EFFECT OF FLOOD DISTURBANCE ON THE RIVERINE VEGETATION IN FOUR SELECTED TRIBUTARIES IN ARAKAWA WATER SYSTEM

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1. INTRODUCTION

According to the Yoshimura at el.(2005), Japanese rivers are still heavily impacted by dam and canalization, loss of most dynamic flood plains, flow regulation, invasion by exotic species, and intensive urbanization. Most of dams and canalization is to provide societal services such as hydropower, irrigation, flood control, and recreation. By regulating natural flow regimes and trapping sediment, an unfortunate substitution of dams is their potential to change historical channel dynamics and vegetation disturbances. The resultant loss of sediment load impounded behind dams and reduced discharge during storms can cause downstream channel incision and entrenchment, which may also lead to contractions in bankfull width and potential abandonment of floodplains. Accompanied by these changes, riparian vegetation along channel banks experiences less frequent flood disturbances, which can lead to an encroachment of increased vegetation abundance on the floodplain but with lower species diversity. The significant and monotonous expansion of stable vegetation areas has been prevalent for gravel-bed Rivers in Japan Attention should be paid to the phenomena since the expansion possibly impairs in-stream ecosystems and flood discharge capacity. This study is conducted to identify relationship of flood disturbance (magnitude, frequency, and intensity) with river forestation by evaluating river flow regime and change of river vegetation condition in Arakawa water system. The specific objective of the study is to clarify the threshold shear stress (or other parameter) for evaluating the possibility of river forestation.

2. MATERIALS AND METHODS

2.1 Study area

Flow regime and riverine vegetation of four main tributaries namely; Tokigawa, Koaze, Oppegawa and Komagawa of Arakawa water system located at Saitama prefecture in Japan, were studied for the period of year1996 to 2002.

2.2. Definition of indicators for classifying the possibility of forestation in a river

2.2.1Vegetation Change Percentage (VC)

Vegetation changed from year 1996 to year 2002 was detected by calculating vegetation change percentage(*VC*) of grassland and forests on flood plain and gravel bar in each river in each river section (1km)

$$VC = \frac{(Veg._{2002} - Veg._{1996})}{Veg._{1996}} \times 100\% \quad (1)$$

Where**;** Veg.$_{1996}$=Total area of vegetation in 1996 (ha), Veg.$_{2002}$= Total area of vegetation in 2002 (ha)

2.2.2 River Flow Regime

Daily stream flow from 1997 to 2002 was studied. Uniform flow calculation with using Manning's equation is allowed the estimation of river discharges, at different stage levels within the river channel that would be important for riparian vegetation (i.e. wash off). Analyzing the historical flow record allows the magnitude, frequency, and intensity of these discharges to be quantified and consequently correlated with the associated vegetation data.

The flood events for each river section were defined as; that the flow which exceed it low channel level. Then it was defined normalized water height (H-Defined) *(2) for each flood event for each river section as shown in equation 3.

$$H(Defined) = \frac{\sum S_i h_i}{\sum S_i} \quad (2)$$

Where ; *H (Defined)*= Normalized water height (m), S_i=River section bed length of the ith section(m), h_i=Water height (middle point) of the ith section(m),

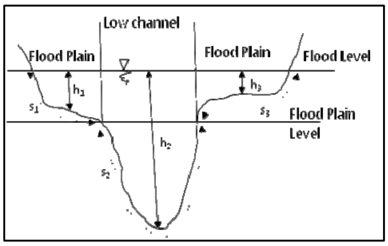

Figure 1: Defining flood plain level and water depth across the river section

2.2.3 Deriving suitable parameter for expressing vegetation change due to floods

Tanaka and Yagisawa(2012) defined indexes to elucidate the relationship between biodiversity on gravel islands in a river and flood disturbance characteristics.

$$WashingOut\,Index(WOI) = \frac{\tau_{*90}}{\tau_{c90}} \quad (3)$$

Where; τ_{*90} is non-dimensionalized shear stress of d_{90} (the grain size for which 90% of the material weight is finer), τ_{*c90} is non-dimensionalized critical shear stress of d_{90},

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To evaluate the shear stress acting on the grain, the non-dimensionalized shields parameter that is usually used for considering 'the gravity force (slope direction)' over 'the weight of the grain in water' was used as below;

$$\tau_* = \frac{\rho g H I_b}{(\rho_s - \rho) g d_i}, \quad \tau_* = \frac{H I_b}{(\rho_s / \rho - 1) d_i} \tag{4}$$

Where; τ_* = non-dimensionalized shields parameter, ρ_s =density of the particles, ρ =density of water, g =gravitational acceleration, d_i=grain diameter at which i volume passes through the sieve, I_b=bed slope, H = water depth. Finding "d_i" is not practical for each and every river section for each tributary. Hence, in this study HI_b was used to represent the "**τ**". By using H (H-Defined) I_b, value for the τ was calculated. Finally, total HI_b was calculated for each river section and coupled with calculated vegetation change percentage.

