EVALUATION OF DRIFTWOOD GENERATION IN THE NORTHERN KYUSHU HEAVY RAIN IN 2017 BY LOGISTIC REGRESSION

Takahiro SHOGAKI, Akiyoshi TSUSUE,and Shinichiro YANO (Kyushu University), Kiyonobu KASAMA(Tokyo Institute of Technology, Japan)

Introduction

Recently, historical recorded heavy rain disasters have occurred in Japan, such as, the West Japan Heavy Rain in 2018, the Typhoon *Hagibis* in 2019, and the Northern Kyushu Heavy Rain in 2017. These heavy rains may be caused by the progress of global warming. In these events, not only inundation, but also deposition of sediments and driftwoods were widely seen in the devastated area (Fig.1). Thus, river manager requires to evaluate a risk of floods with sediments and driftwoods in the heavy rain event.

In this research, we tried to develop a new model to estimate a possibility of slope failure as a source of driftwood generation in a given watershed area. The dataset of slope failure area in the Northern Kyushu Heavy Rain in 2017 was used for the development, because a lot of the simultaneous generation were seen in the event. The logistic regression model was applied as a multivariable statistical way to express the possibility of slope failure generation under a given precipitation condition.

Figure 1. A large amount of driftwood and damage to private houses (The Northern Kyushu Heavy Rain in 2017)

