Land Management and Soil conservation Options for Sustainable Agricultural Production in a Middle Mountain Watershed of Central Nepal

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Abstract: Over the past few decades there have been increasing changes in cropping systems, resource use, and socio-economic conditions due to increasing population growth, technological innovation, and the development of infrastructure in the Middle Mountains of Nepal. A better understanding of these changes is essential for the development of sustainable agriculture production in the region. Therefore, a study was conducted in Pokhare Khola, a Middle Mountain (Mid-hills) watershed (Nepal), in order to determine soil and nutrient losses from different land management practices, and to develop a soil quality index based on measured soil properties. The empirical soil data were collected through soil sampling in different land managements, as well as on-farm runoff plots with four replications of each of three treatments, namely: Traditional Farmer practice (FP) (*Zea mays-Eleusine coracana*), Reduced tillage (RT) (*Zea mays–Vigna ungeuculata*), and Commercial vegetable with a double dose of compost (CV) (*Zea mays - Capsicum species*). Additionally, runoff plots on two forest treatments in community managed and unmanaged forest plots were established. Furthermore, the study also assessed factors affecting the adoption of improved soil conservation practices and sustainable upland farming through a holistic approach combining in-depth socio-economic data collected through household surveys (178 HH), group discussions, workshops, and field observation.

Soil quality assessment indicated that rain-fed terraces (*Bari*) were found to have the highest soil quality index (SQI), followed by forest and irrigated paddy lands (*Khet*). Among the cropping patterns (CPs), maize-millet had a higher SQI than intensive vegetable-vegetable, indicating that commercial vegetable production degraded the soil quality. Of the soil properties studied, soil organic carbon (SOC) had the highest weight in determining soil quality.

Results indicated that more than 60% of the soil loss occurred from the *Bari* land in the first and second major rainstorm events during the pre-monsoon period-most likely due to minimal ground cover and freshly tilled conditions. The result from different land uses revealed that the soil loss from agriculture land (1.3 Mg $ha^{-1}Yr^{-1}$) was significantly higher than forest land (0.3 Mg $ha^{-1}Yr^{-1}$ $p<0.05$), but soil losses were minimal in both land uses. Ground cover and cultivation activities appeared to be the most important factors affecting soil erosion processes.

Soil organic carbon (SOC) and nutrients losses (NPK) from the soil erosion were minimal [25.5 kg ha^{-1} yr^{-1} SOC and 5.6, 0.02, 0.12 kg ha^{-1} yr^{-1} Nitrogen (N) Phosphorus (P) Potassium (K) respectively] and no significant differences among the treatments were found. Nutrient depletion from crop harvest was found to be significantly higher than nutrient loss through soil erosion. CV treatment showed significantly higher N uptake (122.6 kg ha^{-1} yr^{-1}) through crop harvest than other treatments. The interventions measured, such as reduced tillage with the incorporation of crop residue, or the application of a double dose of compost/farmyard manure (FYM) in vegetable production, were found to be more effective in maintaining soil fertility and increasing farm income than the traditional maize-millet production system.

Household survey data analysis, obtained through logistic regression model, predicted seven factors influencing the adoption of improved soil conservation technology in the study area, including years of schooling of the head of household, caste of the respondent, land holding size, vegetable farming, family member occupation in off-farm sector, membership in the Conservation and Development Groups and use of credit. The study showed that technology dissemination through multi-sectoral type community-based local groups is a better option in encouraging the adoption of improved soil conservation technology.

Sustainability assessment showed that adoption of commercial vegetable farming improved the socio-economic conditions of the upland farmers, particularly the poor, women, and disadvantaged groups, in terms of their food security, farm income, resource accessibility, employment opportunities, and social status. However, such achievements have been made at a cost of increasing dependency on external inputs, together with greater resource requirements, and with simultaneously declining soil fertility from commercial vegetable production. Additionally, government support services for vegetable promotion and marketing were minimal, and could not contribute significantly to farm profit and the sustainability of vegetable farming. The study suggests that the government needs to elaborate policy and programs to increase awareness about environmental factors and minimizing the use of agrochemicals, while at the same time supporting market mechanisms for vegetable production which ensure that this type of production is competitive in national and international markets, in order to improve the livelihood of the mountain farmers and maintain the sustainability of agriculture production.

Keywords: cropping patterns, erosivity, food security, leaching, nutrient losses, soil erosion, soil quality, sustainability, soil conservation, terracing, and user groups.