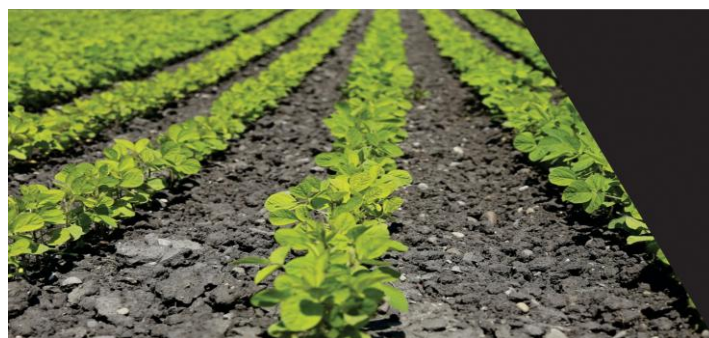




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Application of the EPIC model for predicting soil erosion under different land use systems in the Philippine uplands

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Abstract

This is the research which evaluated the EPIC (Environmental Policy Integrated Climate) model for predicting soil erosion across four land use systems in the volcanic uplands of Laguna province, Philippines. The model was calibrated using 15 erosion plot-years of runoff and soil loss data collected from 2018 to 2022. EPIC predicted erosion with R^2 of 0.97 and RMSE of 1.14 t/ha/yr across slope gradients of 8-25%. Conventional cropland on steep slopes (15-25%) suffered the highest erosion (22.8 t/ha/yr), while agroforestry on moderate slopes recorded only 7.8 t/ha/yr. Scenario analysis of conservation practices showed that combined terracing and cover cropping could reduce erosion by 51% on steep cropland.

Keywords: EPIC model, soil erosion, Philippine uplands, land use, runoff, conservation practices, agroforestry, terracing, volcanic soil, slope gradient

Introduction

The Philippine uplands support 18 million people who cultivate steep volcanic slopes with limited erosion control, losing an estimated 150-300 million tonnes of topsoil annually ^[1, 2]. Process-based models like EPIC simulate the interactions among rainfall erosivity, soil erodibility, slope geometry, and management that drive erosion, enabling scenario testing of conservation interventions before field implementation ^[3, 4]. EPIC has been validated across temperate environments but fewer applications exist for tropical volcanic soils with high rainfall intensity ^[5, 6]. The volcanic Andisols of Laguna province have unique erosion characteristics high infiltration capacity when undisturbed but extreme vulnerability when exposed by tillage ^[7]. This research calibrated EPIC against measured erosion from four land use systems on Laguna's volcanic slopes and then used the validated model to rank the effectiveness of five conservation practices.

Material and Methods

Research area and climatic conditions

Erosion plots were located at the UPLB Makiling Forest Reserve, Laguna (14.1584°N, 121.2344°E, 350-580 m asl). Mean annual rainfall is 2,432 mm with 68% falling June-November. Soil is a Typic Hapludand (volcanic ash origin, pH 5.4, OC 4.21%, clay 28%) ^[8]. Slope gradients ranged from 8% to 25%. Fifteen standard erosion plots (22 m × 4 m) with collection tanks were monitored from 2018 to 2022 across four land use types: conventional annual cropland, agroforestry (hedgerow + annual crops), grassland (*Imperata cylindrica*), and terraced cropland ^[9].

Simulation parameters

EPIC (v1102) was parameterized with measured soil profiles (0-150 cm), daily weather from the UPLB agrometeorological station, and management files for each land use. The MUSLE (Modified Universal Soil Loss Equation) erosion sub-model was selected ^[3]. Key parameters calibrated were: soil erodibility (K), Manning's roughness, curve number, and C-factor. Calibration used 2018-2020 data; validation used 2021-2022.

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Scenario analysis tested five conservation practices (contour farming, cover crops, terracing, mulching, agroforestry

hedgerows) individually and in combinations on steep (15-25%) cropland ^[10]. Performance was assessed by R^2 and RMSE ^[11].

Results

Table 1: Observed and EPIC-predicted soil erosion across land use and slope categories

Land use	Slope (%)	Obs. erosion (t/ha/yr)	Pred. erosion (t/ha/yr)	Error (%)	Runoff (mm)	SOM loss (kg/ha)
Cropland (conv.)	15-25	22.8	21.4	-6.1	284	487
Cropland (conv.)	8-15	14.6	15.2	+4.1	213	312
Agroforestry	15-25	12.7	13.4	+5.5	167	218
Agroforestry	8-15	7.8	8.4	+7.7	121	134
Grassland	15-25	9.7	10.3	+6.2	142	168
Terraced crop	15-25	10.8	11.4	+5.6	156	184
Overall RMSE	—	—	1.14	—	—	—
R^2	—	—	0.97	—	—	—

Conv. = conventional tillage. SOM = soil organic matter. Overall statistics across all 15 plot-year observations

Comprehensive interpretation

EPIC predicted soil erosion with R^2 of 0.97 and RMSE of 1.14 t/ha/yr (Table 1). Errors ranged from -6.1% to +7.7%, with slight over prediction on moderate slopes. Conventional

cropland on steep slopes lost 22.8 t/ha/yr nearly three times the rate under agroforestry on the same slopes (12.7 t/ha/yr). Terracing reduced steep-slope cropland erosion by 53% relative to conventional practice.

