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AI-powered Real-time Data-driven Framework: Tool for Flood Early Warning in Small Stream

MOIS NDMI KIDS

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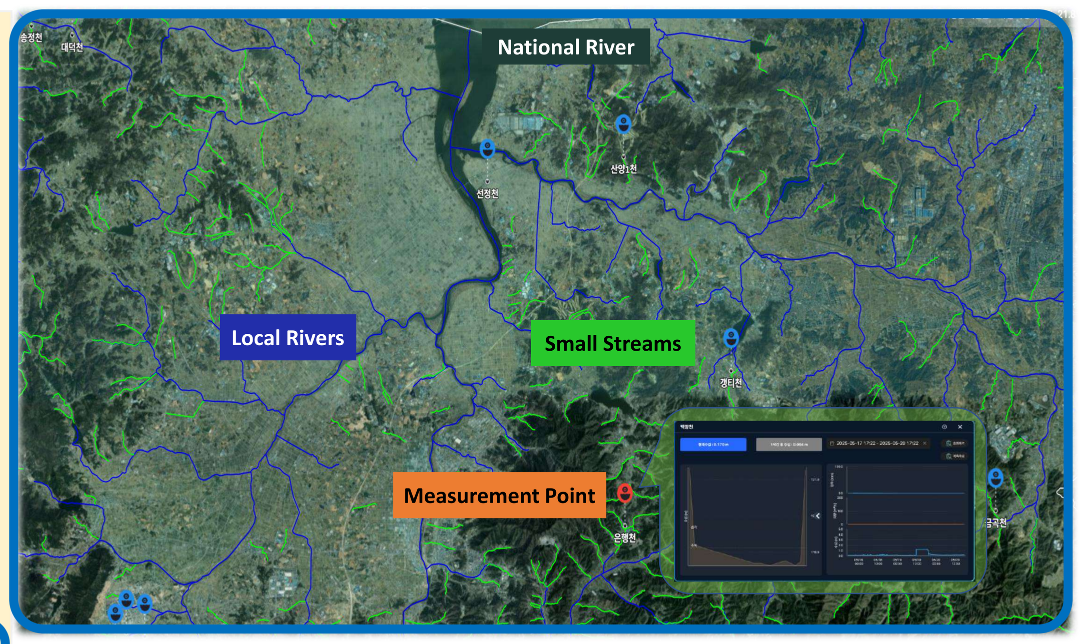
Introduction

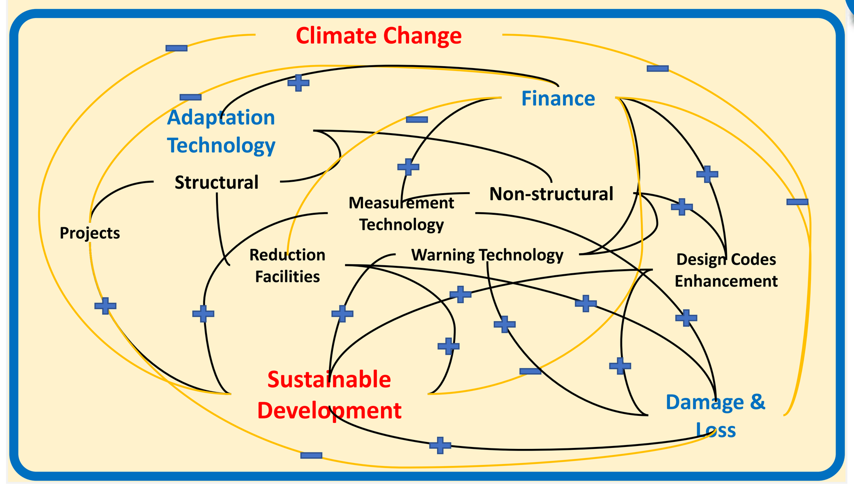
What is the Small Stream?

- Feed into larger water bodies like the Local and the National rivers or lakes
- Fast flow velocity due to steep slope (mean of 0.06)
- Be called a brook, creek or rivulet depending on region

Why Small Stream Management is Needed?

