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## The management of tree genetic resources and the livelihoods of rural communities in the tropics: Non-timber forest products, smallholder agroforestry practices and tree commodity crops

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## ABSTRACT

Products and services provided by trees in forests and farmland support the needs and promote the well-being of hundreds of millions of people in the tropics. Value depends on managing both the diversity of tree species present in landscapes and the genetic variation within these species. The benefits from trees and their genetic resources are, however, often not well quantified because trade is frequently outside formal markets, there is a multiplicity of species and ways in which trees are used and managed, and genetic diversity within species is frequently not given proper consideration. We review here what is known about the value of trees to rural communities through considering three production categories: non-timber products harvested from trees in natural and managed forests and woodlands; the various products and services obtained from a wide range of trees planted and/or retained in smallholders' agroforestry systems; and the commercial products harvested from cultivated tree commodity crops. Where possible, we focus on the role of intra-specific genetic variation in providing support to livelihoods, and for each of the three production categories we also consider wider conservation and sustainability issues, including the linkages between categories in terms of management. Challenges to 'conventional wisdom' on tree resource use, value and management – such as in the posited links between commercialisation, cultivation and conservation – are highlighted, and constraints and opportunities to maintain and enhance value are described.

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## 1. Introduction

The elemental role played by trees in the lives of rural people in the tropics appears obvious through the many uses made of tree products, in construction, fencing, furniture, foods, medicines, fibres, fuels and in livestock feed, and in their cultural value. Indeed, in a World Bank report published a few years ago, forests and trees-outside-forests were reported to contribute to the

livelihoods of more than 1.6 billion people worldwide (World Bank, 2008). Just how trees contribute – and the varying level of dependency of different communities on tree products and services and how this changes over time – is, however, often not well described or adequately acknowledged in the compilation of such figures (Byron and Arnold, 1997). Partly, this reflects the ubiquity of tree products and services and the complex inter-connecting pathways by which trees influence livelihoods, which are often hard to delineate (e.g., Turner et al., 2012). It also reflects the different sources – from inside and outside forests – of tree products and services. Since forest and farmland sources are assessed differently

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by government forestry and agriculture departments, a proper synthesis of the overall value of tree products and services across these sources is hard to achieve (de Foresta et al., 2013). Complexities in quantification and a lack of proper appreciation of benefits help explain why the roles (and limitations) of trees in supporting local peoples' livelihoods have frequently been neglected by policy makers, and why rural development interventions concerned with managing trees in forests and farms have sometimes been poorly targeted (Belcher and Schreckenberg, 2007; World Bank, 2008).

From a genetic perspective, the value of intra-specific variation in tree species and the importance of managing this variation to support rural livelihoods have also received relatively little attention from policy makers (Dawson et al., 2009), despite the benefits that rural communities can gain when proper consideration is given (Fisher and Gordon, 2007). Tree genetic resources exist at different levels of domestication of both populations and species, while the landscapes within which they are located are themselves domesticated to a greater or lesser extent (Michon, 2005). A few forest landscapes can be considered completely natural, but generally some degree of human management has taken place (Clement, 1999; Clement and Junqueira, 2010). Indeed, some trees that provide foods valued by humans have been subject to domestication in forest environments for millennia in processes of 'co-domestication' (*sensu* Wiersum, 1997) of the forest and the tree. The level of domestication of the tree itself – from incipiently- to fully-domesticated (i.e., from being only unconsciously managed and selected to being dependent on humans for its continued existence; Harlan, 1975) – and of the landscape in which it is found are both crucial in understanding how rural communities currently benefit from trees, and how to optimise future value through improved management.

This review, which is derived from an analysis supporting the publication of FAO's recent global synthesis on the State of the World's Forest Genetic Resources (the SOW-FGR, as described by Loo et al., 2014, this special issue; FAO, 2014), provides information on what we know about the value of trees to rural communities in the context of both the level of tree domestication that has taken place and the management setting. Our review supports the SOW-FGR by providing an insight into livelihood issues that goes beyond the limited quantitative data available in the Country Reports used to compile the global synthesis (see Appendix A). We restrict our review to the tropics, where devising appropriate interventions to manage trees and tree genetic resources is important to meet international development goals of poverty alleviation and community resilience (FAO, 2010; Garrity, 2004).