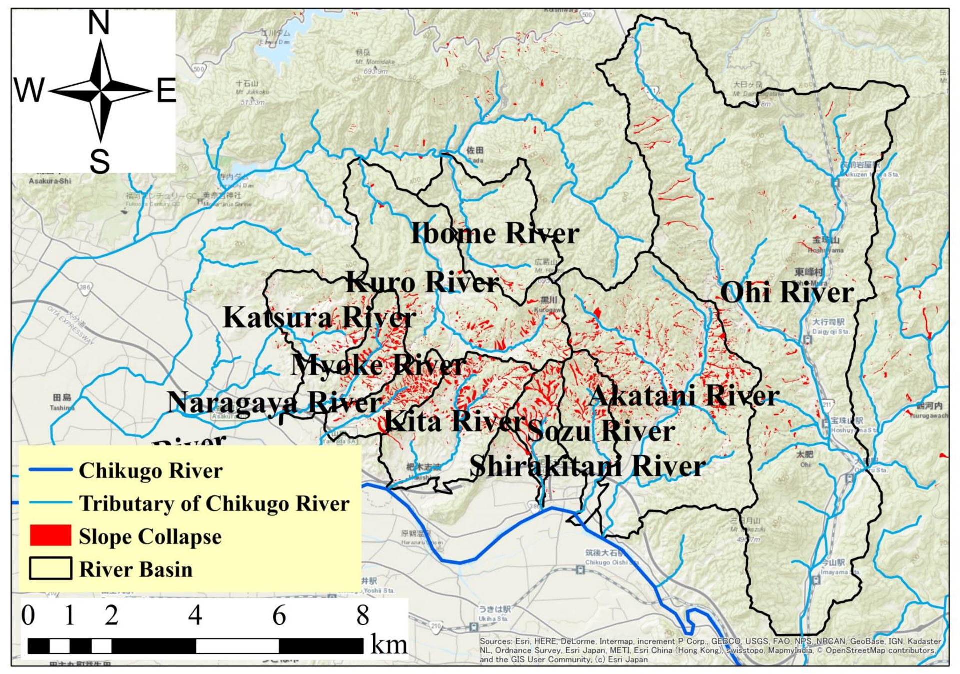

Figure 2. The river basins as a survey target

Model

(1) The logistic regression model

$$P(z) = \frac{1}{1+\exp(-z)} = \frac{\exp(z)}{1+\exp(z)}$$

$$z = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_n X_n$$

(2) The formula to calculate the amount of driftwood

$$V = \beta_w A_{sf}$$

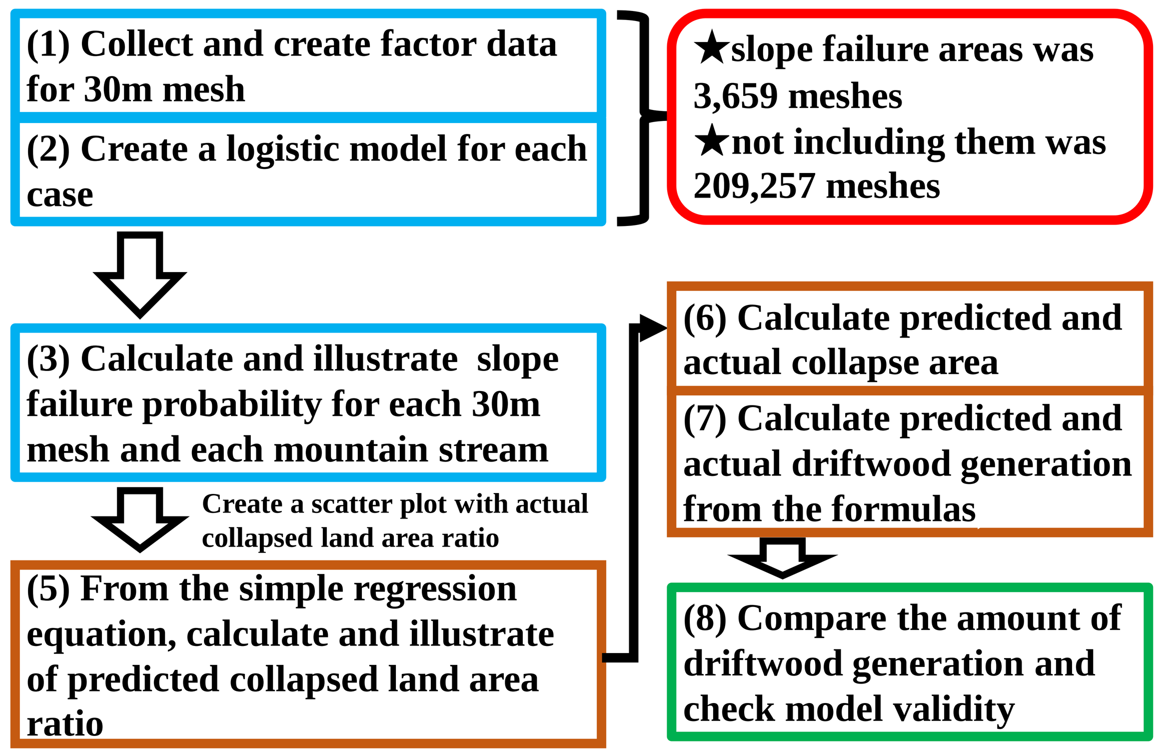

Figure 3. The research process

(1) $P(z)$ is the possibility of the objective variable z, β_i is the regression coefficient, and X_i are explanatory variables. These factors of X_i are the geographical data. In application of the logistic regression model, both numbers of the meshes should be equal. Therefore, 3,659 non-collapsed meshes were selected by random sampling. 20 trials of the random selection were performed to reduce a bias for them. It was confirmed that there was no bias in the random sampling. In this research, we choose 38 combinations for the explanatory variables.

(2) V is the amount of driftwood generation in each river, β_w is the volume of standing trees per unit area, and A_{sf} is the surface area of slope failure. In the present research, β_w =54,900 m^3/km^2 is adapted.

Results

Table 1. Examples of the combination of X_i