- Flood damages is increasing with localized rainfalls due to climate change
- River floods arise from the interaction of streams with widely differing temporal scales and can increase if small streams are not properly managed



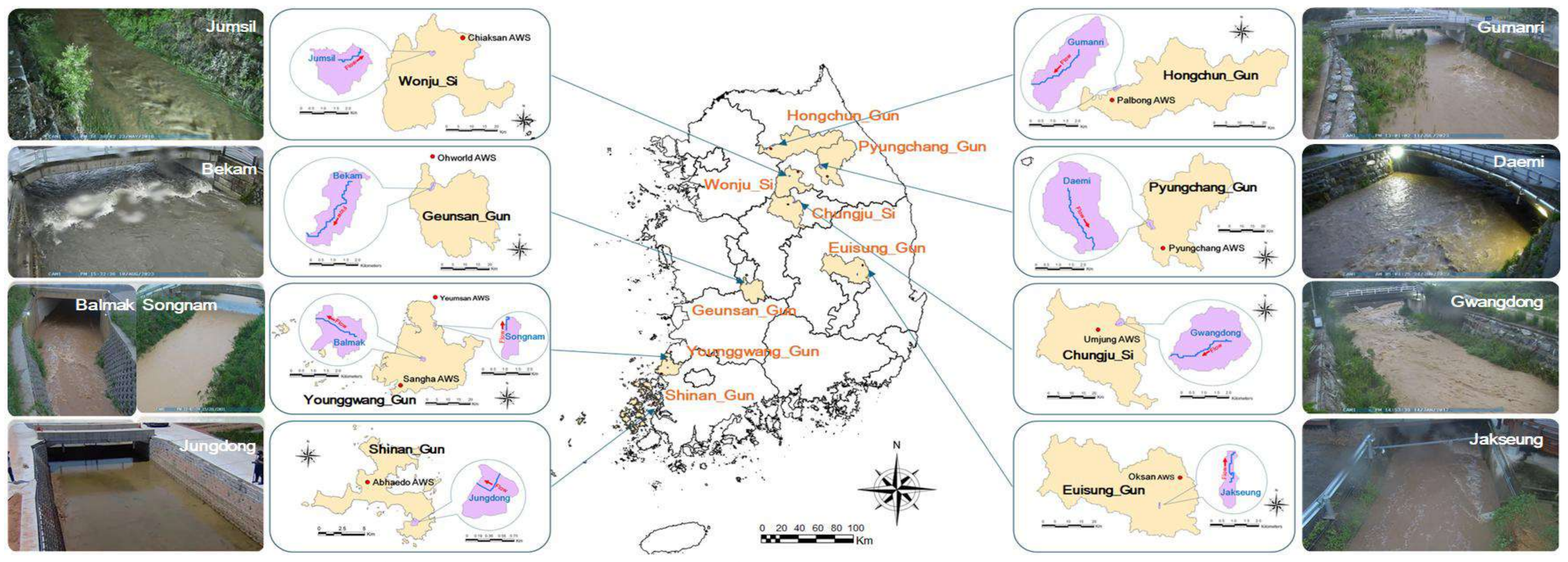


What is the Real-time Data-driven Framework?

- A web tool following a user-centered design approach, consolidating hazards to help decision making and resilience planning
- Real-time rainfall, flow velocity, depth, discharge data and CCTV image monitoring
- Data-driven rainfall-discharge nomograph to predict discharges
- Data-driven depth-discharge rating curve to predict depths
- Real-time monitoring data based flood vulnerability prediction model

Materials

- MOIS establish the Small Stream Smart Measurement & Management System (SMMS) by 2027 in 2,200 small stream, Korea
- Select nine small streams for test-bed to develop and evaluate flood early warning framework



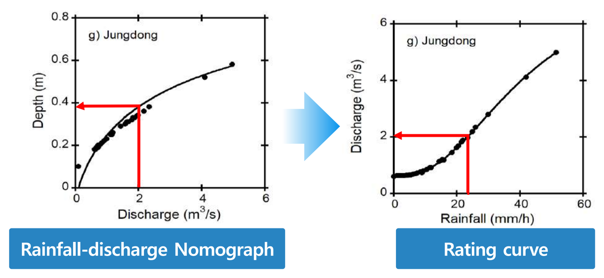
<Flow images captured from CCTV and location of small stream and the AWS which was the cleanest one>

