

ORIGINAL RESEARCH ARTICLE

From Technological Capability to Disaster Governance in North Korea: An Evidence-Bounded Framework from Scientific Publications

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Abstract

This study examines the extent to which scientific publications can support claims about algorithmic disaster governance in an information-limited setting. The empirical corpus consists of two purposively selected 2024 North Korean journal issues—Computer and Software Technology and Geologic and Geographic Science. All 48 scholarly or technical items listed in the two issues were screened, and 14 were retained for structured analysis. Using qualitative document analysis and evidence-bounded coding, the study distinguishes among technological capability, functional compatibility, administrative embedding, and system integration. Three inference rules constrain the escalation of claims: greater functional distance weakens evidentiary support; claims of embedding require connective institutional evidence; and module-level capabilities are non-additive for platform-level claims. The sampled literature documents disaster-risk assessment, remote sensing, terrain processing, deep-neural-network water-depth estimation, routing, sensing, robotics, optimization, and participatory-data workflows. Two qualitative robustness tests clarify the limits of inference. Excluding all transfer-hypothesis cases preserves the modular technical pattern; omitting the principal governance source, however, removes direct support for a full-cycle administrative architecture while leaving the technical-capability portfolio and inference framework intact. The article's general contribution is therefore an evidence-bounded capability–compatibility–embedding protocol. Modular algorithmic disaster governance is the empirical pattern identified by applying that protocol to this bounded corpus, not a claim that an integrated nationwide system has been deployed.

Keywords: North Korea, disaster governance, artificial intelligence, algorithmic governance, digital government, document analysis

Evidence for Practice

- Distinguish technological capability, functional compatibility, and administrative embedding: a published model or algorithm shows what can be done, but it does not by itself demonstrate government deployment.
- System-level claims require connective evidence—such as institutional ownership, shared data standards, interoperability, routine data exchange, and decision authority—not merely the coexistence of multiple technical modules.



- In the North Korean sample, excluding the weakest transfer hypotheses does not alter the modular technical pattern, but the full-cycle administrative architecture depends on one principal governance source; researchers should report this anchor-source dependence explicitly.
- For public managers evaluating modular digitalization, each module should be assessed against a defined governance function, data provenance, interoperability, human accountability, and documented performance before platform-level claims are made or investments are committed.

Disaster governance involves more than simply possessing technical tools. It encompasses the institutional arrangements through which societies understand risk, coordinate across organizations, allocate authority and resources, respond to disruption, and learn across the hazard cycle. Disaster-governance regimes are typically multilevel and only partially integrated, making coordination itself a substantive governance challenge (Tierney 2012). Research on rapidly evolving disaster-response systems likewise shows that access to core information and interorganizational information sharing can materially shape coordination and response capacity (Comfort, Ko, and Zagorecki 2004; Bharosa, Lee, and Janssen 2010). The Sendai Framework for Disaster Risk Reduction 2015–2030 similarly links risk understanding, governance capacity, resilience investment, preparedness, response, recovery, and learning (UNDRR 2015). Recent research on AI for disaster management demonstrates substantial technical capability in remote sensing, deep learning, risk prediction, early warning, decision support, and operational coordination. Methodological and systematic reviews document rapidly expanding applications across floods, fires, earthquakes, logistics, and multiple phases of disaster management while also identifying persistent challenges involving data quality, interoperability, explainability, field validation, and end-to-end integration (Akhyar et al. 2024; Kolivand et al. 2025; Muthukumar et al. 2026). This literature establishes that AI can support disaster-management functions, but it does not resolve a different evidentiary question: when can the presence of a technical capability be treated as evidence that the capability is institutionally embedded in disaster governance? Public administration research shows why this distinction matters. Digital transformation involves changes in organizational relationships, work processes, responsibilities, and decision structures, not merely technology adoption (Mergel, Edelmann, and Haug 2019). Studies of algorithmic bureaucracy and public-sector AI likewise show that administrative effects depend on organizational capabilities, work practices, public values, absorptive capacity, and implementation arrangements (Vogl et al. 2020; Zuiderwijk, Chen, and Salem 2021; van Noordt and Misuraca 2022; Madan and Ashok 2023). A technically successful machine-learning model, routing algorithm, or sensor chain therefore establishes a capability; by itself, it does not establish administrative use, much less system-level transformation. North Korea provides a demanding case for examining this inferential problem because direct observation of administrative systems is limited, while scientific and technical publications reveal research methods, data practices, and bounded technological capabilities. The two 2024 issues analyzed here contain direct disaster-risk research alongside studies of deep neural networks, satellite-image processing, digital elevation models, shortest-path computation, autoencoders, sensors, optimization, and citizen science. This study asks four questions: What disaster-governance functions and data practices are explicitly described in the primary sources? What AI, algorithmic, sensing, geospatial, and participatory-data capabilities are documented? How can those capabilities be mapped onto disaster-management functions without conflating technical possibility with institutional use? And what type of governance architecture can be defended on the basis of the available evidence? The article addresses these questions through an evidence-bounded capability-compatibility-embedding framework and develops modular algorithmic disaster governance as a middle-range concept for cases in which complementary technical modules are observable but organizational integration is not.

