scientific and intelligent governance of emergencies.

## 2. Current Situation and Practical Harms of False Alarms and Missed Alarms in Artificial Intelligence-Based Flood Early Warning

### *2.1 Current Application Status*

In the whole process of flood disaster response, artificial intelligence technology is fully used: at the prevention stage, we use big data platform to analyze historical rainfall, terrain, etc. to find hidden dangers; using the Internet of Things to monitor river water level and rainfall in real time to predict disaster risk.[2]; at the emergency response stage, unmanned equipment such as drone helps us explore the terrain and carry out personnel search and rescue with smart system generating intelligent rescue strategy and resource allocation; at the post-disaster recovery phase, human-computer interaction technology provides public opinion guidance, and models are optimized through reviewing data to provide experience for future responses.[3]. Short duration precipitation intensity of extreme severe convective weather exceeds the prediction scope of numerical forecast models. Multiple numerical forecast models don't have an effective forecasting ability for the occurrence time and intensity of disaster causing short duration heavy precipitation, there exist cases of missing rainstorm alarms. One size fits all method of setting early warning threshold in traditional early warning mechanism does not adjust according to dynamic data (such as real-time rainfall, soil moisture, river water levels) leading to false alarm or miss alarm due to low adaptability of threshold.[4] At present, artificial intelligence technology has deeply involved into the work of flood disaster response but it still faces some practical problems such as relative difficult technology integration and shortage of interdisciplinary talents possess both technical knowledge and disaster response knowledge. We should improve cross department coordination and cooperation mechanisms, continuously optimize the adaptability of algorithm model to different flood scenario, help artificial intelligence technology to achieve large scale and standardization implementation and application in the field of flood disaster response.

### *2.2 Practical Harms*

Firstly, missed alarms aggravate disasters' loss. The essence of flood disaster early warning lies in gaining time for emergency evacuation; however, missed alarms directly place emergency response in passivity. In the severe rainstorm disaster on July 20, 2021 in Henan, artificial intelligence early warning models in some areas failed to detect the risk of urban waterlogging caused by extreme rainfall in advance, and missed alarms directly aggravated casualties and property losses. Secondly, false alarms cause early warning fatigue and waste resources. False alarms will reduce the public's trust in early warning information, with genuine high-risk warnings being ignored, meanwhile false alarms also prompt unnecessary emergency responses that result in ineffective consumption of emergency manpower and materials, increasing the workload of grassroots flood control. Thirdly, false alarms and missed alarms damage the credibility of governments. Flood disaster early warning is one of the key parts of government public services, and failure of early warning directly affect the public's trust in the government's emergency management capability and weaken the government's appeal in emergency mobilization.

## 3. Formation Mechanisms of False Alarms and Missed Alarms from the Perspective of Public Administration

### *3.1 Data Collection Stage: Collaboration Barriers Caused by Administrative Fragmentation, Leading to Source-Level Implementation Deviations*

Characteristics of disaster risks are "trans-jurisdictional" but emergency management follows a principle of "territorial management". Weaknesses of risk handling, information sharing and coordinated response between administrative regions will easily encounter problems of each acting on their own and difficulty in coordination when responding to cross-regional disasters (e.g. basin-wide floods)[5]. Data is the foundation of early warning models; the meteorological, hydrological, topographic, underlying-surface, etc., data required for flood early warning in China belong to various departments such as meteorology, water resources, natural resources, housing and urban-rural development, which are affected by the hierarchical administrative system that features departmental and territorial fragmentation, thus have great obstacles for cross-departmental data sharing. Suitability of disaster monitoring technology systems varies somewhat across different regions. Communication networks, computing infrastructure, and edge node deployment are relatively complete in eastern

coastal and central regions, yet due to limited network bandwidth and weak computing infrastructure in western and remote mountainous areas, it's difficult to deploy complex intelligent algorithms like deep reinforcement learning directly onto front-end terminals.[6] Distribution of monitoring stations in China shows an obvious regional imbalance. It has relatively high monitoring density in eastern regions, whereas in western regions especially mountainous and rural areas with complex terrain, monitoring stations are relatively sparse, and even blank areas exist.