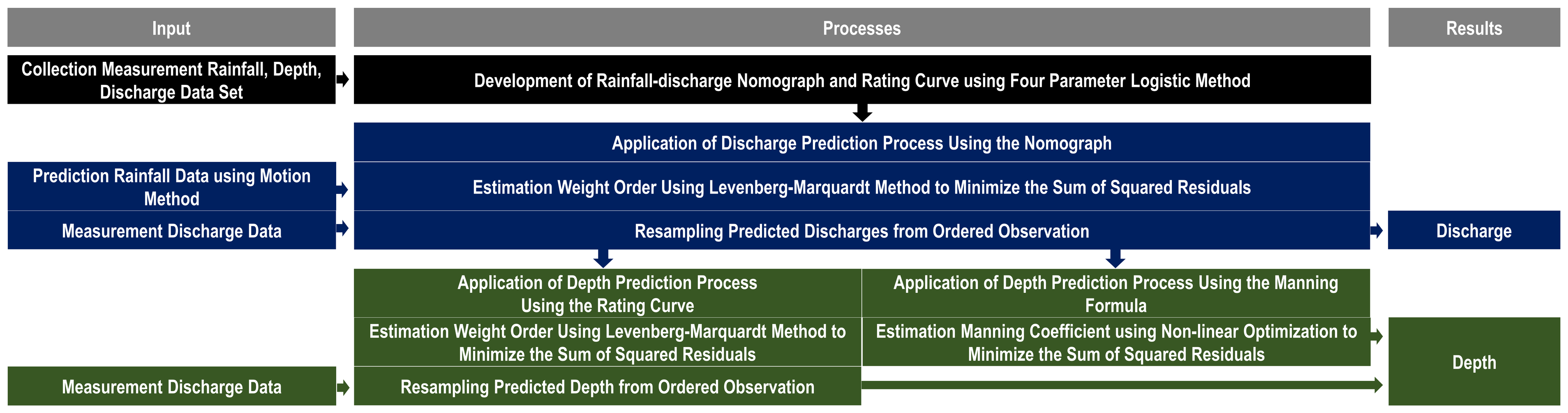
- Nine Small Stream (SS) has small width, length and steep slope located in river head

Small Stream	SMMS		Basin Area (km^2)	Channel Length (km)	Planned Discharge (m^3/s)	Planned Elevation (El.m)	Width (m)	Slope	n	AWS	
	Latitude	Longitude								Name	Distance from SS(km)
Daemi	37.46586036	128.3204602	12.8	4.48	226	529.9	22.4	0.033	0.033	Pyungchang	11.8
Bekam	36.18913770	127.3887096	3.44	3.51	50	119.9	13.5	0.014	0.035	Ohworld	11.4
Jumsil	37.39137582	127.9318512	2.59	1.29	57	105.1	12.6	0.019	0.030	Chiaksab	10.8
Gwangdong	37.09191389	127.9675028	6.36	2.95	96	105.8	11.6	0.048	0.030	Eumjung	6.04
Balmak	35.37031182	126.4892379	0.59	0.53	14	7.700	6.80	0.028	0.035	Sangha	8.00
Songnam	35.27335980	126.4481607	1.61	1.49	45	5.800	18.5	0.008	0.030	Eumsan	10.1
Jungdong	34.83371571	126.3464317	0.50	0.60	13	17.30	15.0	0.004	0.030	Abhaedo	6.81
Gumanri	37.72040949	127.7123560	5.00	2.69	108	86.47	24.0	0.026	0.035	Palbong	3.94
Jakseung	36.30444983	128.7472070	0.94	1.50	13	145.5	15.0	0.039	0.030	Oksan	11.6

Methods

- Step 1: Develop rainfall-discharge nomograph and rating curve using measured data
- Step 2: Predict discharge and depth using predicted rainfall and discharge by the MAPLE and Levenberg-Marquardt method
- Step 3: Predict unmeasured section depth using Manning Formula under assumption as discharge is same in SS