1. Literature Review and Theoretical Framework

1.1 AI, Algorithms, and Public Administration

Public administration research increasingly treats AI as a sociotechnical and organizational transformation rather than as an isolated technical artifact. Wirtz, Weyerer, and Geyer (2019) identify multiple public-sector AI applications but emphasize data, organizational, legal, and governance constraints. Vogl et al. (2020) show how autonomous agents and predictive analytics can become embedded in administrative work, while van Noordt and Misuraca (2022), reviewing 250 European public-sector cases, find that AI is used most often for service delivery and internal management rather than for direct policy decision-making. Madan and Ashok (2023) further identify technological, organizational, and environmental conditions, together with absorptive capacity, as important factors in AI adoption and diffusion. At the micro-organizational level, Maragno et al. (2023) show that introducing an AI chatbot changes roles, competencies, and organizational arrangements. Collectively, this literature suggests that capability is only the first evidentiary step toward administrative use. Scholarship on algorithmic governance further emphasizes that computational tools are embedded in chains of data capture, processing, classification, decision support, and feedback (Janssen and Kuk 2016; Yeung 2018). Young, Bullock, and Lecy (2019) conceptualize artificial discretion as the use of AI for tasks that require nontrivial decisions and show that its administrative consequences vary with task specificity and environmental complexity. A cybernetic vocabulary is useful because disaster management is itself organized around repeated observation, assessment, action, and feedback. Yeung's (2018) account of algorithmic regulation therefore provides a descriptive vocabulary for information gathering, assessment, feedback, and action, but this study does not assume that a political or administrative system is literally an automated control system. This article therefore treats administrative embedding as a distinct evidentiary dimension. Embedding requires source-based evidence that a technical function is connected to institutional ownership, routine data flows, decision authority, interoperable infrastructure, or an operational workflow. Functional compatibility without such evidence remains a plausible interface between technology and administration rather than an observed administrative transformation.

1.2 North Korean Scientific Sources as Evidence of Technological Capability

Recent external studies have documented expanding North Korean engagement with machine learning and AI-related research (Shin 2025). The primary sources analyzed here allow that engagement to be examined at the level of specific methods. They reveal a technically diverse research environment rather than a single, unified "AI sector." In the sampled geology issue, remote-sensing and spatial-information methods are used to extract urban impervious surfaces from fused Sentinel-2 and higher-resolution imagery (Ri Hun and Kim Kwang Chol 2024), construct digital elevation models from contours (Ri Ryong Jin and Ji Kyong Il 2024), map geological sections using DEM and resistivity-CT data (Jang Chol Ju and Pang Hyon Ryong 2024), and calculate shortest paths on large road networks through a hierarchical tile model (Sin Chol Guk and Ju Mun Su 2024). Related work in the same issue evaluates urban afforestation through spatial-information methods (Song Hak Chol and Ri Hyon Chol 2024) and identifies biodiversity-priority areas through nationwide spatial overlay and scoring (Huh Kum Chol and Ri Chung Song 2024). Together, these studies demonstrate spatial-computing capabilities that are relevant to, but not synonymous with, disaster governance. The sampled computing issue similarly documents a diverse set of technical capabilities. Ri Su Jin and Kim Nam Chol (2024) develop a control device for a pipeline-inspection robot using sensor inputs and fuzzy control. Ri Jong Im and Ri Yong Dok (2024) use an autoencoder to construct document and user vectors for recommendation. Ri Yong Chol, Choe Su Hyang, and Ri Hyo Bom (2024) develop a computer-coupled ultrasonic flaw-detection system. Jang Chun Ho and Choe Un Gyong (2024) propose an iterative optimization algorithm for transportation problems. Ri Kwang Chol and Jon Un Chol (2024) describe citizen science as a workflow for recruiting participants, collecting data, evaluating submissions, and using data-science or AI methods to improve data quality. Each article

demonstrates a bounded capability within its original domain. Accordingly, scientific publications are treated here as evidence of research capability and the documented availability of particular methods, not as proof of nationwide deployment. This distinction is especially important when examining institutions for which system-level administrative documentation is sparse.

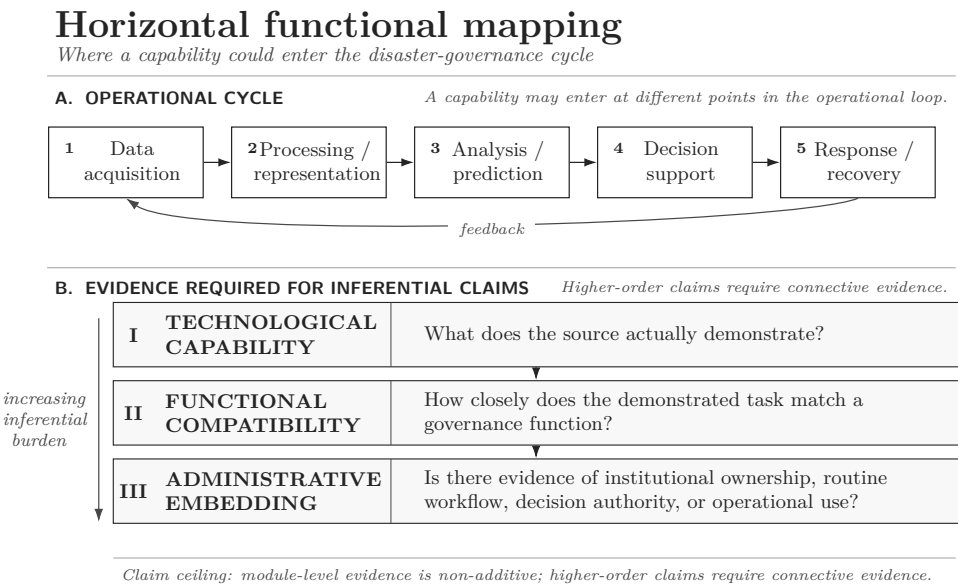
1.3 Disaster Governance and an Evidence-Level Framework