### *3.2 Model Research and Development Stage: Technology－Operations Disconnection Caused by Supply－Demand Mismatch, Leading to Core-Level Implementation Deviations*

Although the potential of artificial intelligence and large models in natural disaster early warning is great, because of its dependence on high-quality labeled data and algorithm bias, it is hard for operational personnel to understand and trust the decision process of artificial intelligence. When facing conflicting results by models against operational experience, operational personnel will choose to believe the former rather than adopt advanced technologies into core operational processes. Black box of artificial intelligence models brings difficulty understanding the decision making process, loss of researchers and decision makers' trust towards forecast result, which reflects the technological supply-mismatched with the core needs of emergency operations.[7] Firstly, aligning authority and responsibility in setting early warning thresholds. It is difficult to adjust the national standardized emergency plan system to distinguish disaster characteristics and emergency needs at the grassroots level, and there is a disconnect between plans at both higher and lower levels that are all generally uniform, resulting in no dynamic adaptability in emergency plans. One of the core components of emergency plans is early warning thresholds. National unified threshold standard cannot adapt to different disaster-inducing environment, disaster-bearing body and risk level in different places, which is essentially a "misalignment of authority and responsibility".[5] Secondly, insufficient scenario adaptability of models. Building physical or numerical models that can accurately simulate the occurrence and development of disasters is the core of early warning, but the complexity, nonlinearity and multi-hazard coupling characteristics of disaster systems bring huge challenges to model construction. Traditional models usually depend on simplifying assumptions, which are difficult to adapt to the complex dynamics of actual disaster scenarios. Uneven monitoring station distribution, and many blind spots in model training data in special geographical scenarios (such as: high mountains, canyons, distant sea, remote forest area) cause models built upon them to be unable to effectively identify and provide early warning for disasters occurring in such areas[8].

### *3.3 Early Warning Analysis and Judgment Stage: Human－Machine Collaboration Failure Caused by Ambiguous Authority and Responsibility, Leading to Interception-Level Implementation Deviations*

The essence of artificial intelligence early warning is only an auxiliary decision-making tool, but manual review is the key point for intercepting false alarm and missed alarm, however, most regions do not build a human-machine collaborative analysis and judgment mechanism with clear authority and responsibility so that it can't correct early warning deviation in time. Firstly, over-reliance on AI early warning without establishing manual review mechanisms. Some grassroots flood control departments takes the output result from AI model directly as the basis for issuing early warnings. If there are serious consequences caused by AI prediction error or drone execution error, then the responsibility can't be pointed at any single human actor anymore, instead, it's scattered among all kinds of people such as the designer of algorithms, provider of data, operator of systems, and human commander that issues final instruction.[9]. Secondly, the standard of early warning classification is not uniform: The flood early warning classification standards between water resources, meteorology, and emergency management departments varies, and the risk level classification of AI models doesn't correspond to the release standards of each department, resulting different early warning information released by multiple departments; grassroots units and the public don't know what standards they should believe and adopt which leads to de facto false alarms or missed alarms. Regarding data sharing and common use, multiple departments (meteorology, geology, emergency management) have inconsistent data standards, lack sharing mechanisms, form "information silos".

### *3.4 Response and Implementation Stage: Early Warning Implementation Failure Caused by Chain Breaks, Leading to Ground-Level Implementation Deviations*