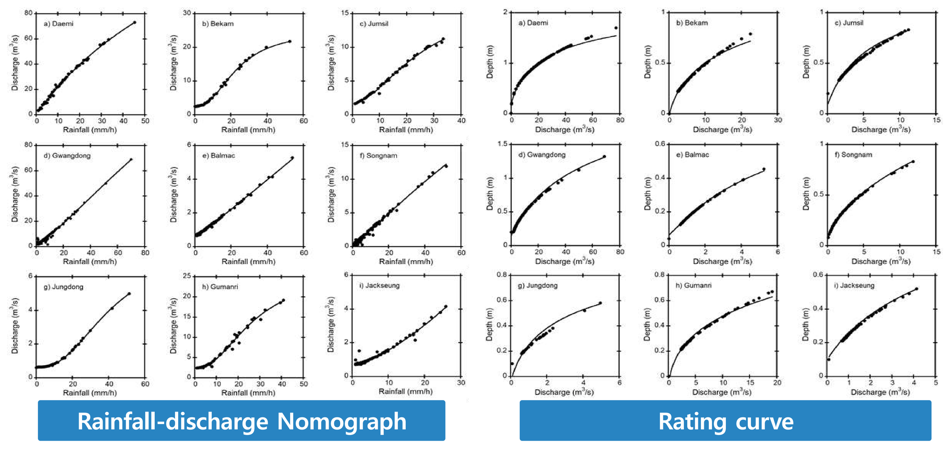




<Concept diagram of predict discharge and depth of the AI-powered flood early warning framework >

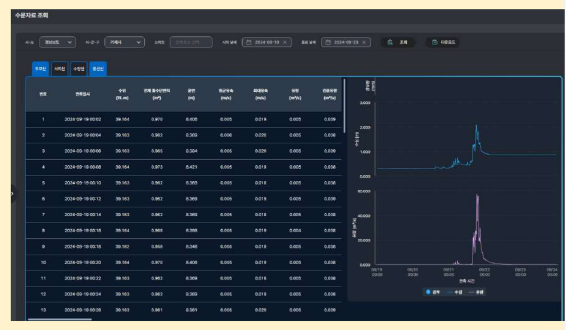
Development & Evaluation

- Develop the nomograph and rating curve using measured data collected from nine small streams

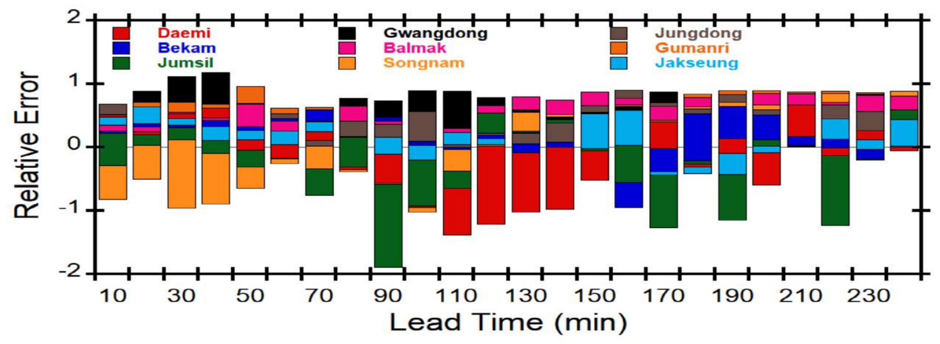


Real-time measuring & monitoring in the Platform

- Water depth, flow velocity and discharge data are collected and monitored at 2-minutes intervals
- Used as warning data for downstream rivers