The primary disaster-governance source, Choe Kwang Su and Kim Yong Myong (2024), defines natural disaster coping capacity as a combination of institutional arrangements, technical capacity, material foundations, and potential that support risk reduction, emergency response, and recovery. Its indicators include disaster monitoring and information management, risk assessment, communication and dissemination, emergency command, material supply, medical services, damage investigation, recovery design, recovery command, and financing. The article also specifies data collection through secondary materials, resident conversations, field surveys, satellite interpretation, hydrometeorological calculations, and modeling. This source provides a direct administrative architecture against which technical capabilities can be mapped. The distinction between a disaster-management function and a governance arrangement is theoretically important. Technical studies can identify prediction, sensing, classification, or optimization functions, whereas governance analysis asks how information, authority, accountability, and coordination are organized around those functions. Tierney's (2012) formulation of disaster governance as multiscale, institutionally embedded, and frequently fragmented reinforces the need to treat technical integration as an empirical question rather than as an assumed property of a disaster system. The mapping uses three evidence levels. "Direct evidence" is assigned when a source explicitly addresses disaster risk, hazard assessment, or a disaster-management function. "Adjacent evidence" is assigned when a demonstrated technology is operationally close to disaster governance—such as environmental monitoring, infrastructure inspection, geospatial routing, or terrain processing—but the source itself does not frame the task as disaster management. "Transfer hypothesis" is used when a technology is demonstrated outside disaster management and the proposed disaster application is introduced by this article. This hierarchy is designed to prevent the empirical claim from becoming stronger than the underlying source and to avoid treating general environmental relevance as direct evidence of disaster deployment. Research in disaster informatics also clarifies why data integration matters. Goodchild (2007) conceptualizes citizens as distributed geographic sensors, while Horita et al. (2015) show that volunteered geographic information and wireless sensor networks can support flood-risk management when interoperable standards and a decision-support layer connect heterogeneous data sources. These studies are used here as comparative conceptual benchmarks, not as evidence of North Korean deployment. They reinforce a central point: technical modules acquire governance significance through institutionalized data flows and decision processes.

1.4 From Capability to Compatibility to Administrative Embedding

The theoretical framework separates three questions that are often collapsed in research on emerging technologies. Technological capability asks what a source actually demonstrates—for example, deep-neural-network regression, geospatial processing, shortest-path computation, sensing, or optimization. Functional compatibility asks how closely that demonstrated function matches a disaster-governance task. Administrative embedding asks whether the source shows that the capability is connected to organizational authority, routine data flows, interoperable infrastructure, decision rights, or repeated operational use. These dimensions are analytically related, but they are not assumed to form an automatic maturity sequence. Figure 1 summarizes the distinction between horizontal functional mapping and vertical evidentiary strength. The framework imposes a claim ceiling through three inference rules. First, the functional-distance rule states that evidentiary strength decreases as the proposed governance use moves farther from the source's original task: a flood-risk model is stronger evidence for disaster-risk assessment than a document-recommendation

autoencoder is for emergency information management. Second, the embedding-requirement rule states that administrative deployment can be claimed only when the source provides connective evidence such as institutional ownership, routine workflow, decision authority, interoperability, or observed operational use. Third, the non-additivity rule states that multiple module-level capabilities do not accumulate into evidence of a platform: sensing + prediction + routing + optimization still does not demonstrate integration unless the links among them are documented. These rules constitute the article’s general inference architecture. “Modular algorithmic disaster governance” is analytically subordinate to that architecture: it names the empirical pattern observed when complementary capabilities are visible across governance functions but connective evidence of system integration is not demonstrated in the sampled sources.



robotics relevant to physical monitoring; machine learning or representation capable of supporting information processing; routing or optimization relevant to decision support; or participatory data collection plausibly relevant to distributed observation. The individual article is the unit of analysis. Supplementary Appendix A reports all 48 screened items, their retention status, and the reason for inclusion or exclusion. The final analytical sample includes 14 articles; 34 screened items were excluded because their demonstrated tasks fell outside the defined disaster-governance functions or did not provide a transferable capability used in the framework. Nine retained articles are treated as core evidentiary sources because they directly anchor one or more coded governance functions or evidence levels and are summarized in Table 1. Five additional articles—on biodiversity-priority mapping, DEM/resistivity-CT geological-section mapping, DEM generation from contours, pipeline-inspection robotics, and urban-afforestation assessment—serve as supporting sources that document spatial, terrain, robotic-inspection, or environmental-analysis capabilities used to contextualize the functional mapping. This distinction keeps the principal governance inference tied to the strongest evidence while preserving technically relevant context. The resulting corpus is a bounded analytical reconstruction, not a census of North Korean AI or disaster research. Exhaustive screening within the two issues improves auditability but does not make the purposively selected issues representative of North Korean science as a whole. The design therefore supports analytical rather than population-level generalization: it evaluates what can be defensibly inferred from the selected documents and does not estimate the national prevalence, maturity, diffusion, or administrative adoption of the identified technologies.

