

Land-use and environmental pressures from bioenergy crop expansion - A literature review

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Aim:

Increasing bioenergy demand (particularly for biofuels) is affecting land-use globally. About 105 M ha will be required for global biofuel crop production in 2050 (IEA, 2011) and this will result in environmental pressures through agricultural intensification or the conversion of native vegetation. Thus it is crucial to understand the dynamics and consequences of bioenergy-driven land-use changes to better inform future sustainable bioenergy and land-use policies. The aim of this study is to review and analyse the patterns and dynamics of bioenergy-driven land-use change. The review is global in its context, but focuses on four focus countries/regions: Brazil, Indonesia and Malaysia, the USA and the EU.



Method:

46 documents addressing past, current and projected land-use changes associated with bioenergy (hereafter referred to as 'bioenergy driven land-use change') were identified from a database search of academic literature (ISI Web of Science), and grey literature. These were reviewed to identify locations, land-use change pathways, causes and consequences of bioenergy driven land-use change.

Results:

1. In what countries are bioenergy driven land-use changes being discussed?

Brazil, with a 30 year history of bioenergy, had the largest number of bioenergy-driven land-use changes reported in the literature, followed by the USA, Argentina, Indonesia and Malaysia.

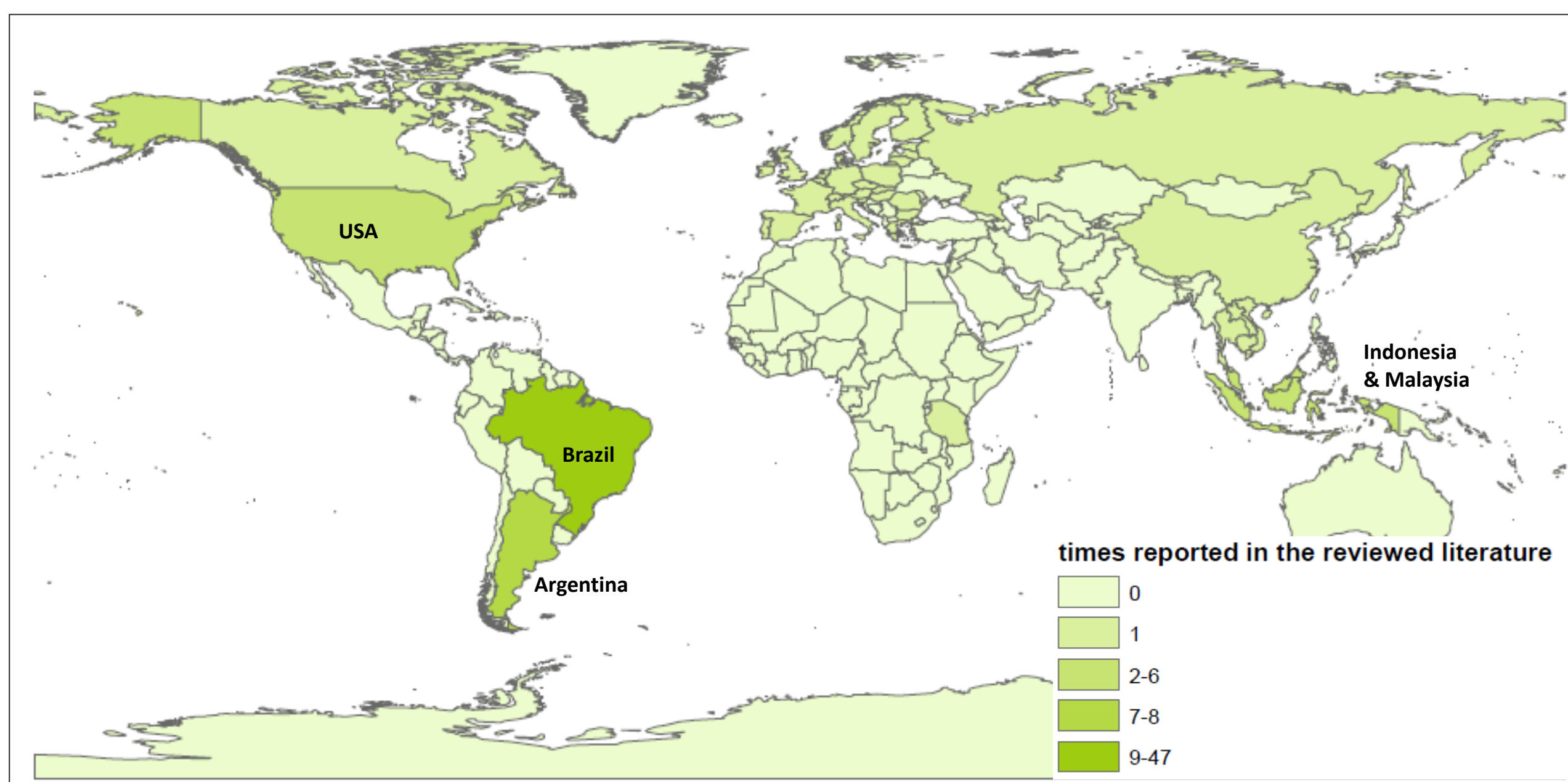


Figure 1: Past and current bioenergy-driven land-use changes

Over the next decades, land-use changes driven by the rapid increase in biofuels demand in the USA and the EU, is predicted to spread into other regions, including India, China, Russia, and Sub-Saharan Africa.

