**Analysis of Ground Subsidence Causes and Development of a Predictive Model in Urban Areas**

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**Abstract**

The frequency of ground subsidence incidents in urban areas, notably Gangnam-gu, Seoul, poses increasing risks to infrastructure stability, public safety, and economic sustainability. This study systematically investigates key subsidence drivers, primarily groundwater depletion, aging sewage infrastructure, and urban tree root intrusion. A robust predictive model integrating Geographic Information System (GIS) and AnyLogic's Agent-Based Modeling (ABM) techniques was developed, producing detailed risk maps. The findings facilitate strategic preventive measures, significantly enhancing urban resilience and disaster management planning.

**Keywords**: Ground Subsidence, GIS, Agent-Based Modeling, AnyLogic, Urban Infrastructure, Groundwater, Sewage Pipelines, Tree Root Intrusion

**1. Introduction**

Urban ground subsidence incidents are increasingly frequent, primarily due to intensified climate variability, rapid urbanization, and aging infrastructures. Particularly in Seoul’s Gangnam-gu, these incidents cause severe socioeconomic impacts. Conventional reactive management strategies have proven inadequate, highlighting the urgent need for preventive measures based on detailed analytical and predictive frameworks. This study addresses this need by developing an integrated predictive model utilizing GIS and ABM, providing essential insights for proactive disaster mitigation strategies.

**2. Materials and Methods**

**2.1 Study Area**

This study was conducted in Gangnam-gu, Seoul, a densely populated district characterized by extensive urban infrastructure and significant economic activities. The area frequently experiences subsidence incidents due to its vulnerable geological conditions and extensive underground infrastructure.

**2.2 Input Variables**

The study utilized comprehensive GIS datasets covering groundwater levels, sewage pipeline networks (age, material, location), and detailed urban vegetation mapping, specifically street tree distributions.

**2.3 Influential Factors of Ground Subsidence** Key factors considered included:

* **Groundwater Depletion:** Resulting from extensive groundwater extraction and infrastructure development, reducing aquifer support and stability.
* **Aging Sewage Infrastructure:** Older pipelines are prone to leaks and ruptures, causing soil erosion and voids leading to subsidence.
* **Tree Root Intrusion:** Roots from specific urban trees, especially Metasequoia, invade underground pipes, accelerating pipeline damage and subsidence risks.

**2.4 Development of Ground Subsidence Predictive Model**

An Agent-Based Modeling (ABM) approach was developed using AnyLogic software integrated with GIS spatial data. Agents modeled included sewage pipes, groundwater systems, and urban tree species, interacting dynamically to predict areas susceptible to subsidence.

**2.5 Generation of Ground Subsidence Risk Map**

The predictive outcomes were validated against historical subsidence records. A detailed subsidence risk map was created, highlighting areas at various risk levels for targeted intervention strategies.

**3. Results**

The predictive model accurately identified groundwater depletion and pipeline deterioration as primary subsidence triggers, significantly impacted by tree root growth. Specifically, Metasequoia roots were found to markedly increase subsidence risks. The risk map provided clear visualization of critical areas, aligning closely with historical subsidence occurrences.

**4. Discussion**

This study provides significant contributions by systematically analyzing critical urban subsidence factors and developing a reliable predictive tool. The model notably benefits urban planning and infrastructure management, though further enhancements are recommended through incorporating detailed soil and environmental data and extensive validation through additional field investigations.

**5. Conclusions**

The findings emphasize the necessity of adopting proactive management approaches to mitigate subsidence risks effectively. Future research should extend to more comprehensive environmental analyses and validate the predictive capabilities across diverse urban settings to enhance general applicability and robustness.

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**References** (Compiled from available project reports, literature, and presentation materials.)