Table 1. Core North Korean Primary Sources and Evidentiary Role

Primary source	Source-demonstrated task / capability	Disaster-governance mapping	Compatibility	Embedding evidence / claim ceiling
Choe Kwang Su and Kim Yong Myong 2024	Coping-capacity assessment; indicators, standardization, weighting	Risk reduction, emergency response, recovery, multi-source data inputs	Direct	Institutional functions described; no AI integration shown. Ceiling: governance architecture.
Kim Jong Ho and Choe Kwang Myong 2024	Flood-risk assessment; hazard-vulnerability-adaptive capacity; AHP	Composite flood-risk assessment	Direct	Routine operational workflow is not demonstrated in the sampled source. Ceiling: direct functional relevance.
Kim Myong Jin and Choe Won Il 2024	DNN river water-depth estimation; Sentinel-2 + field data	Environmental prediction relevant to flood monitoring	Adjacent	No early-warning or command-system link is demonstrated in the sampled source. Ceiling: technical capability + hazard-proximate environmental relevance.
Ri Hun and Kim Kwang Chol 2024	Impervious-surface extraction; image fusion and classification	Runoff / exposure-relevant land-surface information	Adjacent	A disaster workflow is not demonstrated in the sampled source. Ceiling: adjacent geospatial capability.
Sin Chol Guk and Ju Mun Su 2024	Shortest-path computation on hierarchical road-network tiles	Potential evacuation and response routing	Adjacent	Emergency use is not demonstrated in the sampled source. Ceiling: adjacent decision-support capability.
Ri Jong Im and Ri Yong Dok 2024	Autoencoder representation for document recommendation	Potential heterogeneous-data representation	Transfer hypothesis	A disaster context or administrative use is not demonstrated in the sampled source. Ceiling: transferable capability only.
Ri Yong Chol et al. 2024	Ultrasonic flaw detection; sensing, FPGA processing, database display	Infrastructure-condition monitoring logic	Adjacent	Disaster deployment is not demonstrated in the sampled source. Ceiling: adjacent monitoring architecture.
Jang Chun Ho and Choe Un Gyeong 2024	Transportation optimization	Potential relief logistics / resource allocation	Transfer hypothesis	Use in relief logistics is not demonstrated in the sampled source. Ceiling: transferable optimization capability.
Ri Kwang Chol and Jon Un Chol 2024	Citizen-science workflow; distributed collection and quality assessment	Potential local environmental / hazard reporting	Transfer hypothesis	A disaster-monitoring program is not demonstrated in the sampled source. Ceiling: transferable data-acquisition model.

Source: Author's coding of the 2024 no. 6 issue of Computer and Software Technology and the 2024 no. 3 issue of Geologic and Geographic Science. Functional evidence indicates proximity to a disaster-governance task; by itself, it does not indicate operational deployment.

2.2 Coding Scheme and Analytical Procedure

The documents were analyzed using qualitative document analysis (Bowen 2009) and a structured content-analysis approach (Krippendorff 2019). The analytical procedure was organized into three passes. Pass 1 consisted of source-grounded extraction: the original research problem, input data, method, output, and source-reported administrative or technical function were recorded before any reinterpretation in disaster-governance terms. Pass 2 consisted of functional mapping: each demonstrated capability was located within the disaster-governance cycle and coded as direct, adjacent, or transfer-hypothesis evidence. Pass 3 consisted of an embedding audit: the analysis assessed whether each source provided connective evidence of institutional ownership, routine data flows, decision authority, inter-system linkage, repeated operational use, or explicit non-observation of such information. The final interpretation was not allowed to exceed the strongest source-based evidence available. This sequence is important because several articles are not disaster studies. The autoencoder article is first coded as a document-recommendation study; only then is representation learning treated as a transferable capability. Transportation optimization is first coded in its stated domain; relief logistics remains a proposed application. Conversely, flood-risk assessment receives a direct code because the source explicitly addresses hazard risk, whereas deep-neural-network water-depth estimation is coded as adjacent because the source demonstrates an environmental prediction task without framing it as disaster management. Administrative embedding is never inferred from technical relevance alone. The coding record therefore distinguishes the source statement, the author's functional mapping, the embedding evidence (or its non-observation), and the maximum permissible claim. Supplementary Appendix B provides the complete 14-article coding audit matrix with page-level source references.

Table 2. Coding Framework and Decision Rules

Coding dimension	Categories	Decision rule
Original task	Source-reported problem	Record before any disaster-governance reinterpretation.
Demonstrated capability	ML; GIS/remote sensing; routing/optimization; sensing/robotics; database; participatory data	Code only functions and methods actually demonstrated in the source.
Functional compatibility	Direct; Adjacent; Transfer hypothesis	Direct: source explicitly addresses disaster/hazard risk or a disaster-management function. Adjacent: demonstrated in an operationally close environmental, infrastructure, geospatial, or monitoring domain. Transfer: disaster use is supplied by this article.
Governance location	Data acquisition; processing/representation; analysis/prediction; decision support; response/recovery/feedback	Map a capability to a functional location without treating location as deployment.
Administrative embedding	Not demonstrated; Institutional function documented; Operational use demonstrated; Cross-system integration demonstrated	Requires explicit evidence of organizational ownership, routine workflow, decision authority, inter-system linkage, or observed use.
Claim ceiling	Capability; Compatibility; Embedding; System integration	A claim cannot exceed the strongest documented evidentiary state; module-level evidence is non-additive for platform claims.

Source: Author's coding framework. The categories distinguish source-demonstrated facts from analytical transfer and from evidence of administrative deployment.