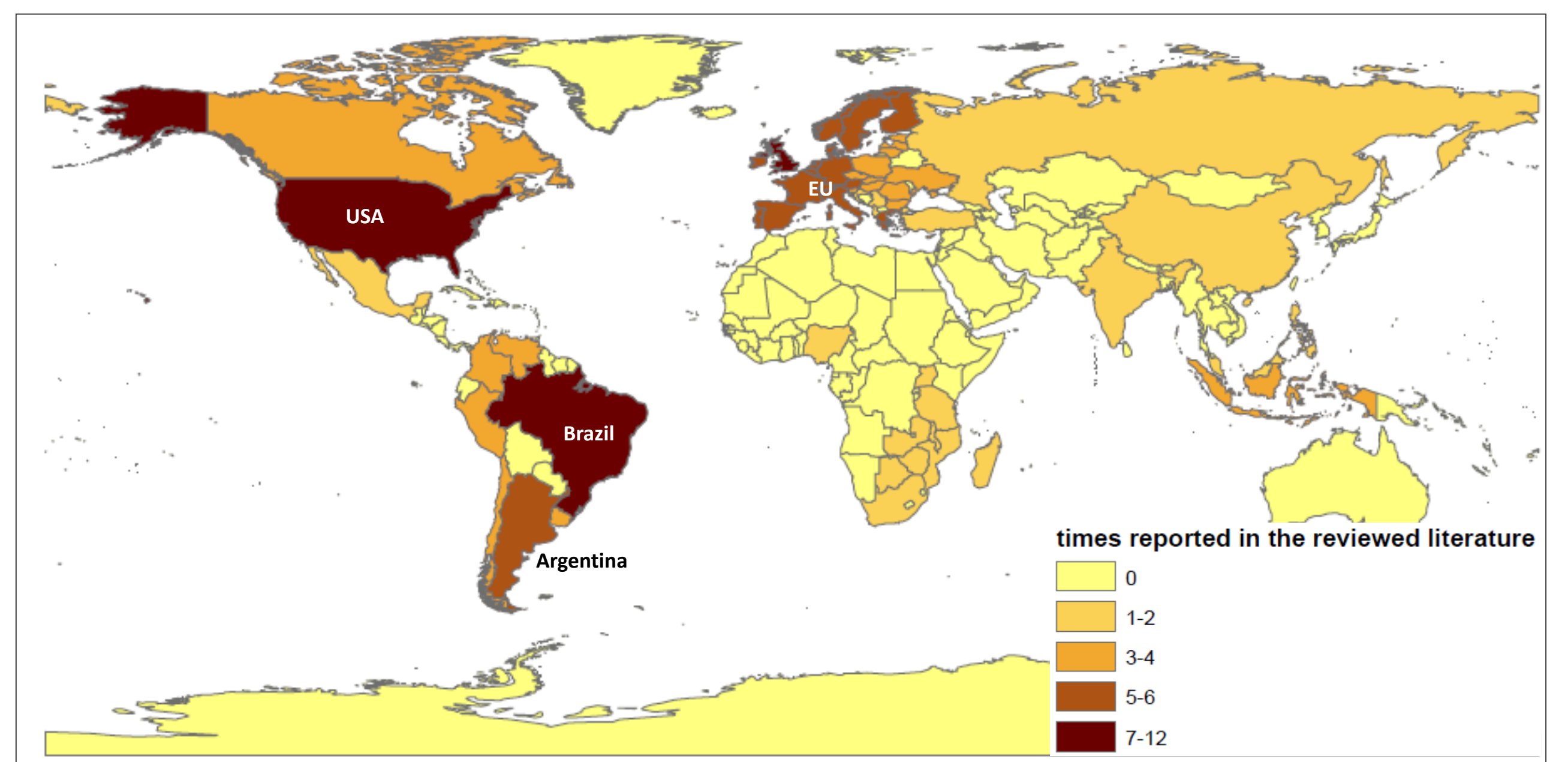


Figure 2: Projected bioenergy-driven land-use change

2. What are the land-use change pathways?

- Pathway 1:** direct conversion of native vegetation (e.g. past/current land-use changes in developing countries)
- Pathway 2:** indirect land-use change through displacement of cattle pasture (e.g. Brazil)
- Pathway 3:** indirect land-use change through displacement of cropland (e.g. USA and EU)
- Pathway 4:** use of underutilised agricultural land (i.e. marginal, degraded or abandoned agricultural land that is not in production, or not suitable for food crop production) (e.g. proposed by many studies for the USA and EU)

