Environmental Impact of a Hydropower Dam in Fincha'a Watershed, Ethiopia: Land Use Changes, Erosion Problems, and Soil and Water Conservation Adoption

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In Ethiopia, the construction of dams has caused social, environmental, and economic problems by increasing the relocation of communities against their will and inducing watershed land degradation. The failure to recognise people as partners in the planning and implementation processes is a major characteristic of watershed-based development projects. Soil erosion is a serious problem in the Ethiopian highland areas, threatening the agricultural sector and causing increased sedimentation of reservoirs and lakes. Unfortunately, there is very little reliable information on the spatial dynamics of the land use types, the factors driving the changes, and the implications of these changes in watersheds where a reservoir has been created. Such information is, however, very important for planning watershed-based development projects such as soil and water conservation (SWC). Studies have shown that despite some achievements, SWC programmes in Ethiopia have not triggered the voluntary adoption of conservation practices outside the project areas.

Fincha'a watershed is a representative watershed for the western highlands of Ethiopia, with a mixed crop and livestock agricultural system. Fincha'a is a special watershed because of a hydropower dam and reservoir that was constructed in 1973. This reservoir has caused several effects on the local community, giving rise to a different situation than in other watersheds in western Ethiopia. The watershed covers 1,318 km^2, while the hydropower reservoir covers approximately one-third of the watershed area.

Elevation in the watershed ranges from 2,200 m to 3,100 m. Most of the area (80%) can be described as an extensive rolling plateau, ranging in altitude between 2,200 m and 2,400 m. About 51% of the watershed is flat (0% to 3% slope) and mainly under the reservoir and swamp. The gently sloping (3% to 8% slope) to sloping (8% to 15% slope) areas cover about 34% of the watershed. Steep (15% to 30%) to very steep (> 30%) slopes account for about 15% of the watershed area. The dominant soils in the watershed have a texture of clay-loam, clay, or loam. The long-term average annual rainfall is 1,823 mm. About 80% of the annual rain falls between May to September. The monthly mean temperature varies from 14.9°C to 17.5°C. The average annual reference evapo-transpiration (based on Penman–Monteith) is 1,320 mm, with small monthly variations.

Fincha'a watershed was selected for a four-year research project to study the impact of the hydropower reservoir on the environment and the people living in the watershed. Options for improvements were also explored. In the presentation, the following research objectives are addressed:
1) Analysis of the impact of the dam on land use and soil erosion in Fincha'a watershed;

2) Determination of the factors affecting the adoption of SWC.

Sets of aerial photos from 1957 and 1980, and an ASTER satellite image from 2001 were used to make three land-use maps of the watershed by means of GIS. Before the dam was built there was no water body in this watershed. Interpretations of the 1980 aerial photos, however, revealed a water body, of 151 km^2, which had increased to 239.3 km^2 by 2001. The lake has inundated a total of 100 km^2 of grazing land, 120 km^2 of swamp, 18 km^2 of cropland and 1.2 km^2 of forest. Cropland has been expanded to steep and fragile parts of the watershed and now occupies 77% of the land potentially available for community use, indicating that there is hardly any possibility for further expansion to accommodate new families. The expansion of the cropland area that has occurred in Fincha'a watershed is much greater than the changes found in the many studies conducted elsewhere in Ethiopia. The enormous expansion of cropland, especially on the steeper parts of the watershed has made the land more vulnerable to soil erosion. Erosion features are visible throughout the watershed area, and also thick layers of sediment have been deposited along the boundary of the lake. Hence, the land-use changes that occurred in the watershed following the construction of the hydropower reservoir could affect the livelihoods of the community and will affect the ability of the dam to deliver the planned economic benefits.

To better understand the erosion and sedimentation dynamics in the watershed, the Morgan, Morgan and Finney (MMF) model was used to predict the spatial soil erosion and sedimentation rates and the subsequent on-site and off-site effects. Erosion data collected from crop fields was used to calibrate and validate the model. This resulted in a coefficient of efficiency of 0.86 for calibration, and 0.79 for validation. After being calibrated and validated, the model was run for two sub-watersheds (Hadocha and Qoricha) using land-use data from 1957, 1980, and 2001. It was found that soil erosion rates have increased to the extent that erosion could potentially undermine crop production in both sub-watersheds. Sediment delivery ratios have increased by 120% in Hadocha and 140% in Qoricha. The major drivers of the erosion and sedimentation problems are the land-use changes that have been induced by Fincha'a dam, coupled with population growth. On most steep parts of the sub-watersheds as well as in Fincha'a watershed, the soil has become shallow, which means that any further soil loss might lead to reduced soil productivity, threaten farmers' food security, and increase offsite reservoir sedimentation. The removal of vegetation cover on steep slopes will have reduced rainfall infiltration and probably also groundwater recharge. Some of the major consequences of soil degradation in Fincha'a watershed are crop failure (due to reduced moisture storage capacities of the soil), inundation from overflowing rivers and streams, and the drying up of most perennial springs. Despite these problems, SWC measures have not been applied to the entire watershed. Neither are any meaningful policies in place to prevent the unwise use of land resources in the watershed.

Knowledge of soil erosion processes, attitudes towards rational use of resources and institutional support affect the capability of farmers to implement SWC measures. A study was conducted to determine the factors that affect adoption of SWC measures in Fincha'a watershed. A total of 50 farmers were interviewed using a semi-structured questionnaire, and two group discussions were held with 20 farmers. Moreover, transects were walked to classify erosion features, and a quantitative erosion survey was made on 19 farm plots during the rainy season of 2004. The results showed that crop fields are affected by annual soil losses ranging from 24 to 160 t ha^{-1}. Farmers are well aware of these erosion problems, and related the soil loss to steep slopes and a decline in soil fertility. However, they do not invest much in SWC measures, but rather apply soil management practices to sustain crop yields. The major factors affecting SWC adoption are the wealth status of farmers, land tenure arrangements, and degree of access the farmers have to information. The high labour demand of SWC measures, and a lack of short-term benefits and free grazing has negatively affected SWC adoption. Relatively poor farmers show more interest in adoption of SWC measures because they generally lack the means to sustain soil fertility on their fields. They however are also reluctant to invest in SWC because of a lack of confidence in the positive effects of SWC on crop yields.

Soil erosion problems in Fincha'a watershed have both on-site and off-site effects that require integrated SWC adoption at watershed scale. For effective implementation of soil conservation and sediment control measures, it is necessary to have sound knowledge of the spatial variability in soil erosion and sediment production within the watershed. Such information, however, should be complemented by other socio-economic information derived from analysing the agricultural problems of the community at watershed-scale. During this analysis, emphasis needs to be given to land tenure, wealth status, gender, age, education, and institutional supports. To avoid further watershed degradation and reservoir siltation problems, a watershed-based SWC programme is required in which incentives are used to stimulate SWC adoption by farmers. Part of the money needed for the programme could come from the revenues of the hydropower scheme, as the power company will benefit from the programme as well.

An important lesson can be learned from the Fincha'a case study. The construction of new dams should proceed only after satisfactory recognition and compensation of the affected population and completion of environmental protection measures. In the process of forging a partnership between the government, civil society, and community in order to use water resources, the prerequisite should be to bring all stakeholders to a common platform. This multi-stakeholder platform can address the social, environmental, and economic problems of new dams, and seek solutions that are acceptable to all stakeholders. In order to reduce funding problems, the concept of payment for ecological services generated by specific land uses within watersheds should be introduced as a key element of watershed intervention.