（Format　No. 3）

SUMMARY OF DOCTORAL THESIS

Name: Derege Tsegaye Meshesha

Title: Spatial analysis of soil erosion and sediment yield in Central Rift Valley of Ethiopia
（　エチオピアの中央地溝帯における土壌侵食と堆積の空間解析 ）

SUMMARY

The Central Rift Valley (CRV) is one of the most environmentally vulnerable areas of Ethiopia. Because, since it is a closed basin, relatively small intervention in land and water resource can have a profound effect in the ecosystem and sustainable use of the land and water resource. Most of the low land in the CRV is arid or semiarid, and droughts occur frequently. The Land and water resources of the CRV is highly deteriorating and negatively changing over time. The soil erosion and sedimentation amount is also significantly high and increasing through time following a serious of vegetation degradation. Soil erosion by water during the rainy season is a serious problem in the region, leading to declining agricultural production, decreased food security, and a sedimentation risk for lakes. To maintain this ecologically sensitive basin, there is an urgent need for improved resource use of land and water that takes into account the carrying capacity of the ecosystem. Hence, economical, social and technical measures must be taken with no further setback.

However, the government, stakeholders and local policy makers looks reluctant and seem to have not yet understood and realized the ongoing land and water deterioration in the region and its future impact on the livelihood of the community and ecosystem, and hence are not on the position to take any action to mitigate the problem or reverse it. It is mainly due to lack of adequate information about the magnitude and seriousness of the soil erosion from agricultural lands, sedimentation to the lakes and the problem that they cumulatively pose in the future; as there has been no systematic study of these problem or of possible management solutions in the region. Meanwhile, development of effective erosion control plans requires the identification of areas vulnerable to soil erosion and quantification of the amounts of soil erosion from various areas. Especially, a move should be started to prolong the life of the local lakes whose size and level is significantly decreasing over time due to mainly land use change, otherwise, may face the same fate like reservoirs of north Ethiopia and lakes of eastern Ethiopia which dried up in similar reasons.

Therefore, this research is designed to address these research gaps with objectives of providing scientific based information and understanding of the valley in terms of land use and cover change, soil erosion, and sedimentation issues in the past 30 years (1973-2006), and to propose options or scenarios whose efficiencies are tested through models for sustainable use of land and water resource in the future.

The dynamics of Land use and cover and land degradation was examined through analyzing Landsat data from 1973, 1985 and 2006 using Geographic Information Systems and remote sensing techniques. The classification accuracy of each images was validated based on GPS recorded ground truth data and other reference maps and aerial photos. The change analysis result revealed that in the last 30 years, water

bodies, forest and woodland decreased by 15.3, 66.3 and 69.2 % respectively; whereas, intensive cultivation, mixed cultivation/woodland and degraded land increased by 34.5, 79.7 and 200.7%. The major causes of Land Use and Cover Change (LUCC) and land degradation in the area were population and livestock growth in regions of limited resources, unsustainable farming techniques, the Ethiopian land tenure system and poverty. Lake level and size decline, and accelerated land degradation are recognized as major environmental impacts of LUCC observed in the region. The environmental and socio-economic consequences of LUCC and land degradation are far-reaching. As a result of the expansion of land degradation over time, agricultural productivity has decreased and worsened food insecurity (shortages) and poverty in the Ethiopian CRV. In addition, if current trends in LUCC continue, Lake Abiyata will dry up by 2021.

The magnitude and dynamicity of soil loss was evaluated using the universal soil-loss equation (USLE) and Geographical Information System (GIS) software, considering the land use change from 1973-2006. The model result was validated by comparing it with others' research output, national average and using photo validation techniques. The result showed that soil erosion increased markedly from 1973 to 2006, with annual rates of 31, 38, and 56 t ha^{-1} in 1973, 1985, and 2006, respectively, as a result of vegetation degradation and particularly the conversion of thousands of hectares of forest or woodland into cropland. The observed soil erosion rates are far from the tolerable rate of soil loss of the country and hence require urgent soil conservation interventions, especially in the hotspot areas. To this end, eight different scenarios were proposed and their effectiveness to reduce existing soil loss was evaluated. Rehabilitating degraded land (using exclosures and planted vegetation) and installing stone erosion-control structures (stone bund) in cropland reduced the total soil loss by 12.6% and 63.8%, respectively. Treating hotspot areas with annual soil loss of more than 20 t ha^{-1} by integrated management (erosion-control structures and exclosures) was the most effective approach, reducing soil loss by 87.8%.

The Soil erosion in the highlands surrounding the Ethiopian Central Rift Valley is not only affecting the productivity of crop lands due to nutrient loss but also becoming a serious threat to lakes of the valley. The measured specific sediment yield (SSY) of 214–611 t km^{-2} yr^{-1} for six catchments in the rift valley shows that there exists a significant sedimentation problem for lakes in the region. Although accurate predictions of SSY are needed to plan and implement policies to mitigate these problems, so far there is little reliable data on sediment yield and no adaptable model to predict SSY has yet been developed for the region. We used field observations and a previously developed factorial scoring model (FSM) that calculates SSY as a function of topography, vegetation cover, gully morphology, lithology, and catchment shape to determine which of these factors have the greatest effect on SSY in the region; we found that gully morphology is the primary factor that controls SSY, followed in order of decreasing importance by catchment shape, topography, vegetation cover, and lithology. We then modified the model by adding a climate factor to account for the effect of rainfall on SSY in the Central Rift Valley. We found that both calibrated models that used modified factors of FSM and our modified version that included climate provided reasonably good matches between observed and predicted SSY during calibration and validation. However, because of significant differences in rainfall among the six catchments, the calibrated model with indices that include climate (Ic: R^2=0.82) performs better than that without climate (Io: R^2=0.77) to predict SSY. Statistical analysis of the validation results also revealed that the model incorporating index with climate *(Ic)* explained about 66% of the SSY variability among the catchments, whereas that incorporating index without climate (I_O) explained only about 60%.