			case20	case21	case22	case23	case24	case20	case21	case22	case23	case24
coefficient of determination								0.3997	0.3968	0.307	0.3107	0.4089
intercept								-13.4719	-11.7139	-7.38794	-8.12986	-17.4159
inherent factor	an angle of inclination		O	O	O	O	O	0.043606	0.052081	0.034386	0.034238	0.053126
	sectional curvature		O	O	O	O	O	-15.683	4.81206	-18.6578	-19.1047	3.477268
	geology	volcanic rock	O	O	O	O	O	0.053588	-0.61927	-0.95539	-0.98608	-0.3442
		plutonic rock	O	O	O	O	O	0.355472	0.251173	0.721172	0.711803	0.088236
		metamorphic rocks	O	O	O	O	O	0.437201	0.555266	0.391972	0.400206	0.515042
	cumulative flow							0	0	0	0	0
	land cover	①glassland	O	O	O	O	O	1.236709	1.379762	1.339182	1.320539	1.364957
		②deciduous hardwood	O	O	O	O	O	1.03072	0.938538	0.828437	0.832068	0.951718
		③evergreen hardwood	O	O	O	O	O	0.286283	0.143633	0.23272	0.238543	0.163669
		④evergreen conifer	O	O	O	O	O	0.363511	0.086872	0.076015	0.089207	0.150757
		⑤bare ground	O	O	O	O	O	-11.997	-11.7202	-11.5315	-11.5447	-11.6938
		①+⑤						0	0	0	0	0
trigger	precipitation	1 hour					O	0	0	0	0	0.066495
		3 hours	O				O	0.047909	0	0	0	-0.02188
		6 hours		O			O	0	0.025578	0	0	0.035618
		12 hours			O		O	0	0	0.011907	0	-0.01997
		24 hours				O	O	0	0	0	0.011927	0.019078

