



# Raising the profile of woodfuels in the forest landscape restoration agenda

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## Abstract

Forest landscape restoration (FLR) is being promoted as a means of tackling global challenges including land degradation, climate change, biodiversity conservation and sustainable development. However, as the FLR agenda gains momentum, it is critical that FLR initiatives pay sufficient attention in promoting the sustainable management of woodfuels, so far overlooked. In many regions, woodfuels (firewood and charcoal) are the main energy source for households and play a pivotal role in local economies; yet they are also associated with environmental degradation and adverse health outcomes. Here we examine the reasons why it is important to raise the profile of woodfuels within the FLR agenda and highlight the enabling conditions needed to promote sustainable management of woodfuels. In landscapes where woodfuel use is prevalent, FLR initiatives should consider enhancing wood fuel supply by growing trees, promoting fuel-efficient cookstoves and kilns, and shifting pressure from natural forests and woodlands to planted trees. We argue that if wood fuel issues are considered in the design, implementation and monitoring of FLR initiatives and are supported by appropriate policies, resources and technical capacity, this will greatly enhance the sustainability and success of FLR initiatives.

## KEYWORDS

bioenergy, Bonn challenge, charcoal, firewood, forest degradation, forest landscape restoration, rural livelihoods

## 1 | INTRODUCTION

Globally, there is significant political and technical interest in implementing forest landscape restoration (FLR) as an approach to restore forest and tree cover in degraded landscapes in order to enhance ecological functionality and improve human-wellbeing (Sabogal, Besacier, & McGuire, 2015). To date, 63 countries and jurisdictions have committed to restoring ~172.8 million ha of

degraded forest land under the Bonn Challenge through FLR initiatives (Dave et al., 2019). In essence, FLR aims to balance environmental and social-economic needs and people's aspirations by integrating different restorative and productive activities within the landscape, from promoting natural forest regrowth to establishing commercial tree plantations and agroforestry systems, to conserving native forests—all guided by participatory approaches, involvement of multiple stakeholders and adaptive

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management (Stanturf, Mansourian, & Kleine, 2017). As countries plan to meet their Bonn Challenge commitments, there is a rapidly growing literature on how to design and implement FLR initiatives (e.g., Chazdon, Gutierrez, Brancalion, Laestadius, & Guariguata, 2020; ITTO, 2020; IUCN & WRI, 2014; Stanturf et al., 2019).

However, one issue that seems overlooked is the need to address woodfuel production and use in a FLR context. In many landscapes where FLR is being proposed, woodfuels (defined here as including both firewood and charcoal) are the primary source of energy, a pivotal component of local livelihoods and economies, as well as an important driver of forest degradation (e.g., Spetch, Pinto, Albuquerque, Tabarelli, & Melo, 2015). Although considerations for strategically inserting woodfuel production and use into FLR initiatives have been outlined for more than a decade (Gilmour, 2005) and proposed as a climate mitigation measure (Stanturf et al., 2015), they have seldom been put into practice. For example, key typologies of FLR goals (e.g., Coppus et al., 2019; Mansourian & Vallauri, 2014) do not explicitly include bioenergy production, current lists of key FLR interventions downplay fuelwood production (e.g., Sabogal et al., 2015), and bioenergy security is rarely highlighted as an important FLR outcome (e.g., Besseau, Graham, & Christophersen, 2018). And although some technical documents recognize harvesting for fuelwood as a potential degradation driver (e.g., ITTO, 2020; Stanturf et al., 2017), guidance on how to mitigate the impact of fuelwood production and use in a FLR context remains largely unaddressed. Early attempts to cope with the 1970s “fuelwood crisis” in developing countries focused on top-down, sectorial approaches to tree planting that ignored on-the-ground needs and goals, power imbalances, and local rights and tenure considerations (Mead, 2005). Issues that are now explicitly addressed in FLR initiatives through six core principles in a holistic approach (Besseau et al., 2018).

Here we argue that the FLR community needs to pay more attention to ensuring the sustainable production and use of woodfuel in order to secure locally-managed energy sources for communities, reduce pressure on forests, and enhance local livelihoods. We first explore the reasons why woodfuels merit greater attention within FLR initiatives, and propose three key actions for improving the sustainability of woodfuel management. We then discuss the ways in which woodfuel production and use can be more prominently integrated into the different stages of FLR design, planning, implementation and monitoring. Finally, we highlight the policy, finance and technical aspects that could facilitate the more effective integration of woodfuels into FLR initiatives.

