Time-varying discharge model and distribution simulation of disaster waste

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INTRODUCTION

In recent years, Japan has had several natural disasters such as earthquake, river flooding, high tide by typhoon, and so on. A massive amount of disaster waste is generated in residential area and occupies public or illegal space for storage whenever the disaster occurs. The heaps of the waste sometimes cause disturbance to the traffic of passenger cars, waste collection vehicles, and pedestrians. Until soon after the flooding settles down, victim households start to clean inside of the house and dispose of muddy sediment, wet lag, tatami, home appliance, furniture and so on. To know the situation of discharging the cleanup waste in disaster area leads to making a good plan of waste collection and transport. In this study, we develop a time-varying discharging models of cleanup waste. The models created for each waste category and depth level of flooding are identified based on affected households' experience of discharging cleanup waste.

MATERIALS AND METHODS

Questionnaire survey

Localized torrential heavy rain attacked the west of Japan in July 2018, and it brought a large flooding disaster at Mabi ward, Kurashiki city, Okayama. In Kurashiki city, resulting in 51 death, and the number of completely destroyed, completely half destroyed, and half-destroyed houses were 4,646, 452, and 394, respectively. In August 2019, we conducted a questionnaire survey about cleaning waste to randomly selected 800 affected households living in the ward. It inquired the level of flooding depth (L) and the total quantity of discharged cleanup waste (W_k) for each waste category (k): muddy sediment(1), combustibles(2), incombustible(1), clothes(4), furniture(11), home appliances(10), wastes in outdoor(4), and building materials(2). Moreover, it inquired the timings such as beginning(t_b), peak(t_p), and end(t_e) of discharging (Figure 1).

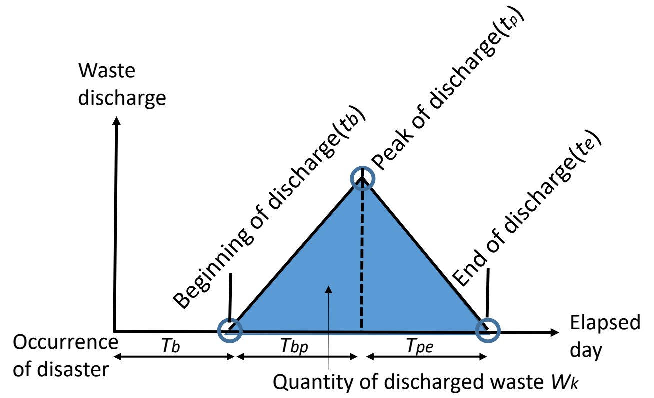


Figure 1 Concept of disaster waste discharging model

$$\varphi_{L,k}(t) = max\left[0, \frac{t - T_{b,L,k}}{T_{bp,L,k} + T_{pe,L,k}}\right],\ t < T_{b,L,k} + T_{bp,L,k} \qquad \ldots(1)$$

$$= max\left[0, \frac{T_{b,L,k} + T_{bp,L,k} + T_{pe,L,k} - t}{(T_{bp,L,k} + T_{pe,L,k})T_{pe,L,k}}\right],\ T_{b,L,k} + T_{bp,L,k} \le t \qquad \ldots(2)$$

$$W_L(t) = \sum_k \left(\varphi_{L,k}(t) / \Phi_{L,k}\right) W_{L,k},\quad \Phi_{L,k} = \sum_t \varphi_{L,k}(t) \qquad \ldots(3)$$

Where, elapsed day t(days), category of waste k(-), flooding depth level L(1~6), total quantity of discharged waste W_k(kg/household), and waste discharge at t W (t) (kg/day/household).

As a result, the recovery ratio of respondence to the questionnaire was 34.2%.

Time-varying model of discharging cleanup waste

Elapsed days from occurrence of disaster until beginning of waste discharge (T_b), period from the beginning of discharge until its highest (T_{bp}), and period from the highest until the end of discharge (T_{pe}). As screening, the long period more than 30 days is excluded from statistic calculation. Cleanup waste discharging rate per day per household is calculated using Eq(1)~(3).