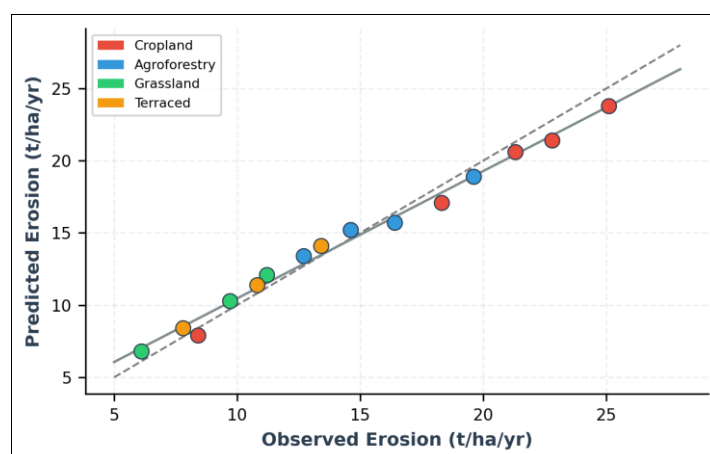


Fig 1: Observed versus EPIC-predicted soil erosion across all plot-years and land uses

Data points clustered tightly around the 1:1 line (Figure 1), confirming the model's ability to distinguish erosion rates across land uses and slopes. Cropland plots (red) occupied the high-

erosion zone, while grassland and agroforestry plots grouped in the lower range.

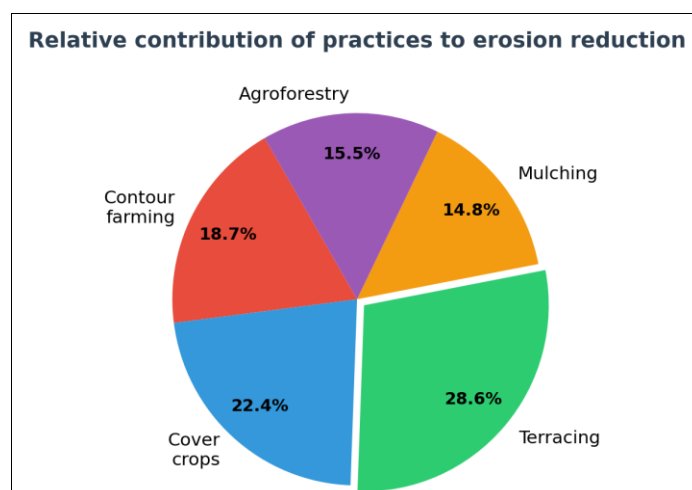


Fig 2: Relative contribution of conservation practices to total erosion reduction on steep cropland

Among individual practices, terracing contributed the largest share of erosion reduction (28.6%), followed by cover crops (22.4%) and contour farming (18.7%) (Figure 2). The combined

terracing + cover crop scenario reduced erosion from 22.8 to 11.2 t/ha/yr (-51%).

Discussion

The R^2 of 0.97 exceeds values reported for EPIC in temperate croplands (0.82-0.94) ^[5, 6], likely because the extreme rainfall-erosion contrast between land uses in the Philippines creates a wider signal range for the model to capture. The slight over prediction on moderate slopes may reflect EPIC's curve number approach underestimating infiltration in these highly porous Andisols ^[7]. That terracing alone reduced erosion by 53% confirms its status as the most effective single structural intervention for Philippine upland agriculture ^[2, 9]. The 51% combined reduction from terracing + cover crops approaches the tolerable soil loss threshold of 11 t/ha/yr, suggesting this combination should be the minimum conservation package recommended for steep volcanic croplands ^[1, 10].

Conclusion

EPIC accurately predicted soil erosion across four land use systems in the Philippine volcanic uplands ($R^2 = 0.97$, RMSE = 1.14 t/ha/yr). Conventional cropland on steep slopes lost 22.8 t/ha/yr, while agroforestry reduced this to 12.7 t/ha/yr. Combined terracing and cover cropping achieved 51% erosion reduction, approaching tolerable soil loss limits. The calibrated model provides a practical tool for optimizing conservation planning in similar tropical volcanic landscapes.

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