18. SOIL EROSION ASSESSMENT ON THE INFLUENCE OF CLIMATE CHANGE IMPACT

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Increase of sediment intrusion into the wetland was assumed to influenced and favor the growth and expansion of alder (Alnus japonica) trees in Kushiro wetland and thus the wetland becoming arid. In this study, we estimated the changes of the potential soil erosion risk on the probable impacts of future climate condition in Kushiro basin. Soil erosion susceptibility was assessed using Revised Universal Soil Loss Equation (RUSLE) integrated with Geographic Information System (GIS). Rainfall erosivity is assessed by comparing the R-factor between the past climate and future climate periods. The relationship of mean annual precipitation and the mean annual sum of individual storm erosion index values were calculated using 10-min interval rainfall records of the six weather stations in Kushiro basin from 2000-2016. Past and future mean annual precipitation data were provided from the d4PDF (database for Policy Decision making for Future climate change) which is a large ensemble of climate simulations. The results of the study evaluated the effects of the expected increase of precipitation to the potential risk of soil erosion and aid for planning and decision making to adapt climate change in Kushiro basin.

Key Words : *soil erosion, rainfall erosivity, RUSLE, GIS*

1. INTRODUCTION

Soil erosion is an occurring problem arising from areas with land degradation, and other anthropogenic activities. In Kushiro, the development of the agricultural areas, deforestation, and river degradation from the upper catchments of the wetland contributes to the increase in sediment inflow that adversely affects the vegetation activity, water quality, hydrological system and the environment.

Soil erosion is affected by many factors such as rainfall, topography, soil physical properties, land use. Rainfall is one of the drivers for soil detachment due to rainfall impact and runoff erosion.

Global changes in precipitation patterns due to climate change are expected to influence the impact on soil erosion including the changes in the rainfall erosivity. This study aims to establish a relationship of the rainfall erosivity and precipitation and estimate the soil erosion changes based on the rainfall erosivity under past and future climate case.

2. DATA AND METHODOLOGY

(1) Study area

Kushiro river basin is located in the eastern Hokkaido region of Japan and has an area approximately 2,510 km2 included in five cities and towns; Kushiro City, Kushiro Town, Tsurui Village, Teshikaga Town, and Shibecha Town.

The average annual rainfall in the basin is about 1,000-1,200 mm. Fog formation is frequent during summer due to the ocean current in the coastal area located downstream thus blocking the sunshine as a result of wet and cool climate in Kushiro river basin.

In this river basin, Kushiro Wetland, with about 190 km2 area, is the largest wetland in Japan. It is registered in the Ramsar Convention which discussed the importance of preserving the biodiversity of the wetland. However, increase of sediment intrusion into the wetland is assumed to favor the growth and expansion of the alder trees, thus the wetland becoming arid.

(2) Methodology

Revised Universal Soil Loss Equation (RUSLE) integrated with GIS was used to estimate soil loss in Kushiro Basin[1].

$$A = R \times LS \times K \times C \times P \tag{1}$$

where A is the soil erosion rate (t ha^{-1} year^{-1}), R defined as rainfall erosivity factor (MJ mm ha^{-1} year^{-1}), LS as topographic factors represent the slope length (L) and slope steepness (S) (dimensionless), K means soil erodibility factor (t ha MJ^{-1} mm^{-1}), C indicates land cover management factor (dimensionless) and P stands for support practices factor (unitless).

a) Rainfall erosivity factor (R)

Rainfall erosivity factor (R) represents the potential of rainfall intensity to cause soil erosion by estimating the erosive power of rainfall.