RESULTS AND DISCUSSION

Distribution analysis of cleanup waste discharge

On the GIS system, dividing Mabi ward into 50mX50m mesh, and evaluating the representative flood depth(L) of each cell based on the Mabi flooding disaster map developed by Geospatial Information Authority of Japan. We multiplied the number of households in the cell with corresponding W_L(t) to get the regional quantity of discharged waste. Figure 1 shows distribution of cleanup waste in Mabi ward. The total quantity of cleanup waste discharged from the ward was estimated to be 63,615(ton). On the other hand, the city hall reported 96,594(ton) was discharged from all Kurashiki city areas. Considering that the flooding damage was concentrated on the ward, the estimated value is not far from the reported.

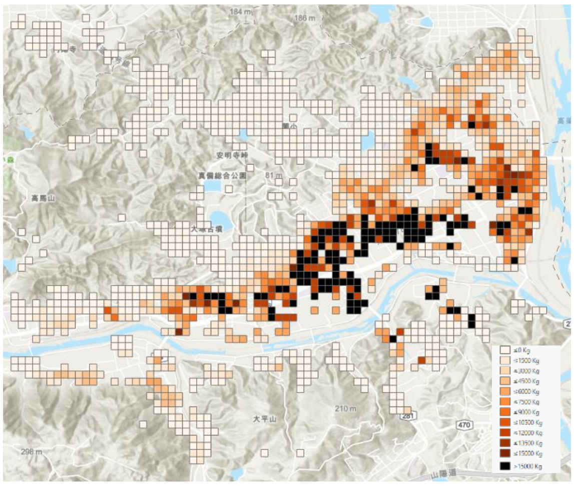
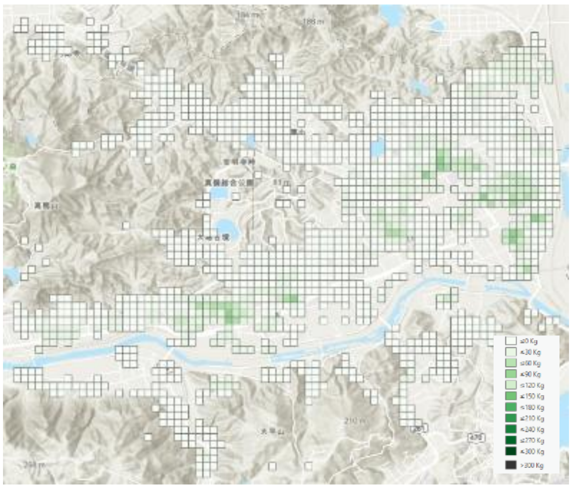


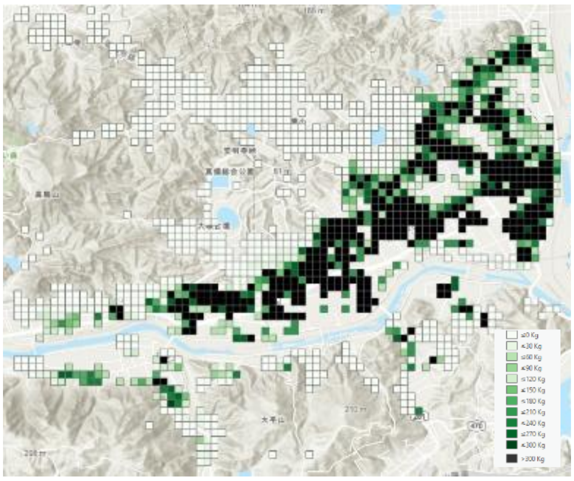
Figure 1 Distribution of total quantity of cleanup waste discharge by 50m x 50m mesh.

Time-varying distribution of discharged cleanup waste

Figure 2(a)(b) show cleanup waste distribution on the 2nd and 8th days, respectively. The two distribution maps are quite different, that is, in small number of cells discharging begins on the 2nd but discharging has spread widely on the 8th day.



(a)Waste distribution on the 2nd day after disaster



(b)Waste distribution on the 10th day after disaster

Figure 2 Time-varying distribution of discharged cleanup waste

CONCLUSION

Distributions of discharged cleanup waste on different elapsed days were visualized. This information is useful for planning of waste collection and transportation. Also, this distribution map tells us where temporal storage space needs to be preserved. Even if the target area has never suffered from flooding, this simulation will able to be performed if flooding hazard map exists.

REFERENCES

Kurashi city local government, Practical plan of disaster waste treatment in Kurashiki city, focusing on the localized heavy rain of July, 2018 (In Japanese), in website of Kurashiki city hall, (2019)