## 2 | WHY WOODFUELS MERIT GREATER ATTENTION WITHIN THE FLR AGENDA

There are at least four reasons why woodfuels merit greater attention within the FLR agenda. First, in many developing countries where FLR is being proposed and implemented, woodfuels are the main energy source especially for local communities. Currently, an estimated 2.6 billion people (roughly 40% of the global population) use firewood or charcoal to cook food, heat their homes or provide energy for small-scale industries (Masera, Bailis, Drigo, Ghilardi, & Ruiz-Mercado, 2015). The reliance on woodfuels is particularly high in Sub-Saharan Africa, where >90% of the population depends on woodfuel for cooking and heating purposes (Iiyama et al., 2014), but woodfuel use is also common across the Asia-Pacific region and parts of Latin America (Bailis, Chatellier, & Ghilardi, 2012; FAO, 2020). Firewood is generally the principal energy source of rural households, while charcoal is preferred by urban households as it is easier to transport and store, has a higher energy content and burns more cleanly (Zulu & Richardson, 2013). Although many developing countries are transitioning toward modern, cleaner types of energy such as electricity, kerosene and liquified petroleum gas, the global demand for firewood and charcoal continues to grow due to rapid population growth, high unemployment and poverty rates, and the lack of alternative, readily-available and affordable energy sources (Arnold, Köhlin, & Persson, 2006; Sola et al., 2019). For example, in Africa, an estimated 600 million people lack access to electricity while another 900 million cannot afford modern fuels; under business-as-usual policy and investment goals, such a continent-wide gap is bound to remain for decades to come in most sub-Saharan countries (IEA, 2019). To enhance social inclusiveness, FLR initiatives need to acknowledge the continuing and growing woodfuel demand and take proactive steps to ensure that these bioenergy needs can be met.

A second reason is that in many regions woodfuel harvests are unsustainable and contribute to environmental degradation. Roughly half of all wood harvested globally is used for firewood and charcoal production (Bailis, Wang, Drigo, Ghilardi, & Masera, 2017). In Africa, 90% of the wood removed from forests and woodlands is used for woodfuel, with about 29% of this converted to charcoal (FAO, 2020). Most firewood for household use is collected from fallen branches or dead trees from non-forest areas such as trees on farms, household compounds, tree plantations, or vegetation along roadsides or rivers (Iiyama et al., 2014). In contrast, wood for charcoal production comes from clear-felling or selectively cutting live trees from natural forests, woodlands

or mangroves, from forest land that is cleared for agricultural production or, less commonly, from trees in managed woodlots (FAO, 2017; Zulu & Richardson, 2013). When harvesting rates are unsustainable (as is often the case with illicit charcoal production or harvesting from open access areas, Bailis et al., 2012), this leads to forest degradation, soil erosion, increased GHG emissions, biodiversity loss, and the loss of ecosystem services (Naughton-Treves, Kammen, & Chapman, 2007). It is estimated that 27–34% of the global wood fuel harvest was unsustainable in 2009, with hotspots concentrated in East Africa and South Asia (Masera et al., 2015). An estimated 275 million people already live in woodfuel depletion hotspots where the demand for woodfuel far exceeds supply (Bailis et al., 2012). Excessive harvesting of wood for charcoal production may also lead to localized deforestation, particularly around urban centers where the demand for charcoal is high (FAO, 2017). FLR interventions that explicitly address fuelwood production can help to minimize overharvesting and habitat degradation.

A third reason why FLR initiatives could benefit from paying more attention to wood fuels is that their sustainable production may translate into livelihood and health benefits to local communities. By ensuring a sustainable supply, FLR initiatives could reduce the significant time, physical effort or income that rural women and children spend securing fuelwood (Arnold et al., 2006). It could also enable income-generating activities (such as baking or brickmaking) that require secured access to energy. Enhancing the sustainability of woodfuel production can also promote food security (Mendum & Njenga, 2018) and further provide vital employment and income for rural households, particularly for those close to urban markets (FAO, 2020; Zulu & Richardson, 2013). An estimated 195 million people in Africa (or roughly 20% of the population) are engaged part-time in the production of woodfuels. The charcoal trade in Africa alone generated a total income of about USD 10 billion in 2011 (FAO, 2020). FLR initiatives could also improve the health of rural households by including measures to promote the use of more efficient stoves that emit less pollutants (Iiyama et al., 2014; Mendum & Njenga, 2018) as the incomplete burning of firewood and charcoal in traditional stoves cause significant health problems due to smoke inhalation (Bede-Ojimadu & Orisakwe, 2020). However, to fully achieve health benefits, exposure to stove pollution must be greatly reduced through the use of clean fuels (Grieshop, Marshall, & Kandlikar, 2011).