2.3 Validity, Reliability, Translation, and Scope Conditions

Validity is strengthened in five ways. First, the analysis preserves each source's original task domain before any governance mapping. Second, source-demonstrated facts, functional compatibility, administrative embedding, and system integration are coded separately. Third, technical claims are anchored in source-reported procedures and page-specific evidence such as Sentinel-2 inputs, indicator standardization, AHP weighting, digital elevation models, hierarchical road-network tiles,

sensor chains, and deep-neural-network regression. Fourth, documentary silence is recorded as non-observation rather than as substantive evidence of absence: when a sampled scientific article does not report interoperability, organizational ownership, or operational use, that silence lowers the permissible claim but does not establish that the institutional feature does not exist. Fifth, international literature is used only to define analytical distinctions and external benchmarks; it is not imported as evidence of North Korean deployment. These safeguards strengthen construct validity by making every inferential move—from source task to governance relevance to deployment claim—explicit. The analysis has clear scope conditions. Two purposively selected journal issues cannot represent the full range of North Korean scientific or administrative practice, even though every scholarly or technical item within those issues was screened. The single-author coding design does not support an intercoder-reliability coefficient; no independent human second coder was used. Reliability is therefore supported through explicit decision rules, exhaustive within-issue screening, source-grounded extraction, page-level traceability, two evidentiary robustness tests, and a complete supplementary coding audit matrix. These safeguards improve reproducibility but are not equivalent to independent intercoder validation. Scientific articles may indicate capability or research interest without revealing deployment scale, procurement, interagency integration, maintenance, training, or policy authority. Specialized Korean technical terminology also introduces translation risk. These conditions require conservative interpretation and make triangulation with policy, organizational, implementation, and field evidence a priority for future research.

2.4 Evidentiary Robustness Tests

Two qualitative evidentiary robustness tests examine whether the article's conclusions depend on its weakest or most structurally important sources. The first is a transfer-exclusion test: all cases coded solely as transfer hypotheses—autoencoder-based document representation, transportation optimization, and citizen science as a disaster-data layer—are removed from the synthesis. This test determines whether the modular pattern is generated by analogical extension from more distant domains. The second is an anchor-source omission test: Choe Kwang Su and Kim Yong Myong (2024), the principal source for the explicit full-cycle disaster-governance architecture, is removed from the synthesis. This test asks whether the governance-level interpretation survives independently of the article that provides the clearest administrative structure. The two tests address different questions and are not statistical sensitivity analyses; they are qualitative checks on evidentiary dependence and claim robustness.

3. Analysis and Findings

3.1 Disaster Governance as a Full-Cycle Assessment Architecture

Choe Kwang Su and Kim Yong Myong (2024, 52) provide the most explicit administrative framework in the corpus. Their assessment of natural disaster coping capacity distinguishes risk-reduction capacity, emergency-response capacity, and recovery capacity. Risk reduction includes monitoring and information management, risk assessment, communication and dissemination, management organizations, structural and nonstructural measures, and public awareness. Emergency response includes early warning, emergency command, rescue and response funds, supplies, medical services, and essential utilities and goods. Recovery includes damage investigation, recovery command, recovery design, equipment and materials, and recovery financing. The same article places data processing at the center of assessment. Indicator values are obtained from secondary materials, resident conversations, field surveys, satellite-information interpretation, hydrometeorological calculations, and modeling results. Because the indicators vary in units and ranges, the article standardizes them into comparable dimensionless values before weighting and aggregation. This provides direct evidence of a data-oriented assessment architecture, although it does not show that AI performs the aggregation. Kim Jong Ho and Choe Kwang Myong (2024, 37) reinforce this pattern through

flood-risk assessment. Their framework combines hazard, vulnerability, and adaptive capacity, standardizes indicators, assigns weights through the analytic hierarchy process, and calculates a composite flood-risk index. This source is important because it operationalizes disaster risk as a multi-indicator decision problem rather than as a purely descriptive hazard map.

3.2 *Geospatial and Remote-Sensing Infrastructure*

The broader geology issue documents a cluster of spatial-information capabilities. Ri Hun and Kim Kwang Chol (2024, 11–12) fuse Sentinel-2 multispectral bands with higher-resolution color imagery and apply rule-based object-oriented classification to extract urban impervious surfaces. Ri Ryong Jin and Ji Kyong Il (2024, 35–36) develop a method for generating a digital elevation model from contour information. Jang Chol Ju and Pang Hyon Ryong (2024, 47–48) combine DEM data and resistivity-CT profiles to construct geological sections using ArcGIS-based spatial processing. These studies are not disaster-response applications in themselves. They nevertheless document the ability to produce and manipulate land-surface, elevation, and subsurface information. Such spatial infrastructure is relevant to flood, landslide, accessibility, and exposure analysis. Its inclusion in the integration framework is therefore based on functional proximity, not on a claim of operational emergency use.

3.3 *Deep Neural Networks for Environmental Prediction*

Kim Myong Jin and Choe Won Il (2024, 48–49) provide the strongest AI-related, hazard-proximate environmental evidence in the corpus. Their study estimates water depth in river sections with heterogeneous bottom material using satellite imagery, field measurements, location coordinates, and a deep neural network. The model combines spatial information with multiple Sentinel-2 spectral inputs and is designed to overcome the limitations of simpler linear and band-ratio methods under heterogeneous conditions. The article's significance for disaster governance lies in its original task: it addresses an environmental prediction problem directly related to river conditions. The study is therefore coded as Adjacent rather than Direct because the source does not itself frame the task as disaster management or flood-risk governance. It nevertheless supports the cautious claim that deep learning is demonstrated in the sampled literature for a hazard-proximate environmental task that could contribute to flood and water monitoring. It does not demonstrate integration with an early-warning center, emergency command system, or automated decision system.