It all comes down to action in emergencies. If early warning results are accurate, then a break in the

implementation chain will result in "ineffective missed alarms". Firstly, lacking a link mechanism between early warning and emergency response: Emergency response involves multiple departments involved but we lack an efficient cross-departmental collaborative command platform/processes. Early warning information can only spread within the issuing department without triggering linked responses from relevant departments at the same time which leads to early warnings hanging in the air that could not implement as a set of coherent cross-departmental actions.[10] In most regions, AI early warning systems and emergency command systems do not achieve data connectivity. The early warning information does not automatically trigger the corresponding emergency response process, resulting in a long time gap between early warning issuance and emergency response with the best opportunity for prevention and control being missed. Thirdly, the early warning information dissemination mechanism is incomplete. Most early warnings use a "full-area broadcast" release model, they have not achieved precise push delivery by region and population group; the early warning information heavily relies on digital channels like mobile apps and social media for release. For "digitally vulnerable groups", such as older adults and low-income groups who are not skillful at using smart devices, early warning information cannot be effectively delivered, completely breaking the early warning chain at the social periphery. They cannot receive information in a timely manner, therefore they naturally cannot perform evacuation or other actions, thus causing "ground-level implementation deviations". People living in no-risk areas become fatigued upon receiving early warnings whereas people in high-risk areas fail to get early warning information in a timely manner, directly expanding the harms of missed alarms.

## 4. Current Shortcomings in the Governance of False Alarms and Missed Alarms

### *4.1 A Full Life-Cycle Closed-Loop Control System Has Not Yet Been Established*

Current control of artificial intelligence flood early warning mostly concentrates on accepting a completed model. No risk control exists at every stage (from data collection, model research and development, early warning analysis and judgment to response implementation); there are great gaps in controlling some links such as data sharing, model calibration and human–machine collaboration which makes it impossible to fully intercept false alarm and missed alarm risks through the whole process.

### *4.2 Cross-Departmental Collaborative Governance Mechanisms Are Seriously Absent*

Due to the fragmented administration at the department level and territory, departments such as water resources, meteorology, emergency management, and natural resources remain in a fragmented governance state that each manages its own segment, without establishing a fully normalized data sharing mechanism or collaborative early warning release mechanism, mechanisms to align demands between research and development institutions and operational departments are imperfect, and the boundary of authority and responsibility among different actors is unclear, preventing the formation of governance synergy which is the core root cause for amplifying false alarm and missed alarm risks.

### *4.3 Supporting Institutional Norms and the Authority and Responsibility System Are Imperfect*

Currently, there is no national management norm for artificial intelligence flood early warning in China: there are no clear regulations on model access standard, threshold settings for early warning, division of authority and responsibility between humans and machines, as well as an accountability mechanism for false alarms and missed alarms which leads to a lack of institutional basis for governance work with grassroots flood control departments facing dilemmas of being "afraid to use" and "unable to use" early warning when issuing early warnings.

### *4.4 Capacity Building for Grassroots Early Warning Implementation Is Insufficient*

Most grassroots flood control organizations lack an application training on artificial intelligence early warning. They cannot correctly understand the result of artificial intelligence early warning and apply the corresponding refined response measures; meanwhile, there exists a mismatch in manpower and material allocation for grassroots flood control with the needs of refined early warning that prevents realization of the prevention and control value of early warning.

## 5. Governance Pathways for False Alarms and Missed Alarms from the Perspective of Public Administration

### *5.1 Build a Full Life-Cycle Closed-Loop Risk Control Mechanism*

Based on the full life-cycle risk governance theory, we should build a control system involving all aspects in the entire early warning process: Firstly, we need to set up a full-process data control mechanism which clarifies the standards and norms for data collection, cleaning, and sharing, achieve normalization of aggregation and quality verification of multi-source data, reducing risks at the source; Secondly, we need to set up a full life-cycle model management mechanism which specifies the requirement for operational departments' participation throughout the whole process of model research and development and establishing a normalized optimization mechanism of pre-flood season verification and post-flood season review and calibration so that models meet the requirements for flood control operations; Thirdly, we need to set up a full-process early warning review mechanism which clarifying the dual-track process of "AI early warning + expert analysis and judgment", and standardizing the authority, responsibility, and process of manual review and intercept model deviations; Finally, we need to set up an early warning–response linkage mechanism to achieve connectivity between AI early warning systems and emergency command systems, clarifying the emergency response processes corresponding to early warnings of different levels and ensuring implementation and effectiveness of early warnings.

