(Form No. 14)

ABSTRACT OF DOCTORAL THESIS

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Title: Role of soil microbes from remnant Church Forest to assist seedling establishment of native tree species in a degraded land
(劣化地での在来樹種の実生定着における遺された「教会の森」由来の土壌微生物の役割)

Land degradation is severe problem in Ethiopia, which affects the agricultural production and other ecosystem services. There have been different efforts made on countermeasures including afforestation and establishment of exclosures. However, scientific information on key ecological indicators of land degradation or afforestation such as soil organic carbon (SOC), total nitrogen (TN) stocks are scarce to prioritize and design evidence-based land management interventions. Moreover, there is lack of studies characterizing the role of microbial communities or evaluating the inoculum potential and the effects of microbes from Church Forests on the early stages of native trees establishment in degraded lands. Thus, the overall objective of this research is to contribute for the assisted-restoration of native trees in degraded lands through using Church Forest soils as a source of native microbes. The specific objectives were to: 1) prioritize severely degraded areas for management intervention through assessing SOC and TN stocks in different land uses and topographic positions found in three agro-ecosystems of the Upper Blue Nile basin; 2) to clarify the soil microbial potential of Church Forest soil and its effect on seedling growth of selected native trees species under glasshouse conditions and 3) to evaluate the role of Church Forest soil in assisting the seedling establishment of a selected native tree under a degraded land field conditions. The studied watersheds; namely, Guder, Aba Gerima and Dibatie represent the highland, midland and lowland agro-ecosystems of the basin, respectively. A total of 352 soil samples taken from 4–land uses, 3–topographic positions and 3–soil depths in the three watersheds were analyzed for SOC and TN. I found that land use, topographic positions, agro-ecosystems and their interactions have a significant influence in both stocks. Not surprisingly, the cropland located in the upper topographic position was found the most degraded land use type, likely due to higher erosion rate. However, unlike the normal assumption, plantations exhibited lower SOC and TN stocks due to poor undergrowth and overexploitation for charcoal and firewood production including the roots. Specifically, among the three watersheds, Aba Gerima was found under a severely degraded situation owing to prolonged cultivation and unsustainable human

activities, thus revealing the need for immediate land management interventions.

The microbial potential of soils from Church Forest in Aba Gerima and its effect on seedling establishment of *Olea europaea* and *Albizia gummifera* native tree species under glasshouse conditions. The results showed significantly higher plant height, root collar diameter, shoot and total biomass for seedlings grown in non-sterilized (with microbes) forest soils than those grown in sterilized (without microbes) soil. Furthermore, the relative abundance of *Acidobacteria*, *Actinobacteria* and *Nitrospirae* was significantly correlated with non-sterilized forest soil bacterial community (r^2 = 0.6–0.8, $p < 0.001$). The favorable soil pH environment of the forest soils was found to affect the abundance of the bacterial community in the Church Forest soils. Overall, seedlings grown in Church Forest soils showed better performance and survival rate, because of higher soil microbial abundance and diversity, than those grown in the soil from degraded land. This effect was more noticeable on the performance of Olea seedlings grown in the soil from *Croton macrostachyus*. This suggests that soil from remnant Church Forests, particularly soil from beneath *Croton macrostachyus,* can serve as a good inoculum source for native tree seedling growth and survival in degraded lands. Therefore, these findings confirm that Church Forest soils are endowed with beneficial native microbes (mainly bacteria and fungi), which can serve as a source for native soil inoculum. Use of this inoculum source can facilitate native trees seedlings establishment, growth and survival in degraded lands restoration.

Note: Chapter 4 has been omitted for certain reason.

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