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SUMMARY OF DOCTORAL THESIS

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Title: ASSESSMENT OF SOIL EROSION AND SEASONAL WATER QUALITY CHARACTERISTICS IN SOCIAL FOREST–DOMINATED WATERSHEDS, LAMPUNG, INDONESIA
(インドネシア・ランプン州の社会林業が支配的な流域における土壌侵食と季節的な水質特性の評価)

The growing population in Indonesia influences land demand for agriculture that accelerates converting land uses from forest to agricultural land. This situation provides issues in soil erosion and water quality degradation. It is important to protect forest from deforestation and forest degradation, as forest has function supporting biodiversity (flora and fauna), determining hydrological characteristics, and support life for communities. Local communities surrounding forest area have strong bonding with forest as they depend on forest resources for living. Utilization of forest area by local communities often rise conflict of forest tenure. Local communities that live surrounding forest area have potential on forest management to ensure forest functions. Therefore, forest management policy for giving legal access to local communities is a solution to use forest resources in order to support economic growth and reduce conflicts with consideration in maintaining forest functions.

Social forestry is the system of forest management that empowers local communities by giving legal access to forest resources. This policy gives equity to local communities for increasing prosperity and economic development, for balancing the relationship between environment and dynamic social culture, and for maintaining sustainable forest function. Besides that, legal access to forest tenure can reduce deforestation and improve rehabilitation. In Tanggamus Regency, Lampung, Indonesia, coffee plantation is predominant land use and cultivated by smallholder in social forestry area. Coffee cultivation becomes one of the important sources to support economic growth. Local community around forest in Tanggamus Regency area has legal access to use forest in order to increase their livelihoods and welfare through community forest and forestry partnership programs, but in other side they have to maintain forest function.

The first study assessed the water quality of Sekampung Hulu and Sangharus Rivers in Lampung, Indonesia, based on their total suspended solids (TSS) concentrations. Subsequently, the extent of soil erosion in the two watersheds was determined and best management practices (BMPs) were recommended for the study area. Water sampling was conducted in 2016 to estimate TSS levels in the two watersheds. Additionally, the Universal Soil Loss Equation (USLE) was integrated with an ArcGIS model to evaluate soil erosion in the watersheds. The results indicate that TSS concentrations in the Sekampung Hulu and Sangharus Rivers ranged from 36–813 mg/L and 16–146 mg/L, respectively. The mean and standard error of TSS concentrations in Sekampung Hulu and Sangharus Rivers were 228 ± 87.5 and 69.3 ± 15.2, respectively. Statistical analysis indicated that the mean TSS concentration for the Sekampung Hulu River was significantly higher than that for the Sangharus River. Further, the average soil erosion rates in the Sekampung Hulu and Sangharus watersheds were 12.5 Mg/ha/year and 5.6 Mg/ha/year, respectively. Erosion rates greater than 10 Mg/ha/year corresponded to 21.8% and 15.5% of the total area for Sekampung Hulu and Sangharus watersheds, respectively. The results indicated that young coffee trees increased soil erosion rates, especially in areas characterized by

vulnerable soil. The USLE results concurred with the TSS analysis and indicated higher erosion rates for the Sekampung Hulu watershed than the Sangharus watershed. The simulation scenarios of BMPs were developed in this study to know the potential reduction of soil erosion. The simulation scenarios indicated that BMPs could effectively reduce soil erosion in the following order (from highest to lowest reduction): agroforestry > cover crops > contour systems. Adoption of agroforestry coffee is the most effective BMP for reducing soil erosion. Furthermore, it is crucial to raise awareness regarding the importance of this system, especially with respect to both income generation and environmental conservation, to encourage the adoption of agroforestry among farmers.

The subsequent study identified seasonal water quality characteristics in two adjacent mountainous rivers (Sangharus and Sekampung Hulu Rivers) in Lampung, Indonesia, and determined the impacts of fertilizer application on river chemistry as a result of social forestry management. Water chemistry was measured in 2016 covering 15 parameters, including calcium (Ca), potassium (K), magnesium (Mg), sodium (Na), chloride (Cl), nitrate (NO_3), phosphate (PO_4), sulfate (SO_4), aluminum (Al), iron (Fe), silicon (Si), water temperature, electric conductivity (EC), dissolved oxygen (DO), and pH. A farmers' questionnaire survey to obtain information on fertilizer application was conducted in study area. The water quality results indicated that seasonal patterns of Ca, K, Mg, Na, Si, Cl, and PO_4 concentrations were significantly higher in the dry season for both rivers relative to the rainy season due to lower water discharge and therefore lower dilution during the dry season.. The seasonal patterns of Al and Fe concentrations in both rivers showed no significant difference. EC and NO_3 were higher in the rainy season, likely linked to the dominant timing of urea fertilizer application during the rainy season. Moreover, geological characteristics played an important role in the Sangharus River in determining its water quality characteristics because the watershed consisted of higher basaltic andesite tuff compared to the Sekampung Hulu watershed. Based on the survey, it was determined that urea application was significantly higher in the Sangharus watershed (166.8 kg/ha) relative to the Sekampung Hulu watershed (120.3 kg/ha). By contrast, the application of mutiara and phonska fertilizers showed no significant difference in both watersheds. Despite the application of fertilizers in the watersheds, NO_3 levels remained below the recommended standard. However, Al and Fe concentrations were higher than the recommended level for drinking water, which was likely due to elevated soil erosion from improper land management. Therefore, we recommend that effective land management policies be implemented through the adoption of soil conservation practices such as cover cropping, contour cropping, terracing, and agroforestry for nutrient loss prevention.

Finally, based on the results of this study, the evaluation of soil erosion and seasonal water quality characteristics in both watersheds could potentially aid sustainable land management in the study area. Application of BMPs in social forestry is necessary to decrease soil erosion and improve water quality in stream water. The Batutegi Dam reservoir is a water supply source for irrigation, drinking water, and nearby power plants, and is located downstream of the rivers in the study area. The adoption of BMPs such as agroforestry, cover crops, and contour cropping could maintain hydrological characteristics and prevent reservoir from decreasing functions. Policy makers could develop regulations about future conservation plans of applying BMPs in order to prevent water quality degradation in the Batutegi Dam, maintain forest function, implement water resources management, and protect fresh water resources.