3. RESULTS

Totally 29 river sections (Komagawa:7, Koaze:6, Oppegawa:9 & Tokigawa: 7) were studied for no. of floods, total HI_b and Vegetation Change percentage.

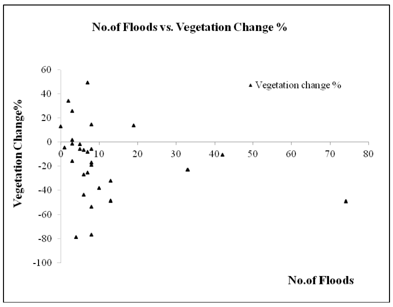

Figure 2: Relationship between no. of floods and vegetation change %

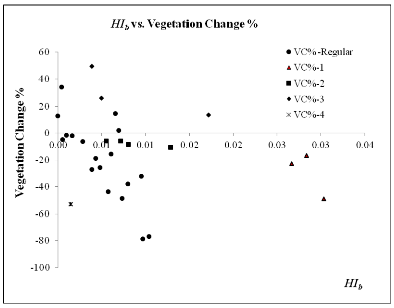

Figure 3: Relationship between HI_b and vegetation change %

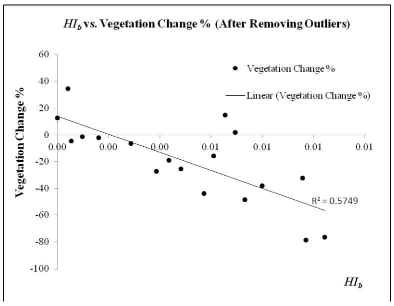

Figure 4: Relationship between HI_b and vegetation change % (after removing outliers)

Data shown in Figure 2 are scattered. According to the figure, even with the lesser no. of floods shows both positive and negative changes of Vegetation Change %. Thus any clear trend of vegetation change vs. number of floods cannot be identified.

In Figure 3: (HI_b vs. Vegetation Change %;) data series **"VC% -Regular"** is the data from the river section with regular flood disturbances. Data series **"VC%-1"** in Figure 3: is from the river sections with higher HI_b in midterm floods and lower HI_b during later period, which allow less possibility of washing out vegetation which established after midterm floods. At the same time data labeled as **"VC%-2"** is from the river section experienced only with peak floods (higher HI_b) but without regular floods, and such a condition enables vegetation succession. Even though some river section show higher HI_b (due two or three peak floods) shows positive VC%. It is because time laps in between floods allowed succession and establishment of vegetation, data from that type of river sections are labeled as **"VC%-3"**. The datum labeled as **"VC%-4"** is from the river section in which 92% of vegetation initially (1996) covered with herbs/grass. There for -53% of vegetation reduction is acceptable with even small HI_b. With the above facts, it is not possible to identify strong relationship in-between HI_b and Vegetation Change % in Figure 3.

After removing outliers (data series "VC%-1, 2, 3 & 4in Figure 3) behavior of the vegetation change% with HI_b is shown in the Figure 4. According Figure 4 there is a negative relationship in between HI_b, vegetation change%. When increase the HI_b, vegetation change% decreases. That means lesser amount of riverine vegetation is resultant by the higher no. of floods (high disturbances).

4. CONCLUSION AND DISCUSSION

A single expression of flood disturbance by no. of floods per considered period is not good criteria to evaluate the river forestation of the studied tributaries. The developed flood disturbance index HI_b, is strong enough to show the quantitative value for the flood magnitude, frequency, and intensity. Even though the riverine vegetated area found to be correlated with the HI_b at this point cannot be concluded as a good index since the coefficient of determination is small (R^2=0.57). Since the grain diameter of the soil is a critical factor for the tree washing out condition, it should also be considered for future studies. This information can be used for further studies for the applicability of the HI_b and for the evaluation of river forestation in the study area.

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