Finally, it is important that FLR initiatives insert fuelwood during planning and implementation as a climate mitigation measure. Globally, the inefficient production of charcoal and the inefficient combustion of wood fuels are responsible for 2–7% of the global GHG emissions,

including 20–30% of global black carbon (Masera et al., 2015). In addition, if charcoal production leads to the permanent clearing of forests or woodlands, this can result in additional GHG emissions. Many countries are including FLR initiatives as part of their nationally-determined contributions (NDCs) to reduce greenhouse gas emissions under the UNFCCC Paris Agreement (Dave et al., 2019). To achieve these mitigation goals, FLR initiatives will need to enhance carbon stocks by increasing forest and tree cover and reduce GHG emissions from degradation, charcoal production and cookstoves (Hofstad, Köhlin, & Namaalwa, 2009; Stanturf et al., 2019). Studies suggest that shifting from traditional earth-mound and earth pit kilns (with efficiencies in the range of 10–15%) to highly efficient charcoal kiln (with efficiencies of 35% or higher), could reduce emissions from charcoal production by 80% (FAO, 2017). Consequently, FLR initiatives to meet climate mitigation targets may benefit by including woodfuel production which, in turn, could help to operationalize NDCs. For example, in most Sub-Saharan African countries, NDCs remain vague as to how to tackle woodfuel production despite its importance as a domestic energy source (Amugune, Cerutti, Baral, Leonard, & Martius, 2017).

### 3 | STRATEGIES FOR EFFECTIVELY ADDRESSING WOODFUEL PRODUCTION AND USE WITHIN FLR INITIATIVES

In order to effectively ensure the sustainability of woodfuel production and use in landscapes where wood fuels are the dominant energy source, we suggest that FLR initiatives may need to consider three broad, complementary strategies: (a) enhancing the overall supply of woody biomass at a level sufficient to sustainably meet local and market demand by planting trees (e.g., in agroforestry systems, community forests, and small-scale fuelwood plantations), encouraging natural forest regrowth and promoting sustainable harvesting practices, (b) improving the efficiency of charcoal kilns and cook stoves, thereby reducing overall demand for woodfuel, and (c) restricting the extraction of woodfuel from natural forests thereby reducing environmental degradation.

While the benefits from integrating woodfuel will vary from one landscape to another and will depend on the specific interventions undertaken, addressing these issues as part of a broader FLR initiative could lead to multiple ecological and social outcomes (Table 1). Potential ecological benefits could include the reduced loss and degradation of natural forests, reduced GHG emissions, enhanced erosion control, enhanced biodiversity conservation and

**TABLE 1** Key actions to improve the sustainability of woodfuel production and use in forest landscape restoration initiatives and the associated environmental and socioeconomic benefits

Key actions to address woodfuel issues	Benefits from addressing woodfuel issues in FLR initiatives	
	Environmental benefits	Socioeconomic benefits
1. Enhance the availability and sustainability of woodfuel biomass within the landscape, by planting and growing trees and implementing sustainable management and harvesting practices	<ul style="list-style-type: none"> <li>Reduced degradation of remaining forests and other woody ecosystems</li> <li>Greater likelihood that forests or land that have been restored through FLR will be maintained over time</li> <li>Reduced GHG emissions, due to reduced degradation of forests and woodlands and use of efficient charcoal kilns and cookstoves</li> </ul>	<ul style="list-style-type: none"> <li>Improved energy security of local communities, due to access to a more sustainable source of firewood and charcoal</li> <li>Reduced time and physical effort spent by household members to collect firewood, freeing up time for other productive activities</li> </ul>
2. Reduce woodfuel demand by promoting the use of more efficient charcoal kilns and cookstoves	<ul style="list-style-type: none"> <li>Potential for enhanced erosion control</li> </ul>	<ul style="list-style-type: none"> <li>Increased opportunities for employment or income generation from sustainable firewood or charcoal value chains</li> </ul>
3. Restrict the extraction of woodfuel biomass from intact forests or other ecologically sensitive areas	<ul style="list-style-type: none"> <li>Enhanced conservation of biodiversity due to forest conservation</li> <li>Restoration or maintenance of key ecosystem services that underpin local livelihoods due to the conservation and restoration of forest</li> </ul>	<ul style="list-style-type: none"> <li>Improved household food security due to availability of woodfuel for cooking food</li> <li>Improved health due to the adoption of more efficient wood and charcoal stoves</li> <li>Increased local support for the FLR initiative, since it has provided them with clear, tangible and important benefits</li> </ul>