We also restrict our consideration to three production categories: non-timber forest product (NTFP) harvesting (from natural, incipiently- and/or semi-domesticated forests and woodlands); agroforestry tree products (AFTPs) and services (provided by a wide range of mostly semi-domesticated local and exotic trees in smallholder-farm landscapes); and woody perennial commodity crops (which are often completely domesticated, exotic in major production centres, and grown in both smallholdings and larger plantations, though our concern here is only with the former). The boundaries between these production categories are not always easy to define, as evidenced, for example, by often subtle transitions in landscapes between forests and agroforests in a gradient of transformation and intensification (Balée, 2013; Michon, 2005; Wiersum, 1997). In fact, one category often depends upon another for supporting sustainability, as, for example, many AFTPs and tree commodity crops were once NTFPs, and often also still are (thus, the continued improvement of AFTP and tree commodity crop production may depend to a greater or lesser degree on accessing genetic resources maintained in natural stands; Hein and Gatzweiler, 2006; Mohan Jain and Priyadarshan, 2009; Simons and Leakey, 2004).

Our three production categories have received considerable attention for their roles in meeting development targets for small-scale harvesters and smallholder farmers in the tropics, both of which groups are the subject of our attention here (Belcher et al., 2005; Garrity, 2004; Millard, 2011). Our categories are, however, not fully exhaustive of the benefits received by tropical rural communities from trees, as we do not, for example, consider the value of commercial forest timber harvesting by local people (e.g., Menton et al., 2009). Nonetheless, the division into our three categories provides a useful way to structure the different benefits of trees to communities, to illustrate the issues faced in describing value and to determine appropriate interventions for improved management. Considering these different categories also demonstrates the importance of taking a wide view in determining where best to intervene for maximum impacts on livelihoods, for example, in minimising unintended consequences due to potentially negative interactions between different production systems (the same attention to interactions is important when promoting appropriate tree conservation interventions among a range of options, see Dawson et al., 2013).

In the following sections, each production category is taken in turn and information outlined in three sub-sections relating to: the benefits of production; the domestication and movement of germplasm; and the conservation issues associated with harvesting, management and/or cultivation to ensure sustainable use and benefits. Where possible, we focus on genetic resource management issues and highlight where 'conventional wisdom' on tree resource use, management and value needs to be challenged in order for pathways to more sustainable, resilient management systems to be developed.

## 2. Non-timber forest product harvesting

### 2.1. Benefits to rural communities

While there are many thousands of references in the literature to the importance of NTFPs, only a small proportion of publications proceed beyond general statements on use to quantify value in meaningful ways that support comparisons across products and sites. Despite this, some overall estimates of value have been attempted. Pimentel et al. (1997), for example, estimated very approximately that 90 billion USD worth of food and other NTFPs were harvested annually from forests and trees in developing countries. FAO's latest (2010) Global Forest Resources Assessment (GFRA) provides more recently estimated (based on 2005 figures) but lower worldwide values of 19 billion and 17 billion USD annually for non-wood forest product- and woodfuel-removals, respectively, but the country data compiled for the GFRA were acknowledged to be far from complete (one problem is that many countries, when they do report value for NTFPs, only do so for the 'top' few species of commercial importance; FAO, 2010). In the 2010 GFRA, in most tropical regions the most important use for non-wood forest products was indicated to be as food.

A good illustration of the discrepancy between current estimates of importance comes from comparing the value for woodfuel reported for Africa (most woodfuel is harvested from naturally-regenerating rather than planted sources in the continent) in the 2010 GFRA (1.4 billion USD annually) with the World Bank's (2011) much higher estimate of the value of the charcoal industry in the sub-Saharan region (eight billion USD annually). Several reasons have been highlighted as to why it is difficult to adequately represent NTFP value, including the multiplicity of products, informal trade and bartering that occurs in unmonitored local markets, direct household provisioning without products entering markets at all, and the fact that wild-harvested resources

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