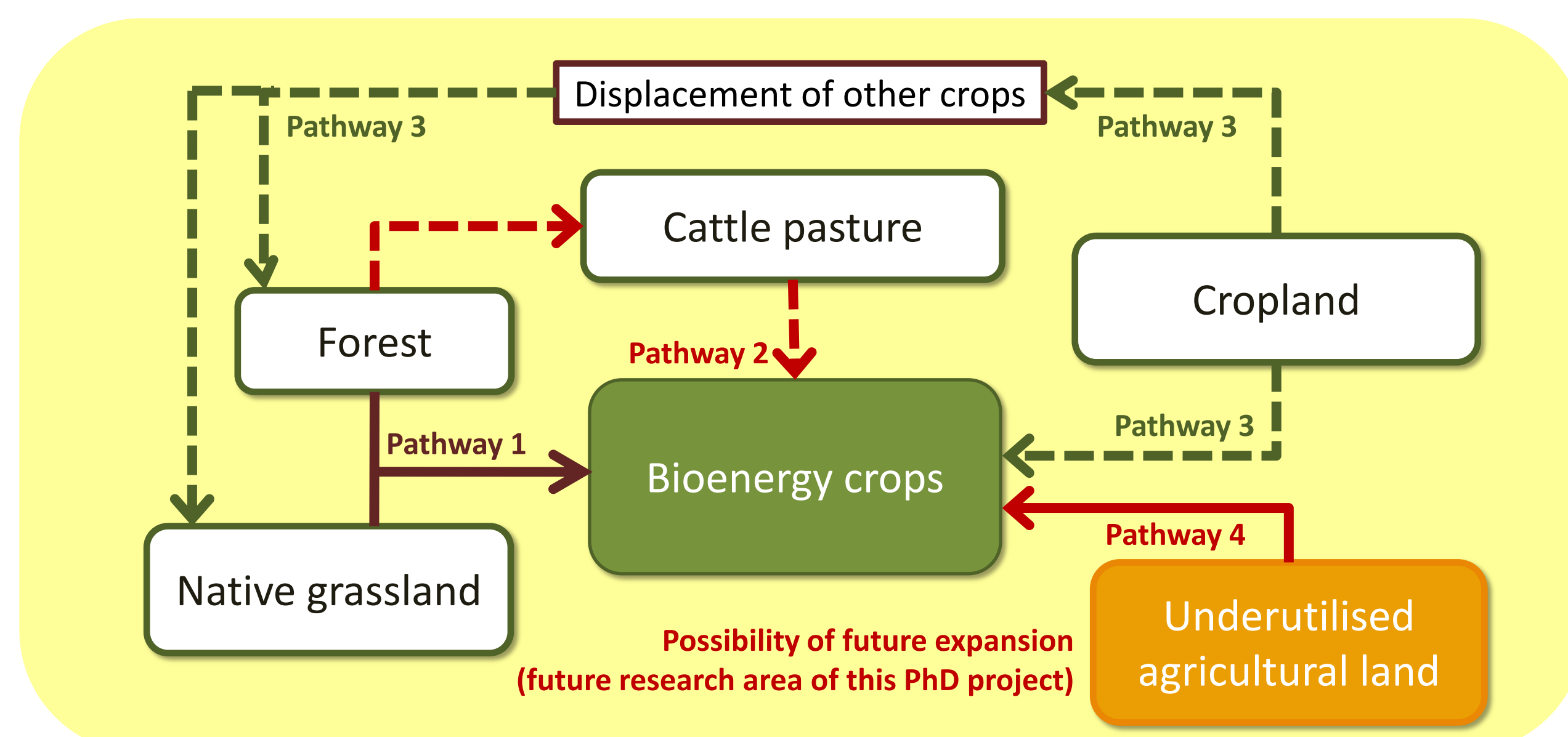


Figure 3: Land-use change pathways for bioenergy crop expansion

3. What are consequences of bioenergy-driven land-use changes?

The level of impact varies according to the land-use change pathway (Fig.3). The conversion of rainforest to oil palm (pathway 1) has greater impact than growing native grasses on abandoned cropland (pathway 4) (e.g. Fargione, 2008). Overall, following possible adverse consequences were identified:



Source) AFP/AFP/Getty Images

- **Environmental:**
 - Climate (global):** release of soil and biomass carbon
 - Climate (regional):** change in temperature, precipitation, wind pattern
 - Air:** air pollution from burning
 - Water:** degraded water quality (N, P and sediment loads)
change in hydrological balance
 - Soil:** soil erosion, soil quality degradation
 - Biodiversity:** loss of native biodiversity through habitat loss and fragmentation
- **Socio-economic:** increased land price, social polarization, land dispute

4. What are opportunities for sustainable land-use option for bioenergy crop production?

- detailed evaluation of consequences of different land-use change pathways
 - ➔ e.g. the use of underutilised agricultural land for future bioenergy crop production (pathway 4)
- introduction of economic mechanisms and institutional improvements through international political action and cooperation
 - ➔ e.g. Reducing Emissions from Deforestation and Forest Degradation (REDD)
- development in sustainability requirements and certification schemes
