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SUMMARY 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. Soil erosion has become severe threats to food security for developing countries like Ethiopia, where the livelihood of most of the population depends predominantly on agriculture. The multitude adverse on- and off-site consequences of soil erosion are reduction in soil fertility and crop production, loss of vital ecosystem services, siltation of reservoirs, etc. In Ethiopia, these environmental and socioeconomic consequences are further aggravated by human intervention, including deforestation, overgrazing, poor farming practices and lack of suitable land management (LM) practices.
So far, Ethiopia has made many efforts to control soil erosion and its consequences using different bio-physical LM practices and promising results have been obtained. However, effectiveness of these practices was less studied across land uses and agro-ecologies. Furthermore, the practices focused on reducing soil erosion and less attention was given to alternative management practices dealing with conditioning the soil, such as Polyacrylamide (PAM) that improve soil properties. Earlier studies indicate that application of PAM integrated with other soil amendments, such as gypsum, lime and biochar, could further improve effectiveness of PAM in reducing soil erosion through improving soil properties. But PAM technology as a soil conditioner has not been tested for soils in the tropical highland humid environments, such as northwest Ethiopia.
The main aim of this study was, therefore, to contribute for the development of alternative LM practices against soil erosion through testing the separate and combined effectiveness of bio-physical and soil amendment practices by integrating laboratory and field studies. The study was conducted under laboratory using a rainfall simulator as well as field conditions in the UBN basin. The specific objectives were (1) to determine the effectiveness of bio-physical practices [soil bund (SB), fanya juu (F), soil bund with grass (SBG), trench with exclosure (T+E) and different crop types] on the bases of the *C*- and *P*-factors of the Revised Universal Soil Loss Equation (RUSLE); and (2) through first determining the effective PAM rate under laboratory condition, to investigate its effectiveness when applied alone or integrated with other soil amendments (gypsum, lime and biochar) in reducing runoff, soil loss, and RUSLE's C-factor under field condition. These objectives cover chapters 2–4 of this thesis, which comprises a total of five Chapters, including the introduction; and the general synthesis, conclusions and recommendations, as summarized below:
Chapter 1 explains the introductory section of the study that contains background, problem statement, objectives, description of the study area, general methodological framework and overall organization of the thesis.
Chapter 2 evaluates effectiveness of various bio-physical LM practices (SB, F, SBG and T+E) implemented to tackle soil erosion in the UBN basin, Ethiopia, 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 seasons daily soil loss data were collected from 42 runoff plots. The result showed that P-factor values ranged from 0.15 to 0.53 for SB, 0.18 to 0.5 for F, and 0.06 to 0.44 for SBG in cropland, the lowest being for SBG; and 0.03 to 0.42 for T+E 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 SBG was found the most effective bio-physical practice across all the three studied 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.

Chapter 3 determines the effective PAM rate that best reduces runoff and soil loss from Oxisols, one of the dominant soils in humid tropics/Ethiopia. Different PAM rates of 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 simulated rainfall storms of 70 mm h^{-1} intensity for 1-hr duration to determine the effective PAM rate. The P20 was found to be more effective in reducing runoff in the beginning while P40 and P60 were more effective in reducing both 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.

Chapter 4 evaluates the potential of the selected PAM rate (i.e. P40) to reducing soil erosion in field runoff plots condition at Aba Gerima site in northwest Ethiopia. We assessed the effectiveness of PAM alone or integrated with gypsum, lime, or biochar in reducing soil loss. We collected daily runoff and sediment loss data from plots planted with teff during the 2018 and 2019 rainy seasons and investigated associated changes in soil properties and crop growth parameters. Treatments reduced seasonal runoff by 12–39% and soil loss by 13–53%. The highest reduction in soil loss was observed from PAM combined with lime (P+L) treatment. Integrating PAM with other amendments improved soil moisture content, pH, organic matter and crop biomass yield. The effects of these treatments were also reflected in improving *C*-factor of the RUSLE model, contributing for erosion modeling in this region and beyond. Unlike PAM, biochar, and lime amendments take time to be effective after application, hence, continuing the field experiment and studying associated physicochemical mechanisms for extended periods will better elucidate their effectiveness over time.

Chapter 5 provides the general synthesis, concussions and recommendations of the whole thesis based on the key findings obtained from Chapter 2–4. Soil loss prediction scenarios considering best performing practices out of the tested bio-physical and soil amendment practices (i.e. SBG from bio-physical and/or P+L from soil amendment), were estimated using RUSLE model to evaluate the separate and combined effectiveness of these best alternative LM practices in reducing soil loss on cropland (teff) runoff plot of 3m by 30m. The results showed that P+L and SBG separately reduced soil loss by 48 and 68%, respectively, while their combination reduced by 83%. Although SBG was more efficient in reducing soil erosion, as compared to P+L treatment, the effect of P+L in improving soil properties and hence crop and biomass yield could compensate its relatively low efficiency in reducing soil loss. Hence, further study to compare the overall costs and benefits of these practices from the view point of ecosystem services could help to better evaluate the efficiency of the practices.