restoration and maintenance of key ecosystem services such as water provision or pollination. Potential social outcomes could include enhancing local energy security, reducing effort and cost of fuelwood collection, improved employment opportunities, improved food security and human health outcomes, and greater support for restoration activities, among others. These benefits, however, will only be achieved if woodfuel issues are carefully integrated into the design, planning, implementation and monitoring of FLR initiatives and if these initiatives are backed by appropriate policies, technical capacity and financial resources.

#### 4 | ADDRESSING WOODFUEL ISSUES IN FLR DESIGN, PLANNING, IMPLEMENTATION AND MONITORING

In order to improve the sustainability of woodfuel production and use, woodfuel issues should be considered in all stages of FLR initiatives (Table 2). The first stage of the FLR process consists of understanding the landscape context so to bring together stakeholders to develop a shared and agreed-upon vision through a participatory process (Mansourian, 2020; Stanturf et al., 2019). In this design phase, it is critical to carefully assess the scale, dynamics, and impacts of woodfuel harvesting, use and sale to understand the role of woodfuel in securing local energy security, enhancing livelihoods, and as a driver of forest degradation. It is important to identify the quantities and sources of harvested wood (for fuelwood, as well as for timber and other uses), ownership and access to forest and tree resources, household effort spent securing firewood, types of stoves and charcoal kilns used, importance of fuelwood for employment and income generation, and trends in fuelwood availability and demand. In areas where charcoal production is prominent, understanding commercialization patterns will be critical, as most charcoal demand is driven by consumption in urban centers (FAO, 2017). In addition, it will be important to identify the key actors and networks (and their vested interests) involved in the firewood and charcoal value chain (including producers, collectors, wholesalers, retailers and transporters), understand the specific needs and goals of each group, and to jointly visualize how the restored landscape is to look like.

The second (planning) stage involves articulating specific landscape goals and objectives and identifying the activities and interventions needed to achieve these goals (Mansourian, 2020). While the specific woodfuel-related goals will vary from one landscape to another, all FLR plans should carefully articulate what actions will be

**TABLE 2** How to raise the prominence of woodfuels in different stages of FLR interventions

Stage	Key actions
Design and conceptualization	<ul style="list-style-type: none"> <li>• Assess the current woodfuel situation including sources of woodfuel, availability, access, harvesting rates, production methods, commercialization and consumption</li> <li>• Assess trends in production and use, and consider potential future demand</li> <li>• Assess current contribution of woodfuels to forest and land degradation</li> <li>• Understand land tenure and access issues that affect access to woodfuel</li> <li>• Assess importance of woodfuel production and use for local livelihoods, as a source of energy, income generation and employment</li> <li>• Identify and engage key stakeholders involved in woodfuel collection, harvesting, transportation, sale and consumption, and identify their key needs and goals</li> </ul>
Planning an FLR intervention (and selecting potential interventions)	<ul style="list-style-type: none"> <li>• Identify clear goals related to firewood harvesting and charcoal production within the landscape</li> <li>• Identify which restoration approaches are most likely to increase the supply of woodfuel and where these interventions should be located</li> <li>• Establish management plans for woodfuel production and harvesting</li> <li>• Identify appropriate tree species, management and silvicultural systems for firewood and charcoal production</li> <li>• Identify areas where natural regeneration can be used to restore land and provide fuelwood</li> <li>• Identify natural forest areas where woodfuel harvesting should be restricted and specify enforcement policies</li> <li>• Identify approaches for preventing harvesting of natural forests such as the use of protected areas, community- managed forests, and payments for ecosystem services</li> <li>• Identify options for improving the efficiency of charcoal kilns, wood stoves and charcoal cookstoves</li> <li>• Consider potential tradeoffs or synergies of woodfuel interventions with other FLR activities</li> <li>• Ensure that the FLR plan addresses the needs and goals of all key stakeholders within the woodfuel sector</li> </ul>
Implementing FLR	<ul style="list-style-type: none"> <li>• Promote a wide suite of FLR interventions to help enhance the availability of woodfuels, including both tree planting and natural regeneration</li> <li>• Promote fuel-efficient woodstoves and improved charcoal kilns to reduce overall demand for wood and charcoal</li> <li>• Restrict the harvesting of woodfuel from intact forests or other ecologically sensitive areas</li> <li>• Promote and facilitate access to alternative fuels to reduce wood harvest pressure</li> <li>• Promote the development of sustainable value chains for the woodfuel sector</li> </ul>
Monitoring FLR and assessing impact	<ul style="list-style-type: none"> <li>• Monitor levels of fuelwood and charcoal production and demand, and ensure sustainable extraction rates</li> <li>• Monitor changes in the availability, or ease of access, or income spent on acquiring fuelwood for communities, as well as income and employment from woodfuel value chain</li> <li>• Monitor use of improved charcoal kilns, efficient wood stoves, efficient charcoal stoves, and overall demand for wood resources</li> <li>• Track incidence and severity of respiratory illnesses due to smoke inhalation</li> <li>• Monitor impacts of firewood and charcoal production on income generation and employment</li> <li>• Track degradation levels within forested areas including woodfuel harvesting</li> <li>• Assess reductions in GHG emissions, if possible</li> </ul>
Creating the enabling environment for FLR	<ul style="list-style-type: none"> <li>• Ensure policies and regulations encourage the sustainable production, sourcing and use of woodfuel and charcoal</li> <li>• Create financial incentives and investment for sustainable woodfuel production and management</li> <li>• Provide technical guidance on how to effectively integrate woodfuel management into FLR initiatives</li> </ul>

