



# Reversing land degradation through grasses: a systematic meta-analysis in the Indian tropics

Debashis Mandal<sup>1</sup>, Pankaj Srivastava<sup>1</sup>, Nishita Giri<sup>1</sup>, Rajesh Kaushal<sup>1</sup>, Artemi Cerda<sup>2</sup>, and Nurnabi Meherul Alam<sup>1</sup>

<sup>1</sup>ICAR-Indian Institute of Soil and Water Conservation 218, Kaulagarh Road, Dehradun-248195, Uttarakhand, India

<sup>2</sup>Department of Geography, University of Valencia, Blasco Ibañez, Valencia, Spain

Correspondence to: Debashis Mandal (dmandalcswerti@gmail.com) and Pankaj Srivastava (pksnbri@gmail.com)

Received: 14 October 2016 – Discussion started: 21 October 2016

Revised: 13 January 2017 – Accepted: 20 January 2017 – Published: 22 February 2017

**Abstract.** Although intensive agriculture is necessary to sustain the world's growing population, accelerated soil erosion contributes to a decrease in the environmental health of ecosystems at local, regional and global scales. Reversing the process of land degradation using vegetative measures is of utmost importance in such ecosystems. The present study critically analyzes the effect of grasses in reversing the process of land degradation using a systematic review. The collected information was segregated under three different land use and land management situations. Meta-analysis was applied to test the hypothesis that the use of grasses reduces runoff and soil erosion. The effect of grasses was deduced for grass strip and in combination with physical structures. Similarly, the effects of grasses were analyzed in degraded pasture lands. The overall result of the meta-analysis showed that infiltration capacity increased approximately 2-fold after planting grasses across the slopes in agricultural fields. Grazing land management through a cut-and-carry system increased conservation efficiencies by 42 and 63 % with respect to reduction in runoff and erosion, respectively. Considering the comprehensive performance index (CPI), it has been observed that hybrid Napier (*Pennisetum purpureum*) and sambuta (*Saccharum munja*) grass seem to possess the most desirable attributes as an effective grass barrier for the western Himalayas and Eastern Ghats, while natural grass (*Dichanthium annulatum*) and broom grass (*Thysanolaena maxima*) are found to be most promising grass species for the Konkan region of the Western Ghats and the northeastern Himalayan region, respectively. In addition to these benefits, it was also observed that soil carbon loss can be reduced by 83 % with the use of grasses. Overall, efficacy for erosion control of various grasses was more than 60 %; hence, their

selection should be based on the production potential of these grasses under given edaphic and agro-ecological conditions. The present analysis also indicated that grass must be used as a vegetative strip to maintain soil quality in sloppy arable areas (8.5 Mha) of Indian hilly regions. Similarly, due attention should be paid for establishing grasses in 3 Mha of degraded pasture lands and 3.5 Mha of shifting cultivation areas in India to reverse the land degradation.

## 1 Introduction

Water erosion is the main cause of land degradation, affecting an area of about 2 billion ha throughout the world, with the largest part in tropics, and affecting the two most important natural resources, namely soil and water (Mandal and Sharda, 2011a; De Oliveria et al., 2010; Keesstra et al., 2014; Novara et al., 2011, 2016; Seutloali and Beckedahl, 2015). Worldwide loss of water and sediment due to soil erosion is a major environmental threat (Prosdocimi et al., 2016; Pimentel, 1993). Soil erosion is accelerated due to high rainfall intensities (Keesstra et al., 2016), steep slopes (Beskow et al., 2009) and the fragile nature of topsoil (Lal, 1998; Rodrigo Comino et al., 2016; Ochoa et al., 2016). Many parts of the tropics in India have high annual rainfall confined to only 4 to 5 months (June–September). During the 7–8-month dry period, scarcity of water causes a severe shortage of fodder in farmlands, which leads to an increase in grazing pressure on forest and community lands. Nearly a third of the fodder requirement in India is met through forest resources in the form of grazing and cut fodder (MoEF, 1999). The process of land degradation in croplands and grasslands has been ac-