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Integrating isotopic tracer techniques with Bayesian modelling for improved assessment and management of sedimentation problems in the Gilgel-Gibe catchment, Ethiopia

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Soil erosion and associated downstream siltation of dams and lakes is becoming serious threat to catchment ecosystem services supporting water, food and energy security in Ethiopia. Sediments originate on catchment hillslopes but mobilisation processes vary depending on land use and terrain. The Gilgel Gibe hydroelectric dam is one of a series of development projects launched by the Federal Government of Ethiopia. The catchment is characterised by erodible, deforested agricultural land which is also overgrazed. Siltation and nutrient enrichment are significant issues given 'hotspot' sheet erosion estimates of 2210 ton per square km. The annual contribution of sediment from the Gilgel Gibe River to the dam was estimated at 277 thousand tons per year leading to accumulations of 3.75 x 107 cubic metres per year of silt behind the dam. The primary driver for mobilisation and translocation to downstream is believed to be erosion on agricultural lands and collapse of steep banks, through landsliding into river channels in the highland headwaters. The relative importance of specific sources of siltation are unknown and sediment source apportionment has been identified as a first essential step before soil conservation measures can be implemented. Knowledge of sediment source and transfer dynamics is critical to inform management policy decisions to maintain and enhance future food, water and energy security To test the applicability of a new combination of Bayesian unmixing modelling with sediment fingerprinting in this terrain (IMIXSED approach) a demonstration sub-catchment was selected through field assessment in the upper Gilgel-Gibe water-supply catchments (Unta River) and sampling strategies designed. Accordingly, sources, i.e. soil samples from landslides (n=40), eroding channel bank (n = 5), cultivated land (n = 30), grasslands (n = 30), wooded areas (n = 10), homestead plots (n = 10) were collected alongside 10 spatially-integrated sediment deposits from the receptor cobble bed river after the 2016 rainy season. In order to extract reliable information on the sources of fine sediment delivered into rivers and dam, new isotopic techniques (e.g., Compound Specific Stable Isotopes (CSSIs)) combined with other isotopic techniques (fallout radionuclides) and geochemical tracer properties (via WD-XRF) were employed to quantify sediment sources. Results from this demonstration catchment are discussed in the context of the wider sediment pressures on the Hydro-Electric Power infrastructure of the Gilgel Gibe system.