3.4 *Sensing, Inspection, and Robotic Monitoring*

The computing issue contains two articles that illustrate physical monitoring. Ri Yong Chol, Choe Su Hyang, and Ri Hyo Bom (2024, 8) develop a computer-coupled ultrasonic flaw-detection system that collects sensor signals, performs hardware-assisted processing, displays results, and supports database functions. Ri Su Jin and Kim Nam Chol (2024, 2–3) develop a control device for a pipeline-inspection robot that includes motor control, temperature, humidity, current sensing, and posture control. Neither article is a disaster-management study. Their relevance is architectural: both demonstrate closed chains from physical sensing to digital processing and control. Within the evidence hierarchy, they therefore support adjacent claims about monitoring capability rather than direct claims about disaster detection.

3.5 *Representation, Optimization, and Routing*

Ri Jong Im and Ri Yong Dok (2024, 6–7) use an autoencoder to derive vector representations of documents and users from browsing histories and word embeddings. The demonstrated function is representation learning in a recommendation context. For disaster governance, the transferable capability is the transformation of high-dimensional information into representations suitable for

similarity calculation or subsequent modeling. Because the study does not use disaster data, this case is coded as a transfer hypothesis. Jang Chun Ho and Choe Un Gyong (2024, 16–17) propose an iterative method for improving a feasible solution to a transportation problem. The article establishes optimization capability but does not demonstrate use in relief logistics. By contrast, Sin Chol Guk and Ju Mun Su (2024, 33–34) demonstrate shortest-path computation on large road networks through hierarchical road-network tiles and an Arc Flag method. The latter is more closely related to disaster operations because route computation is directly applicable to access planning, although the original test does not involve an emergency scenario.

3.6 Citizen Science as a Potential Data-Acquisition Layer

Ri Kwang Chol and Jon Un Chol (2024, 31–32) describe citizen science as an organized research workflow involving problem definition, participant recruitment and training, data submission, communication, evaluation, and data-quality analysis. The article discusses web-based participation and notes that data-science and AI techniques may be used for processing or accuracy assessment. This article is relevant because disaster governance often depends on geographically distributed observations. However, the source does not report a North Korean disaster-monitoring program based on citizen science. It would therefore be inappropriate to describe citizen science as an established component of a national AI disaster system. The defensible claim is narrower: the sampled technical discourse includes a participatory data-acquisition model that could be adapted to environmental or hazard information.

3.7 Evidence-Bounded Capability-to-Governance Mapping

When the evidence is organized by function, five analytical layers emerge: data acquisition; processing and representation; analysis and prediction; decision support; and administrative response and feedback. This constitutes a horizontal functional mapping: it shows where a documented capability could enter the disaster-governance cycle. The capability-compatibility-embedding framework provides a separate vertical evidentiary test: it assesses the strength of the empirical connection between the technical module and administrative practice. One principal governance source directly documents the full-cycle administrative architecture, while technical capabilities are distributed across other direct, adjacent, and transfer cases. Administrative embedding and cross-system integration are not demonstrated in the sampled scientific sources.

Table 3. Evidence-Bounded Capability-to-Governance Mapping

Layer	Primary-source evidence	Potential governance function	Evidentiary status
Data acquisition	Satellite interpretation; field survey; resident conversation; sensors; citizen-science workflow	Hazard observation and local information collection	Direct + adjacent + transfer
Processing / representation	Indicator standardization; databases; autoencoder vectors; DEM construction	Harmonization and machine-readable representation	Direct + adjacent + transfer
Analysis / prediction	Flood-risk index; GIS; deep-neural-network water-depth regression	Risk assessment and environmental prediction	Direct + adjacent
Decision support	Shortest paths; transportation optimization	Routing, prioritization, and resource allocation	Adjacent + transfer
Administrative response / feedback	Early warning, emergency command, supplies, recovery command, reassessment indicators	Implementation, recovery, and learning	Direct administrative framework; AI integration unproven

Source: Author's synthesis of the North Korean primary sources listed in Table 1 and related articles from the same 2024 journal issues.

The horizontal model can be summarized as data acquisition → processing and representation → analysis and prediction → decision support → administrative response and recovery → feedback. This sequence resembles a cybernetic information loop, but the empirical claim is deliberately

limited. The sampled journals demonstrate relevant functions in separate studies, and the principal disaster-governance source identifies administrative points at which some of those functions could be used. The vertical evidentiary test prevents a further inference: multiple compatible modules do not constitute an integrated platform unless independent sources demonstrate shared standards, interoperable software, organizational ownership, routine data exchange, and operational decision use. Those system-level conditions are not demonstrated in the sampled scientific publications.

3.8 *Evidentiary Robustness Results*

The transfer-exclusion test leaves the modular technical pattern intact. After the autoencoder, transportation-optimization, and citizen-science transfer cases are removed, the remaining direct and adjacent evidence still spans data acquisition, processing and representation, analysis and prediction, decision support, and source-described administrative response/recovery functions. The technical portfolio becomes narrower, as expected, but the sampled publications still demonstrate multiple functionally complementary capabilities, while cross-system interoperability and integrated AI decision authority remain unobserved in the documentary corpus. The modular technical interpretation therefore does not depend on the most speculative mappings. The anchor-source omission test yields a different result and defines an important boundary condition. Removing Choe Kwang Su and Kim Yong Myong (2024) leaves substantial evidence of disaster-relevant and hazard-proximate technical capability—flood-risk assessment, remote sensing, terrain modeling, water-depth prediction, routing, sensing, and infrastructure inspection—but removes the corpus’s clearest direct evidence of a full-cycle administrative architecture spanning risk reduction, emergency response, and recovery. The general capability-compatibility-embedding inference protocol therefore does not depend on the anchor source, and the modular technical portfolio remains observable. However, the stronger empirical characterization of that portfolio as situated around a documented full-cycle disaster-governance architecture is anchor-dependent. The article treats this dependence as a finding rather than concealing it: the governance-level claim is narrower and more source-dependent than the technical-capability claim.