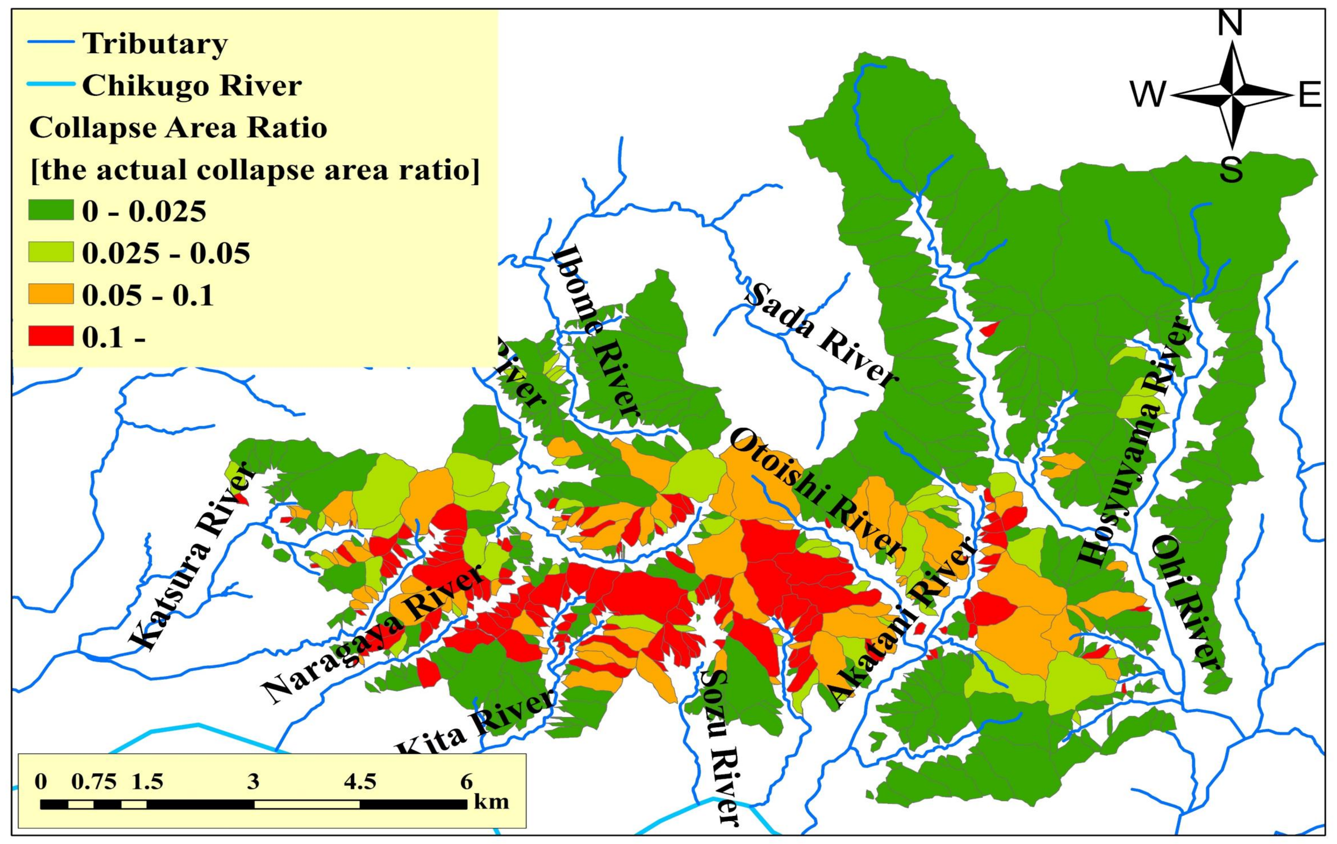

Figure 4. Map of actual slope failure area ratio

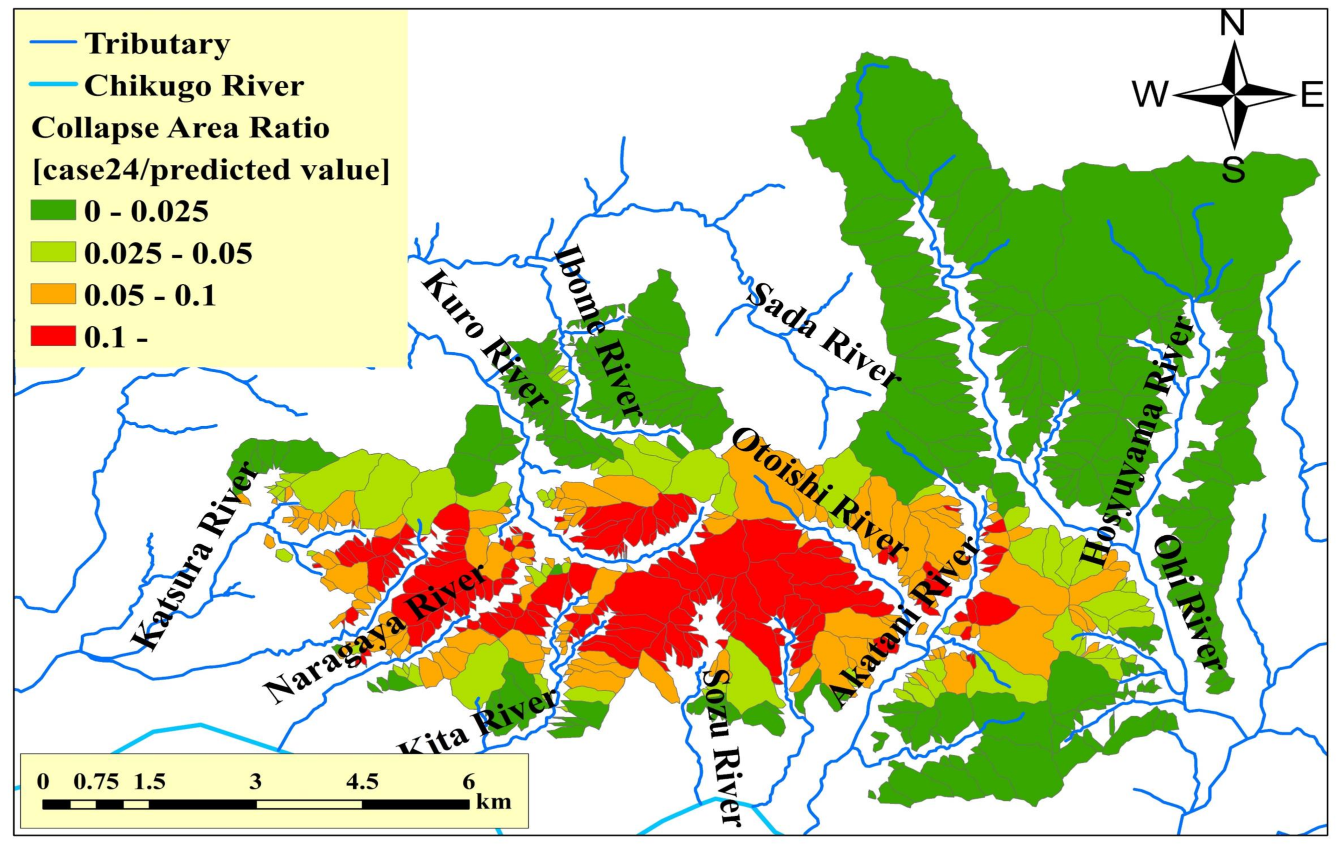

Figure 5. Map of estimated slope failure area ratio in the optimal case (case24)