$$R = \frac{1}{n}\sum_{j=1}^{n}\sum_{k=1}^{mj}(EI_{30})_k \tag{2}$$

where, R is the average annual rainfall erosivity (MJ mm ha^{-1} h^{-1} yr^{-1}); n is the number of years of the rainfall records, m_j is the number of erosive storms of each year j, EI_{30} is the rainfall erosivity index of a single erosive storm k. The total storm kinetic energy (E) is estimated as

$$E = \sum_{j=1}^{m}(e_r \Delta v_r) \tag{3}$$

where, e_r is the rainfall kinetic energy per unit rainfall depth area (MJ ha^{-1} mm^{-1}); Δv_r the volume of rainfall in rth minute of the storm rainfall (mm). The unit rainfall energy (e_r) is estimated using Laws and Parsons equation[2],

$$e_r = 0.119 + 0.0873 \log i_r \tag{4}$$

where, i_r is the rainfall intensity during the time interval defined as $\Delta v_r \,/\, \Delta t_r$ in which Δt_r is the time interval.

b) Topographic factor (LS)

The effect of topography on erosion is quantified by the slope and slope length factors. The slope length is upslope contributing area factors[3].

c) Soil erodibility factor (K)

The soil erodibility factor is estimated using the soil texture information. The comprehensive soil classification of the soil map was used to determine the estimated soil texture of the soil in the area to quantify the soil erodibility factor[4].

d) Cover management factor (C)

Vegetation cover contributes to control soil erosion. The effect of the vegetation cover is indexed by cover management factor. The remote sensing derived Normalized Difference Vegetation Index (NDVI) values are scaled to approximate C values[5].

e) Support Practice factor (P)

The support practice factor (P) accounts the effect of the practices in the surface such as terracing, However, for regional scale analysis, it is hardly diagnosed thus assumed as equal to 1.

3. RESULTS AND DISCUSSION

(1) Estimation of rainfall erosivity (R factor) using the annual precipitation

The rainfall erosivity was calculated using the historical observed 10-min interval rainfall data (2000-2016) of the six rainfall stations in the Kushiro basin. The relationship of the annual precipitation and the R factor values of each rainfall stations is,

$$R = 0.2745 P_{annual}^{1.28} \tag{5}$$

(2) Impact of climate change on rainfall erosivity based on Precipitation

The past and future climate was estimated from mean annual precipitation of the large ensemble of climate simulation based on d4PDF[6].

Past climate scenario is based on the historical climate simulation data (1951-2010) and the future climate scenario is based on the +4K future climate simulation data (2051-2110). Using **Eq.5**, **Fig.1a** presents the rainfall erosivity of the past climate and **Fig.1b** presents the rainfall erosivity of the future climate. Overall, the rainfall erosivity increased due to the increase of the precipitation of the future climate.

(3) Soil erosion risk on past climate

Potential risk on soil erosion was estimated by integrating the R, LS, K, C factors. **Fig.2** shows the spatial distribution of the soil erosion using the past climate. From the analysis, 73.66% area is very low risk (0-1 t ha^{-1}yr^{-1}), 14.14% area is low risk (1-5 t ha^{-1}yr^{-1}), 4.5% area is moderate risk (5-10 t ha^{-1}yr^{-1}), 3.16% area is high risk (10-20 t ha^{-1}yr^{-1}) and 4.5% area is very high risk (>20 t ha^{-1}yr^{-1}).

(4) Potential soil erosion risk on future climate

Potential risk on soil erosion was estimated by integrating the R, LS, K, C factors. Soil loss changed between the past and the future as shown in **Fig.3** Overall changes in the basin increased up to 22.5%.

