



# Land use sustainability on the South-Eastern Amazon agricultural frontier: Recent progress and the challenges ahead



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## ABSTRACT

The recent decoupling of deforestation and soybean production has raised optimistic expectations towards enhanced land use sustainability in the South-Eastern Amazon agricultural frontier. Nonetheless, assessing land use sustainability implies not only the consideration of how agricultural activities affect natural ecosystems but also how they impact on society and how society can cope with them. We review some of the forthcoming challenges that the agricultural sector should address to confirm its significant progress towards land use sustainability. Firstly, we assess the recent efforts to adopt environmentally friendly practices with regard to the ongoing intensification process mainly based on double cropping systems. Secondly, while rapid agricultural development has brought major social advances, we evidence a recent trend towards a decoupling of soy production and the Human Development Index at municipality level. We then put this result into perspective considering that the trend towards agricultural intensification based on the use of large amounts of agrochemicals could lead to major health concerns which are still too rarely considered. Finally, we discuss how the recent efficient policies to contain deforestation in the Amazon can cause indirect land use changes in the Brazilian Cerrados and in African Savannas, thus potentially leading to an “illusion of preservation” at global scale. We conclude that new indicators involving social sciences are necessary to better address the complexity of land use sustainability on the still very dynamic agricultural frontier in the South-Eastern Amazon.

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## 1. Introduction

The rapid expansion of cultivated areas in the South-Eastern Amazon has long been pointed out as a major threat to the environment (Dubreuil, 2002; Fearnside, 2001; Morton et al., 2006). This is especially true in the state of Mato Grosso where the area covered by soybean crops grew from 1.5 to 8.9 million hectares from 1990 to 2015 (IBGE, 2016) while 139,917 km<sup>2</sup> of forests were cleared between 1988 and 2015, i.e. 33.8% of total deforestation in the Legal Amazon (INPE, 2016). Nonetheless, the last decade has been marked by a decoupling of deforestation and soybean production (Macedo et al., 2012), since deforestation rates in Mato Grosso experienced a 90% decrease between 2004 and 2014 (from 11,814 to 1075 km<sup>2</sup>/year; INPE, 2016) whereas crop production continued to increase thanks to the adoption of intensive agricultural practices (from 14.5 to 26.5 million tons of soybean; IBGE, 2016).

Whereas a few studies suggest that this recent slowdown in deforestation in the South-Eastern Amazon may be partially due to the scarcity of available land suitable for agricultural development in Mato Grosso (Spera et al., 2014) or to the adaptation of land owners who clear forest in a way that cannot be detected by the remote sensing-based monitoring systems (Richards, Arima, VanWey, Cohn, & Bhattarai, 2016), most authors emphasize the importance of the implementation of effective environmental public policies (Arima, Barreto, Araújo, & Soares-Filho, 2014) and market-oriented agreements (Gibbs et al., 2015; Nepstad et al., 2014) involving well-designed public-private instruments (Lambin et al., 2014). Increased considerations for environmental governance to contain deforestation have led to initiatives promoted at i) international level (e.g. “Amazon Fund” with a Norwegian commitment; Nepstad et al., 2009), ii) federal level (e.g. Low Carbon Agriculture Plan (Ministerio da Agricultura, 2012); or the implementation of efficient monitoring and licensing systems (INPE, 2016; SFB, 2016)), iii) state level (e.g. Soy and Beef moratorium; Rudorff et al., 2011; Gibbs et al., 2015) and iv) local level (e.g. Lucas Legal and SorrisoVivo projects; Le Tourneau et al., 2013) to establish an improved environmental-friendly agricultural model.

Such evolution raised optimistic expectations towards enhanced land use sustainability (Galford, Soares-Filho, & Cerri, 2013; Hecht, 2012; Lapola et al., 2013; Martinelli, Naylor, Vitousek, & Moutinho, 2010; Nepstad et al., 2014). Nonetheless, land use sustainability in the Amazon is often approached from an environmental perspective, for example assessing how the adoption of new agricultural practices may contribute to maintain ecosystem services such as climate regulation through the reduction of greenhouse gas emissions (Galford et al., 2013). Yet, at a time when a new integrated governance model with complementary socio-economic and environmental policies is being promoted (Arvor, Daugeard, et al., 2016), other dimensions of sustainability deserve to be considered in order to get a better overview of the level of sustainability on the Amazon agricultural frontier. In this regard, a special attention must be paid to interrelated issues that embody both challenges and opportunities created by the development of frontier regions (Gardner, Godar, & Garrett, 2014). For instance, economic development through agricultural intensification may

both lead to improved living conditions and to the eviction of people from rural areas due to monoculture and land concentration, thus increasing inequality among local communities (Lapola et al., 2013; Tritsch & Le Tourneau, 2016).

Based on this assertion, the objective of this paper is to analyze recent land use changes in the South-Eastern Amazon agricultural frontier in order to raise underexplored questions about the forthcoming challenges that the Brazilian Amazon agricultural sector should address to confirm its recent progress towards land use sustainability.

In order to achieve this objective, we consider that sustainability deals with analyzing society–environment interactions with respect to the possibility of continuing the observed trajectories into the future (Haberl, Fischer-Kowalski, Krausmann, Weisz, & Winiwarter, 2004). In this regard, assessing land use sustainability of society–environment interactions implies not only the consideration of (1) how socio-economic activities affect natural ecosystems, i.e. which driving forces for which environmental impacts, but also (2) how these changes impact on society and (3) how society can cope with them (Haberl et al., 2004). To address these issues, we joined an interdisciplinary research team under the frame of the H2020 ODYSSEA European project (Observatory of the Dynamics of Interactions between Societies and Environment in the Amazon) in order to review papers about recent agricultural dynamics in the South-Eastern Amazon and also cross-reference agricultural, socio-economic and health data.

In the first section, we discuss the recent generalization of new agricultural practices in a context of global climate-change. In the second section, we consider how land use changes related to large scale agricultural activities have enabled social development in Mato Grosso but also raised new concerns about human health. Finally, in the third section, we put into perspective the recent decrease in deforestation, considering its potential implications for other biomes and countries elsewhere.

## 2. New agricultural practices: a sustainable pathway in a context of global change?

### 2.1. New agricultural practices towards sustainable intensification

While crop expansion has long been the main pillar of agricultural growth in the Amazon (Fig. 1), the adoption of new agricultural practices currently represents the main pathway to increase crop production with limited impacts on wildlands. In this regard, the Low Carbon Agriculture Plan (ABC Plan) launched by the Brazilian government in 2010 includes six programs to support the adoption of environmentally friendly practices (R\$10 billion of loans had already been allocated to farmers by February 2015; Ministerio da Agricultura, 2015). Amongst the main technologies promoted, no-tillage practices, nitrogen fixation, integrated crop-livestock-forestry systems and the restoration of degraded pastures are of particular importance.

The wide and rapid generalization of no-tillage practices in Brazil (31.811 million hectares in 2012; FEBRAPDP, 2015), especially in the Cerrado biome, is quite impressive. It consists in leaving the soil profile undisturbed, sowing successive crops in between the

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