4. Discussion

4.1 *The Empirical Pattern: Modular Algorithmic Disaster Governance*

When applied to this bounded corpus, the inference framework yields an empirical pattern of modular algorithmic disaster governance rather than an integrated platform. Platform-government scholarship emphasizes highly integrated infrastructures that combine cloud computing, big data, mobile systems, the Internet of Things, and AI while reshaping public-management roles and decision processes (Kim, Andersen, and Lee 2022). A comparable platform claim for North Korea would require connective evidence of common data standards, interoperable systems, organizational ownership, operational workflows, and routine cross-agency use. Such connective evidence is not demonstrated in the sampled scientific publications. What the corpus does demonstrate is a set of complementary technical modules together with one explicit source describing a data-oriented, full-cycle disaster-governance architecture. The term modular algorithmic disaster governance names this empirical pattern; it is not the article’s general theory. “Modular” indicates that capabilities are documented as separate solutions to bounded problems. “Algorithmic” includes machine learning, optimization, formal risk indices, routing, and spatial calculation without collapsing them all into AI. “Disaster governance” refers to the institutional cycle of risk reduction, emergency response, and recovery explicitly described in the principal governance source. The anchor-source robustness test is therefore conceptually important: without that source, the corpus still supports a modular portfolio of disaster-relevant technical capabilities, but the full-cycle governance characterization becomes weaker. Modularity remains an evidentiary safeguard because it prevents separate research capabilities from being recast as an unsupported platform claim.

4.2 The General Contribution: Capability, Compatibility, and Administrative Embedding

The framework's central theoretical claim is that capability, compatibility, and administrative embedding are distinct evidentiary states. Capability asks whether a technique is demonstrated in a bounded task. Compatibility asks whether that function can serve a disaster-governance task without distorting the source's original domain. Embedding asks whether institutions connect the module to authority, data flows, routines, and operational decisions. Public-sector AI research shows that organizational capacity, absorptive capacity, implementation arrangements, and role redesign mediate the transition from adoption to organizational use (Maragno et al. 2023; Madan and Ashok 2023). Disaster research similarly shows that information becomes operationally consequential through coordination, interoperable data flows, and decision-support arrangements rather than through isolated technical performance alone (Bharosa, Lee, and Janssen 2010; Horita et al. 2015). The three inference rules clarify the resulting claim ceiling. Functional distance disciplines analogical transfer; the embedding requirement separates use-case relevance from institutional deployment; and non-additivity prevents a portfolio of disconnected technologies from being recast as a platform. This moves the framework beyond a descriptive typology and turns it into an inference protocol: the analyst must specify the evidentiary threshold required for each level of claim. Table 4 states those thresholds explicitly.

Table 4. Minimum Evidence Required for Escalating Governance Claims

Claim type	Minimum evidence required	What this evidence does not establish
Technical capability	A method is demonstrated on defined data or a defined technical task.	Disaster relevance, institutional use, or deployment.
Functional compatibility	The source task is directly or adjacently matched to a defined disaster-governance function; the mapping is explicit.	Routine organizational use or decision authority.
Administrative embedding	Explicit evidence of institutional ownership, routine workflow/data flow, decision rights, or observed operational use.	Cross-system integration, national scale, or performance unless separately documented.
Integrated platform / system	Connective evidence across modules: shared standards, interoperability, repeated data exchange, coordinated workflows, and organizational responsibility.	Nationwide coverage, effectiveness, resilience, or accountability unless independently demonstrated.

Source: Author's framework. The thresholds are cumulative: higher-order claims require connective evidence rather than simply a larger number of lower-order capabilities.

4.3 What the North Korean Primary Sources Add

Using North Korean primary scientific sources as the empirical foundation changes the structure of the argument. Rather than beginning with a general claim about state digitalization and then searching for supporting examples, the analysis begins with what individual articles actually demonstrate. Flood-risk research shows standardized multi-indicator assessment; the water-depth study shows deep-learning prediction; remote-sensing studies show land-surface extraction; DEM studies show terrain-data construction; routing work shows large-network shortest-path calculation; and computing articles show representation learning, sensing, robotics, optimization, and participatory data workflows. The governance mapping is therefore constructed inductively from source-demonstrated functions rather than deductively from an assumed national AI strategy. This emphasis on primary sources also makes the documentary limits visible. No sampled scientific article demonstrates interagency data sharing, a national AI disaster platform, autonomous emergency decisions, or nationwide deployment. This non-observation does not show that such arrangements do not exist; scientific articles may simply be an inappropriate genre for documenting them. It does, however, prevent those system-level propositions from being treated as findings of this study.

4.4 Implications for Digital-Governance Research

The findings support a broader methodological point for digital-governance research in information-limited settings: evidence about technology should be matched to the level of the institutional claim. Scientific papers are often strong evidence of bounded capability and sometimes of functional relevance, but they are structurally weak evidence of procurement, ownership, routine use, authority, cross-agency interoperability, and organizational consequences. The framework therefore converts a problem of limited information access into a problem of inference discipline. It is especially useful in settings where administrative documentation is scarce, strategically selective, historical, security-sensitive, or otherwise difficult to verify. The cybernetic analogy should also be used carefully. The disaster-coping-capacity framework already contains measurement, assessment, response, recovery, and reassessment; algorithms may augment particular information-processing steps without transforming the institutional system into an automated control architecture. The relevant questions are where automation enters the loop, what information it changes, who validates its output, who retains decision authority, how failure is handled, and whether the output is connected to routine administrative action. This framing is analytically more precise than labeling an entire disaster-management system “AI-based.”