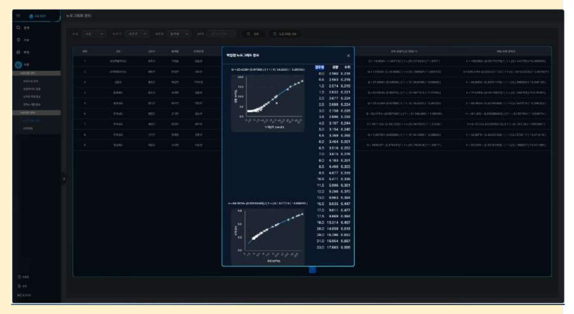


- One hour before predicted rainfall is used to predict depth

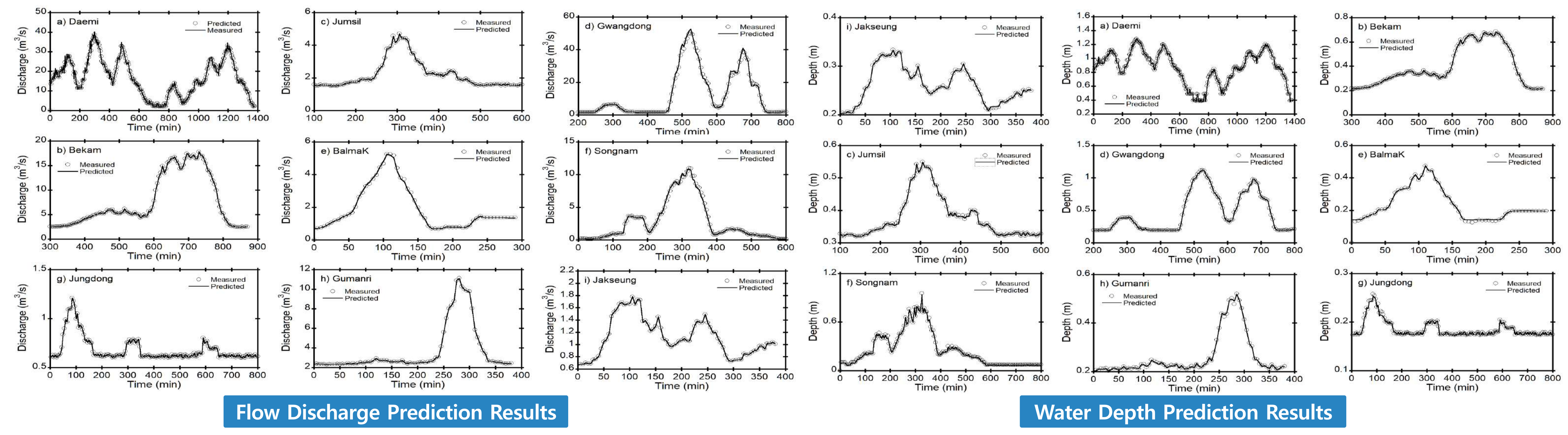


Develop nomograph & rating curve

- The Platform is capable of automatically generating nomograph and rating equation
- For development, three years of sufficient data is required



- Evaluate the prediction values of flow discharge and water depth with measured data collected from nine small stream
- Prediction model well represents the measured flow discharge and water depth data

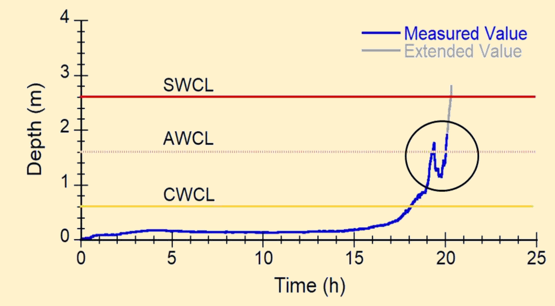


- Comparison of RMSE and determinant coefficient

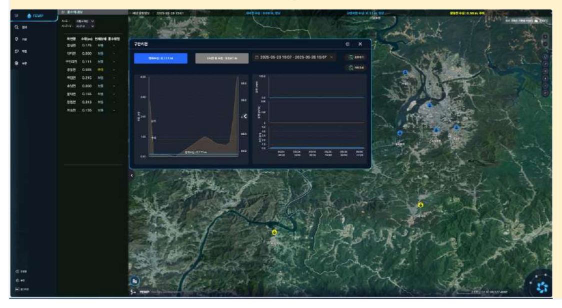
Small Stream	Discharge (m^3/s)		Depth (m)	
	RMSE	R^2	RMSE	R^2
Daemi	0.521	0.996	0.006	0.998
Bekam	0.009	0.992	0.001	0.994
Jumsil	0.001	0.988	0.001	0.920
Gwangdong	0.433	0.997	0.033	0.997
Balmak	0.036	0.996	0.002	0.984
Songnam	0.077	0.998	0.005	0.999
Jungdong	0.001	0.936	0.002	0.996
Gumanri	0.007	0.994	0.002	0.997
Jakseung	0.003	0.974	0.001	0.999