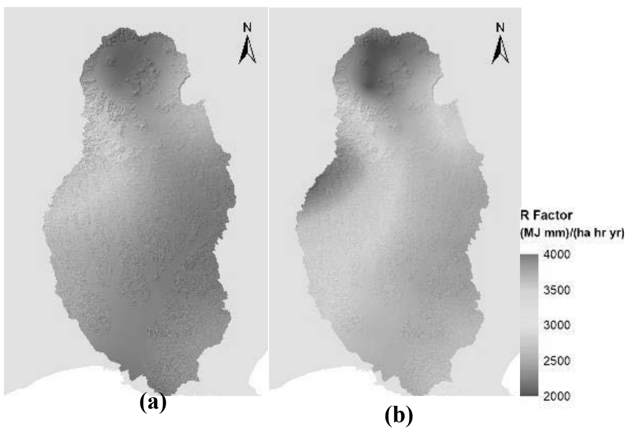

Fig.1 Rainfall erosivity (a) past climate (b) future climate

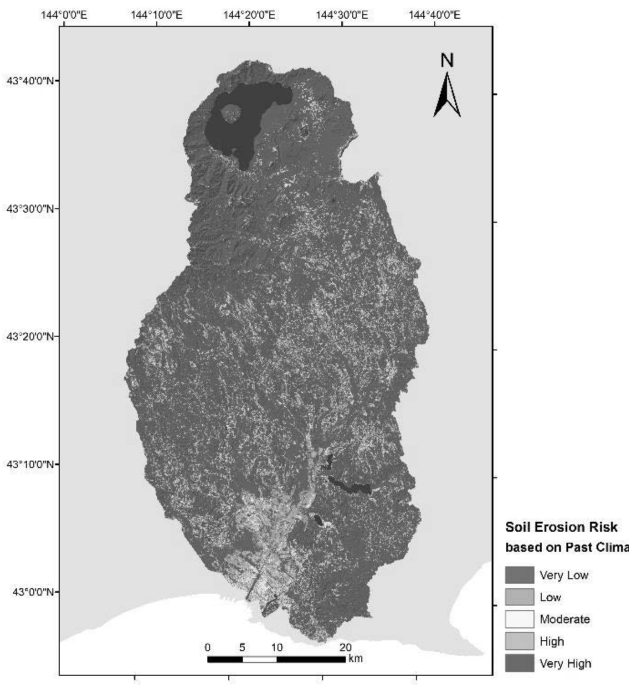

Fig.2 Potential soil loss based on the past climate

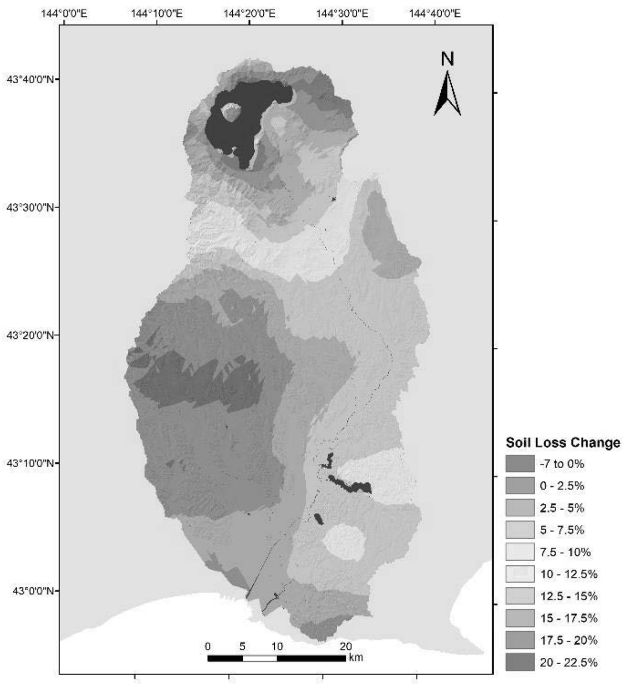

Fig.3 Percentage change of soil loss of the past and future

3. CONCLUSION

RUSLE was used to understand the spatial distribution of the potential annual soil loss in Kushiro basin. Although it is empirical based on the conditions of the experimental plot, the information from the RUSLE is helpful to understand the overview potential changes of soil loss in the influence of climate change.

Future rainfall erosivity was estimated by using the power equation based on the relationship of the annual precipitation and the rainfall erosivity from the observed 10-min rainfall data from (2000-2016). This study utilized the precipitation from the large ensemble climate simulations of d4PDF to estimate the past and future rainfall erosivity. The results of this study showed a significant increase of the rainfall amount and changes in the spatial distribution of annual precipitation between the past and future climate case. With this changes, rainfall erosivity increased in the study area.

Expected increase of rainfall erosivity have significant changes in the soil loss in the future for the Kushiro basin. The present study does not provide an estimate of amount of soil loss but rather provide an understanding of the possible soil erosion change in the future due to the influence of climate change.

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