4.5 Comparative and Policy Research Agenda

Comparative extension of the framework requires matched evidence across cases. A defensible comparison with China or other national settings would require equivalent source types, periods, functional categories, and deployment evidence. The capability–compatibility–embedding framework can then be applied comparatively without assuming that similar technical vocabularies reflect similar administrative models. The appropriate comparative object is therefore the relationship between documented capability and institutional embedding, not a simple inventory of technologies. For the North Korean case, the empirical implication is specific: the most valuable additional evidence is connective rather than simply another technical demonstration. Documentation of operational early-warning systems, routine satellite-data flows, emergency-logistics software, organizational ownership, links between scientific institutions and disaster-management bodies, inter-system standards, and records showing whether quantitative outputs alter administrative decisions would directly test the embedding and integration claims that remain unobserved in the present corpus. The anchor–source result also indicates that additional independent governance documents would be especially valuable because they could determine whether the full-cycle architecture identified here is institutionally corroborated beyond a single principal source. A separate, framework-derived design implication follows from the broader public-sector AI and disaster-governance literature rather than from the North Korean corpus alone. For public managers evaluating modular digitalization, a defensible sequence is to verify data quality and provenance; define the governance function; establish interoperability and data standards; assign institutional ownership and human decision authority; validate the module under realistic operating conditions; document performance and failure modes; and only then make system-level integration claims. This sequence reflects the broader lesson that information creates governance value when it reaches authorized decision points through coordinated, usable institutional arrangements (Comfort, Ko, and Zagorecki 2004; Bharosa, Lee, and Janssen 2010).

4.6 Boundary Conditions and Limitations

Five limitations define the boundaries of the contribution. First, issue selection is deliberately narrow and purposive; exhaustive screening of all 48 scholarly or technical items within the two issues improves auditability but cannot establish representativeness across North Korean scientific publishing. Second, publication evidence is selective in two directions: scientific journals may omit operationally sensitive systems, and they may also present experimental capabilities without revealing whether

those capabilities survive implementation constraints. Third, single-author coding and translation introduce interpretive dependence. The complete screening log and coding audit matrix make the analysis reproducible, but they do not substitute for independent intercoder validation. Fourth, the full-cycle governance characterization is partly anchor-dependent: one source provides the clearest direct administrative architecture, as shown by the anchor-source omission test. Fifth, the framework evaluates evidentiary status rather than technical performance; it does not benchmark model accuracy, system reliability, cost, cybersecurity, ethical acceptability, or real-world disaster outcomes. Accordingly, modular algorithmic disaster governance should be treated as an analytical description of the sampled evidence, not as a performance assessment of North Korea's disaster-management system. These limitations also define the framework's conditions for transfer. It is most useful when researchers have heterogeneous technical documents but incomplete organizational evidence. Where administrative records, field observations, system logs, interviews, or implementation data are available, those sources should supersede document-based inference and can be used to test whether documented capability translates into administrative embedding. The framework is therefore a bridge to stronger evidence, not a substitute for it.

5. Conclusion and Policy Implications

This study examined the extent to which North Korean scientific publications can support claims about the relationship between technological capability and disaster governance. Exhaustive screening within two purposively selected 2024 issues identified 48 scholarly or technical items, of which 14 were retained for structured analysis. The retained corpus documents direct disaster-risk assessment together with a broader portfolio of geospatial, sensing, routing, robotics, representation, optimization, and hazard-proximate environmental capabilities. One principal governance source also documents a full-cycle architecture of risk reduction, emergency response, and recovery, together with multisource data collection, standardization, weighting, and composite assessment. These capabilities can be mapped horizontally onto data acquisition, processing and representation, analysis and prediction, decision support, response and recovery, and feedback, while their evidentiary strength is assessed vertically through capability, compatibility, administrative embedding, and system integration. The transfer-exclusion robustness test shows that the modular technical pattern does not depend on the weakest analogical mappings. The anchor-source omission test, however, shows that direct support for a full-cycle administrative architecture is more source-dependent than the technical-capability finding. This asymmetry is central to the article's claim discipline: robust capability evidence does not automatically produce equally robust governance evidence. The article's general contribution is the capability-compatibility-embedding inference protocol and its functional-distance, embedding-requirement, and non-additivity rules. Modular algorithmic disaster governance is the empirical pattern generated when that protocol is applied to the present corpus: complementary technical modules are observable, a disaster-governance architecture is documented but partly anchor-dependent, and cross-system integration is not demonstrated in the sampled scientific publications. The methodological contribution is therefore not a claim that North Korea possesses an integrated AI disaster platform, but a reproducible procedure for matching the strength of institutional claims to the strength and type of documentary evidence available in information-limited settings. For disaster-management policy and digital-system design, the implication is straightforward but demanding: technical sophistication should not substitute for evidence of organizational connection. Interoperability, data provenance, institutional ownership, human accountability, workflow integration, realistic validation, and documented failure handling provide the bridge from a successful technical module to defensible claims of operational governance. Future research should broaden the source base and, above all, seek the connective evidence needed to test whether the modular structure identified here is institutionally linked and consequential for real-world decisions.

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Conflict of Interest Statement

The author declares no conflict of interest.

Data Availability Statement

The documentary materials analyzed in this study are the cited 2024 issues of Computer and Software Technology and Geologic and Geographic Science. No newly collected human-subject data were generated.

Ethics Statement

This study is based on published documentary materials and does not involve interviews, surveys, interventions, or personally identifiable human-subject data.

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