Develop the warning criteria

- Divided the warning criteria level into two stages such as the caution warning criteria level (CWCL) and the severe warning criteria level (SWCL)

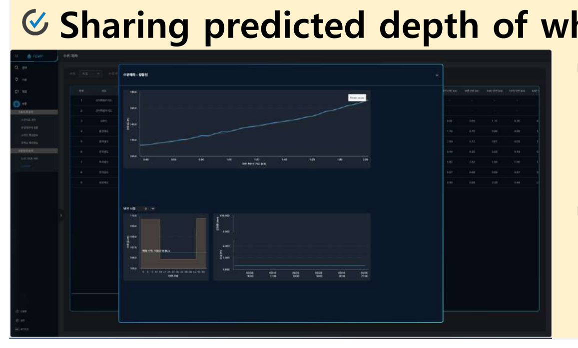


Flood warning in the Platform



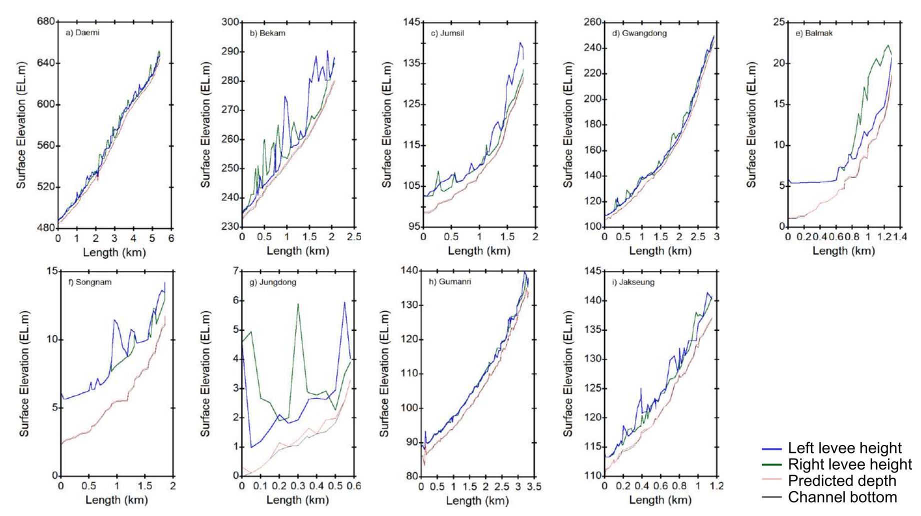
- Find predicted and measured water depths with cross-section data
- Warning level (caution) reached at 50 cm, severe reached at planned depth

Sharing predicted depth of whole section of SS



- Depth prediction & warning for unmeasured sections at 10-minutes intervals
- Find vulnerable section area easily by real-time monitoring in the Platform

- Predict depth on unmeasured section using the Manning Formula in nine small streams
- Determine optimum manning coefficient to minimize errors between predicted and measured depth data



Conclusions

- Advancements in technology and real-time measurement, including imagery, have significantly improved the availability and accessibility of monitoring data.
- Building on these developments, our research developed a real-time, data-driven framework that integrates a user-centered design approach to co-create a web-based decision-support tool.
- The framework was applied to nine small streams in Korea to assess vulnerabilities and evaluate the effectiveness of early flood warning systems.
- A stakeholder workshop was conducted in Seoul to test and validate the framework, where participants provided positive feedback regarding its usability and potential impact.
- This study exemplifies the effective utilization of real-time monitoring data in developing flood early warning tools, ultimately contributing to reduced flood damage and enhanced resilience planning for small streams in Korea.

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