 - ➔ e.g. certification criteria for biofuels in the EU, international initiatives towards sustainable crop production (e.g. Roundtable on Sustainable Palm Oil (RSPO))
- priority to more sustainable/emerging technologies for the long-term
 - ➔ e.g. bioenergy production from residues and wastes

Conclusions:

- Increased bioenergy demand has directly and indirectly caused the conversion of native vegetation with major consequences in South America and Southeast Asia. These pressures will spread to other regions and impact severely on 'land-abundant' developing countries over the next few decades. Currently, there is limited capacity for implementing sustainable land-use policies and planning system in developing countries due to political and institutional constraints.
- Changes in international commodity markets have been the major driver of these land-use changes in most countries. Stronger emphasis should be placed on economic mechanisms in future land-use policy development and implementation, and a more considered choice of lands for future crop production. Opportunities have been identified in recent international climate change policy, certificate schemes and market pressures for sustainable bioenergy products.
- Next-generation technologies must be given high priority to minimise the land-use impacts of crop production in the long term.

References:

- IEA 2011, *Technology roadmap: Biofuels for transport*. International Energy Agency, Paris.
- Fargione, J, Hill, J, Tilman, D, Polasky, S & Hawthorne, P 2008, 'Land clearing and the biofuel carbon debt', *Science*, vol.319, no. 5867, pp. 1235-8.

