Alternative land use options for Philippine grasslands: a bioeconomic modeling approach using the WaNuLCAS model

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Introduction In the Philippines, pure grasslands occupy 1.8 million ha and another 10.8 million ha (33% of the country's total land area) is under extensive cultivation mixed with grasslands and scrub. Most of these grasslands are under-utilised and dominated by *Imperata cylindrica*. *Imperata* grasslands generally represent areas of degraded soils that are acidic, low in organic matter and susceptible to erosion. However, conversion of these grassland areas into upland farms planted to annual crops and perennial trees is proliferating at a fast rate. This is triggered by the interacting factors of rapidly increasing population, the system of landholding, scarcity of jobs and the declining arable area in the lowlands.

Materials and methods The biophysical and economic consequences of land-use change from *Imperata* grasslands to continuous maize and agroforestry (*Eucalyptus deglupta* + maize hedgerow) systems were assessed using bioeconomic modeling. The Water, Nutrient and Light Capture in Agroforestry Systems (WaNuLCAS) model (van Noordwijk, Lusiana & Khasanah, 2004) was used to examine tree and crop growth and productivity, soil fertility changes, soil erosion and water balance. The different land-uses were modeled in the sloping upland areas of Southern Philippines characterised by rugged topography, clayey soils and annual rainfall of about 2500 mm.

Results Simulation showed that the dynamics of nutrients (N and P) in the systems differ. More than half of the total nitrogen in the three systems is tied up in the soil organic matter (SOM). Leaching and lateral flow are the main avenues of nitrogen losses in the three systems. Much of the P (90%) is tied up in SOM and immobilised in the *Imperata* grasslands.

Results of modeling the water balance of the three systems showed that *Eucalyptus*-maize hedgerow system had the highest subsurface flow and surface run-off (Table 1) compared with the other two systems. Maize cropping and *Imperata* grassland had significantly more drainage compared with the agroforestry system.

Simulation results also showed significant competition for light between trees and crops under the *Eucalyptus*-maize hedgerow system. Maize yield was initially higher in the continuous annual cropping system (2.4 t/ha) than under the *Eucalyptus*-maize hedgerow system (1.8 t/ha).

The benefits obtained from the maize cropping system is the grain yield, from the *Eucalyptus*-maize hedgerow system the benefits are maize grain yield and *Eucalyptus* timber, while biomass from the *Imperata* grassland is the harvested and sold as roofing material. Cost benefit analysis showed that the *Eucalyptus*-maize hedgerow system had the highest NPV after 9 years of simulation (P 304,323), compared with the *Imperata* grassland (P 10,722) and continuous maize (P 20,872).

Table 2 Water balance (li /m^2) in the three land use systems

Component	Agroforestry	Continuous crop	*Imperata* grassland
Surface	18,311	18,284	18,243
Subsurface flow	214,206	204,186	205,121
Drainage	4,151	153,844	156,255
Soil	274	9,555	7,331
Canopy	1,962	342	342
Crop	4,753	21,514	21,514
Tree	9,237		
Total	249,150	407,720	408,800

Conclusion This study has shown that land-use change from *Imperata* grasslands or continuous maize cropping system to *Eucalyptus*-maize hedgerow systems provide significant improvements to a range of biophysical and economic measures of productivity and sustainability.

Reference

Van Noordwijk, M., B. Lusiana & N. Khasanah (2004). WaNuLCAS version 3.1, Background on a model of water nutrient and light capture in agroforestry systems. International Centre for Research in Agroforestry (ICRAF), Bogor, Indonesia.