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ABSTRACT OF DOCTORAL THESIS

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Title: Effectiveness of bio-physical and soil amendment land management practices in reducing soil loss

（生物物理的手法及び土壌改良剤を用いた土地管理が土壌侵食の削減に及ぼす効果）

Soil erosion by water is a major cause of land degradation globally and in the Upper Blue Nile (UBN) basin of Ethiopia specifically. Many efforts have been made to control soil erosion using different bio-physical measures. However, effectiveness of these measures was less studied across land uses and agro-ecologies in the UBN basin of Ethiopia. In addition, land management (LM) practices that reduce soil loss through conditioning the soil, such as anionic polyacrylamide (PAM) has not been tested in Ethiopia. Studies indicate that application of PAM integrated with other soil amendments, such as gypsum, lime and biochar, could also further improve effectiveness of PAM in reducing soil erosion and promotes soil fertility. But PAM technology as a soil conditioner has not been tested yet in Ethiopia. Hence, determining the appropriate PAM rate, and evaluating its effectiveness in reducing soil loss when applied alone or integrated with gypsum, lime or biochar is important before wide scale adoption of the technology as land management measure in Ethiopia. Hence, aim of this study was to evaluate the effectiveness of bio-physical and soil amendment land management practices in reducing soil loss by integrating laboratory and field studies. The specific objectives were (1) to evaluate the effectiveness of bio-physical practices (soil bund, *fanya juu*, soil bund with grass, trench, exclosure and different crop types) in reducing soil loss through determining C- and P-factors of Revised Universal Soil Loss Equation (RUSLE) model; (2) to determine the effective PAM rate that best reduces runoff and soil loss under consecutive simulated rainfall storms; (3) to investigate the effectiveness of PAM alone or integrated with other soil amendments (gypsum, lime and biochar) in reducing runoff, soil loss and RUSLE C-factor at field runoff plot condition using natural rainfall; and (4) to synthesize scenarios by considering best performing bio-physical and soil amendment practices and evaluate the separate and combined effectiveness of the practices in reducing soil loss. Various bio-physical land management (LM) practices were implemented to tackle soil erosion in the UBN basin, Ethiopia. Effectiveness of the practices was evaluated through adopting the RUSLE model and determining support practice (P) and cover and management (C) factors for different LM practices in three agro-ecologies: Guder (highland), Aba Gerima (midland), and Dibatie (lowland). Two season daily soil loss data were collected from 42 runoff plots. We found that P-factor ranged from 0.15 to 0.53 for soil bund, 0.18 to 0.5 for *fanya juu*, and 0.06 to 0.44 for soil bund with grass in cropland; and 0.03 to 0.42 for trench with exclosure in non-cropland plots. The average P values also varied with agro-ecology in the order Aba Gerima > Guder > Dibatie for cropland and Guder > Dibatie > Aba Gerima for non-cropland plots, which could be attributed to climatic and other bio-physical variations among study sites. The C-factor values varied from 0.004 to 0.64 in cropland and from 0.001 to 0.49 in non-cropland plots implying that the management

practices were more effective in non-crop lands than croplands due to better cover condition in most seasons of the year than tilled croplands. Improved understanding of the dynamics of C- and P-factors will help in future soil loss prediction in the basin and other similar regions.
On the other hand, the effective PAM rate that best reduces runoff and soil loss under simulated consecutive rainfall storms was determined in laboratory. Different PAM rates, i.e. 0(C), 20 kg ha^{-1} (P20), 40 kg ha^{-1} (P40), and 60 kg ha^{-1} (P60) were applied onto soil surface and run for six consecutive rainfall storms of 70 mm h^{-1} intensity for 1-hr duration, and the effective PAM rate was determined. The P20 was found to be effective in reducing runoff in the beginning while P40 and P60 were more effective in reducing runoff and soil loss starting from the third storm through the end of the consecutive storms, but with no statistically significant difference between P40 and P60. Hence, P40 was selected as the most suitable rate for the given test soil and rainfall pattern. This effective PAM rate was applied with gypsum (G) (4 t ha^{-1}) or lime (L) (2 t ha^{-1}) to verify if its effectiveness can be further enhanced. The mixed application of P40 with G or L increased infiltration rate (IR) in the first two storms through improving soil solution viscosity. However, effectiveness of the mixtures had diminished by various degrees as rain progressed, as compared to P40 alone, which could be attributed to the rate and properties of G and L. In conclusion, the variation in effectiveness of PAM rates in reducing runoff with storm duration could indicate that the effective rates shall be selected based on the climatic region in that lower rates for the short rains or higher rates for elongated rains. Moreover, combined application of PAM with L improve soil pH, which could offer good option to both fairly reduce soil erosion and improve land productivity especially in acidic soils like Oxisols, which requires further field verification.

The fourth chapter has been omitted for a certain reason.

"* In addition, some of the figures, etc., have been omitted."