### *5.2 Break Departmental and Territorial Fragmentation and Build a Multi-Actor Collaborative Governance System*

Based on the collaborative governance theory, we should remove the collaborative barriers inside the hierarchy administrative system: First, set up a cross-departmental collaborative governance task force under the leadership of water resources department together with other departments (meteorology, emergency management, and natural resources) defining the boundary of authority and responsibility of each department in data sharing, early warning release, and emergency response, establish a normalized collaborative linkage mechanism, breaking down the barrier of data sharing, unifying the standard of early warning classification, and synchronizing the release of early warning information from multiple departments; Secondly, establish a supply–demand alignment mechanism between research and development institutions and operational departments, clarify the leading position of demand of flood control operational departments, require that model research and development takes the actual needs of grassroots flood control as the core, establish a research and development, verification, and optimization process involving operational departments throughout so as to solve the mismatch between technology and operations; Finally, establish an upward–downward linkage grassroots coordination mechanism, promote the extension of AI early warning to the grassroots, clarify the responsibilities of grassroots flood control organizations for implementation of early warnings, connect the "last mile" of early warning dissemination.

### *5.3 Improve Institutional Norms and Build a Management System with Clear Authority and Responsibility*

The release of national management measures for artificial intelligence flood early warning needs to be done as quickly as possible, and there are improvements in related institutions: Firstly, clarify the access and verification standards for models, standardize the technical requirements and scenario adaptability requirements of AI early warning models, establish unified reliability verification norms; Second, clarify the division of authority and responsibility between humans and machines, define the auxiliary decision-making position of AI early warning, clarify the main responsibility of manual review, avoid over-relying on or overly interfering with AI early warning; Thirdly, establish a reasonable accountability and fault-tolerance mechanism, according to the principle of "whoever uses it is responsible, and whoever develops it bears responsibility", clarify the standards for dividing responsibility for false alarms and missed alarms; Clarify the boundary of fault tolerance for model deviations (extreme weather) to avoid the problem of grassroots units being "afraid to use" early warning due to excessive accountability.

### *5.4 Strengthen Capacity Building and Improve the Effectiveness of Grassroots Early Warning Implementation*

Firstly, Train applications in AI early warning for grassroot flood control personnel so that staff can better understand AI early warning results and emergency responses, solve the problem of not using early warning; Secondly, Improvement of resources allocated for grassroots flood control: according to the requirement of refined early warning, we need to fully equip flood control manpower and materials for communities and villages to implement emergency response measures corresponding to the early warning level at grassroots; Thirdly, Improving the mechanism of releasing early warning information: promoting accurate push delivery of early warning information by region and population group with accessible risk interpretations and response guidance, improving the public's understanding and response capacity towards early warning information, address the problem of early warning fatigue.

## 6. Conclusion and Outlook

We analyzed the formation mechanisms of false alarms and missed alarms by artificial intelligence-based flood early warning based on public administration (not only technical issues), which are deep-seated governance dilemmas. We found that "implementation deviations" lead to the failure of the early warning process at every stage, including "departmental and territorial fragmentation" during data collection, "supply–demand mismatch" during model research and development, "ambiguous authority and responsibility" during early warning analysis and judgment, and "chain breaks" during implementation. There is a core deficiency in the current governance, such as lack of full-process control, barrier of cross-departmental collaboration, incomplete institutional authority and responsibility system, and insufficient grassroots implementation capacity. Establishing a closed-loop risk control mechanism covering the whole life cycle of data, models, analysis and judgment, and implementation; breaking down departmental barriers to achieve collaborative governance synergy; clarifying human–machine authority and responsibility through improving institutional norms and strengthening grassroots capacity building, thus fundamentally realizing the transformation of artificial intelligence technology from "usable" to "trustworthy", "reliable," and "effective". To improve the scientific and intelligent level of flood disaster emergency management and effectively safeguard people's lives and property. Due to its limitation, we did not do an empirical analysis combining cases from specific cities. In future studies, it could combine practical cases of local flood control to further optimize the operability of the governance pathways, providing ideas for efficiently, scientifically, and intelligently governing emergencies.

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