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Rainfall-induced shallow landslide early warning index

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Rainfall-induced shallow landslides have become more frequent owing to recent extreme weather in Japan. In particular, it is well known that the early detection of a sudden rainfall-induced shallow landslide is quite difficult compared with typical landslide behavior. In response to this problem, each local government provides residents with rainfall-induced disaster early warning information via an email service and a website based on the Japanese weather radar system and Automated Meteorological Data Acquisition System. However, rainfall information is not enough to predict the risk of individual slope disasters occurring behind residential areas. In contrast, with regard to civil infrastructure, Japanese expressway companies also have their own regulation standards to prevent rainfall-induced slope disasters based on historical rainfall data. However, sometimes it too early or too late to judge whether a shallow landslide will occur because rainfall information does not directly reflect the soil moisture condition of the slope. In addition, both local governments and Japanese expressway companies need sufficient lead time to announce evacuations and road closures, respectively. To solve these problems, an initial quasi-saturated (IQS) volumetric water content index has been proposed as a rainfall-induced shallow landslide early waring index. Its real-time monitoring system was developed utilizing Internet of Things (IoT) and wireless sensor network (WSN) technology. Based on our past research results, it is confirmed that IQS can be expressed by the relationship between rainfall intensity and its maximum volumetric water content under vertical one-dimensional rainfall infiltration condition and no shear-deformation in a slope unless the volumetric water content exceeds IQS. Therefore, by using IQS as a shallow landslide early warning index, it is possible to prepare for the evacuation of residents or road closure with sufficient lead time until the shallow landslide occurs. From this research finding, a rainfall-induced slope disaster early warning system utilizing soil moisture sensors and tilt sensor is developed. This system is driven by a compact battery system with a solar-powered panel. The monitoring data is sent to the web server every 10 min via IoT with WSN technology. We are currently working with a Japanese expressway company to build this early warning system for practical use.