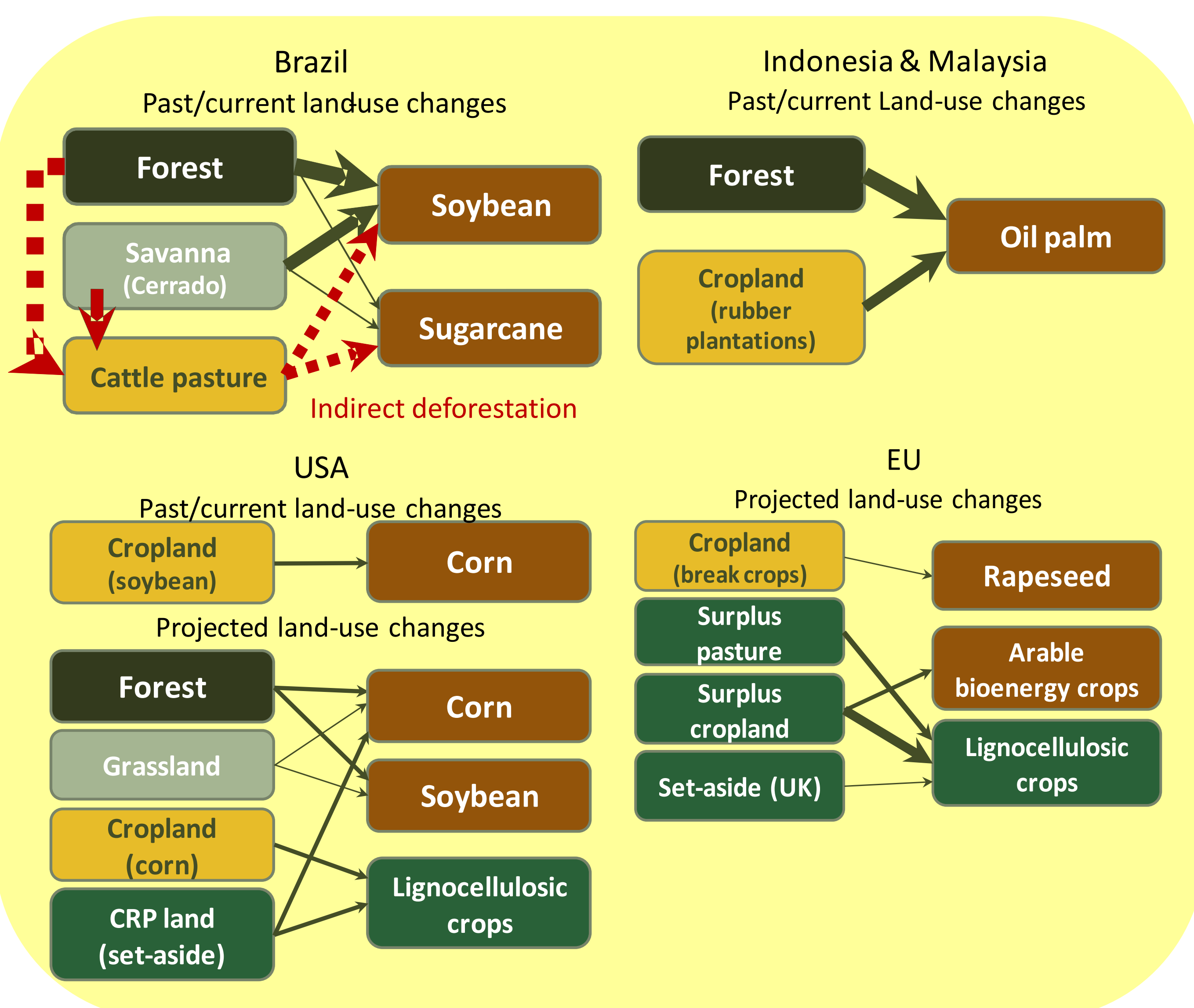


Figure 4: Land-use change pathways described for focus regions/countries