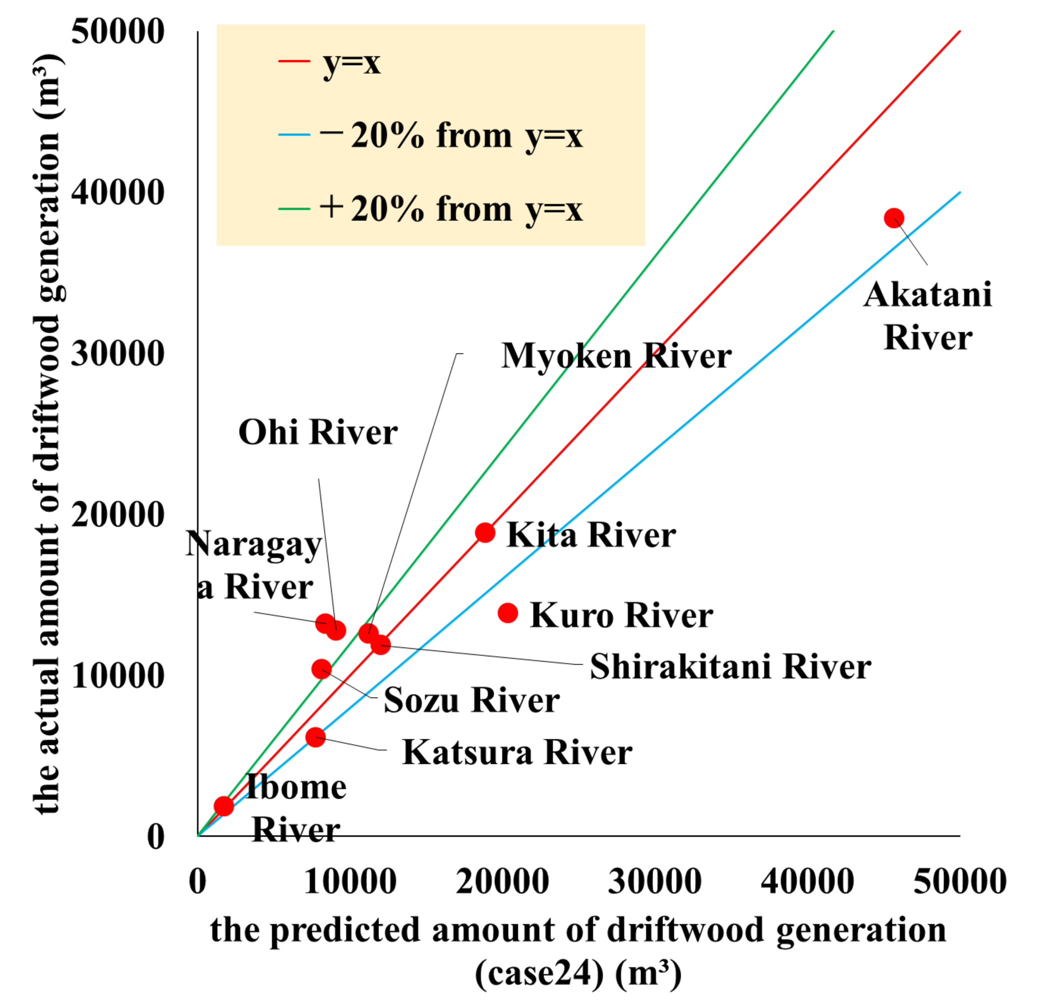

Figure 6. Comparison between estimation and actual record for driftwood generation for each river

✓The case 24 can reproduce the actual results most precisely. Additionally, other cases with high reproducibility were chosen. These cases included the maximum accumulative precipitation for 3 hrs or/and 6 hrs.

✓Figure 6 shows a comparison between the estimation of driftwood generation in each river by the model and the actual generation by MLIT. These estimation shows result within accuracy of 20%.

✓However, in the case including multi precipitation variables like case 24, some regression coefficient for accumulative precipitation shows negative value such as 3 hours and 12 hours accumulative precipitation in the case 24 (Table 1). It may be caused by the multicollinearity among accumulative precipitation.

Conclusions

✓As a result, it was succeeded to reproduce the slope failure and driftwood generation by logistic regression analysis in the Northern Kyushu Heavy Rain in 2017.

✓In further research, we will confirm the proposed model applicability by adapting it to other big flood events, e.g., heavy rain by the Typhoon 1919.

✓In addition, we will study how to incorporate parameters that take into account the soil rainfall index and the rainfall multicollinearity.

Reference

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