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The impact of tropical industrial tree plantations on site nutrient status, site productivity and economic profitability

Introduction

The establishment of industrial plantations in the tropics in increasing. International efforts to credit plantation for carbon sequestration will further enhance this development. As the rate of carbon sequestration equals the stand productivity the main question is on how sustainable industrial plantation management can be-for both timber production and carbon sequestration? Industrial tree plantations are known for their nutrient mining impact. Nutrient loss is unavoidable but depends on the management intensity. For the generally weathered tropical soils already a modest soil nutrient loss can result in nutrient deficiency, which in turn has an impact on the stand productivity. The main objective of the research conducted was to assess management dependent nutrient losses and the economic impact of the required nutrient compensation, which is to be considered for economical carbon sequestration schemes.

Site and approach

In this assessment, we draw partly on global or regional data, partly on own data from the PT.IHM plantation concession in Garoua, Northern Cameroon. Ali- and Acrisols are found on 80% of the site exhibiting low pH (pH (H2O): 4.5-4.8), high aluminum saturation (56-91%), an effective cation exchange capacity (ECEC) of 18-26 cmol + kg-1 clay and a clay content of 20-42%. Eucalyptus deglupta and Acacia mangium are the dominant species. Investment calculation is based on mean annual increment (MAI) of 25m3 ha-1 for both species during a rotation length of 8 years resulting in an expected harvest volume of 200m3 ha-1. By deriving relative values for nutrient losses due to stem harvest, leaching, erosion and slash burning and applying them to relevant site-specific parameters such as soil parameters, species, and management intensities, we derived the best estimate available for assessment of off-site losses under industrial plantation management. Nutrient input through precipitation and weathering was considered. The approach is considered a first approximation but no substitution for detailed and long-term site-specific nutrient losses. In awareness of the methodological uncertainties we applied a conservative estimate for management-dependent nutrient losses.

Results

Average management induced nutrient losses within one rotation ranged from 10 to 50% of plant available soil nutrients. The calculated nutrient losses for the assumed harvest volume and according to management intensity and soil fertility ranger between 14-63% for N, 3-17% for P, 14-53% for K, 5-52%for Ca 3-33% for Mg. Under high and medium-impact management scenarios nutrient losses due to leaching, burning and erosion were comparable or even higher than nutrient export caused by stern harvest. Slash burning contributed most to nutrient losses. Erosion caused significant losses of Ca, Mg and P. Ca-losses are especially high for Acacia stands, whereas K- and Mg-losses were higher in Eucalypt stands. Nutrient depletion will first occur on nutrient poor sites such as Ferral- and Aeronosols or shallow Ali- and Acrisols at the study site, but is also expected to occur after 2-5 rotations on average plantation sites.

Compensation for these nutrient losses is essential to avoid distinctive depletion of soil nutrient storage. Without fertilizer application intensively managed tree plantations generally have a negative nutrient are lost from the system than gained. Fertilizer compensation for nutrient losses incurred due to tree harvest increased standard plantation establishment cost by 18 to33%. As a consequence, the internal rate of return dropped from 14% to 9-12%. Fertilization costs are species specific. Considering the fertilization costs, which can

potentially make up for any carbon credit gain, strategies to reduce management-dependent nutrient losses are unavoidable. A low-impact management including alternatives to slash burning, soil-conserving harvesting techniques, and appropriate site selection are recommended.

Discussion

Plantations establishes on poor soils in the humid tropics incur significant nutrient losses due to harvesting and site management. Even though these losses can be reduced by low-impact management, they are still high compared to plant available soil nutrient stocks, accumulated losses under intensive short-rotation management will result in severe soil nutrient depletion and subsequently decrease stand productivity and carbon sequestration rates, if not compensated for. Compensation of nutrient losses will raise plantation establishment costs significantly, especially on marginal sites. Our result point to the need for developing better nutrient management in industrial plantations. Nutrient losses and thus fertilization costs can be reduced by appropriate site management. The abandonment of slash burning is the single most important factor for potential nutrient savings. Between 10 to50% of total nutrient losses could be avoided if alternatives to slash burning were adopted. Additional leaching and erosion losses triggered by slash burning will also be reduced.