undertaken to improve the sustainability of woodfuel production, to reduce woodfuel demand, and to reduce unsustainable harvesting of native forests. In many cases, this planning stage will include a spatial analysis to identify which areas within the landscape could be restored with forest or tree cover for bioenergy production and which areas will be dedicated to agricultural production, biodiversity conservation or other uses (IUCN & WRI, 2014). Since stakeholders depend on trees for multiple purposes, including not only bioenergy but also fruit and timber production, these other uses must also be considered in the planning of tree planting including their type, scale and location. Previous experiences in developing countries suggest that community forestry, agroforestry systems, joint forest management strategies and small-scale farmer planting were usually more successful than large-scale plantations for bioenergy purposes (Mead, 2005). The FLR plan should also include aspects such as who can access, harvest and use different tree and forest resources, what quantities can be extracted and how these harvest levels will be enforced (Hofstad et al., 2009). Finally, it will be important to also identify measures to reduce the collection of firewood or felling of trees from native forests that are important for biodiversity conservation or ecosystem service provision. A wide array of conservation tools could potentially be used to address deforestation and forest degradation from wood fuel harvesting, including the use of zoning, the establishment of community-managed forests or protected areas, watershed management initiatives, and conservation policies and regulations, among others (Ervin et al., 2010). If these measures are implemented as part of a FLR initiative, the chances of conserving forests and their biodiversity over the long-term are likely to be enhanced (Beatty, Cox, & Kuzee, 2018; Chazdon, 2019).

The third stage consists of implementing the FLR plan. As highlighted above, key woodfuel-related interventions include planting and growing trees to increase the supply of biomass for firewood and charcoal, improving the efficiency of charcoal kilns, promoting the use of more efficient cookstoves, restricting the harvesting of biomass from native forests, and/or applying regulations on harvesting and sale of wood fuel products (Hofstad et al., 2009; Zulu & Richardson, 2013). If trees are grown specifically for woodfuel use, priority should be given to fast-growing and locally-adapted species that resprout following harvesting, and are easily-marketable so that communities get a quick return on their investment (Kimambo, L'Roe, Naughton-Treves, & Radeloff, 2020; Mead, 2005). However, mixed plantings of both fast-growing (with short biomass returns but a low wood caloric content) and slower growing tree species (with long biomass returns yet higher wood caloric content and

timber value) may help to satisfy multiple needs at the household level. However, care should be taken to avoid planting trees that might become invasive or negatively impact the provision of ecosystems services (Veldman et al., 2015), drawing on scientific evidence to guide decision making. For example, in many tropical and subtropical locations, *Eucalyptus* spp. are the preferred fast-growing species for fuelwood production. Although they are often perceived to have undesirable environmental consequences (Florence, 1986), eucalypt restoration plantings generate many positive social, economic and ecological outcomes (e.g., Brancalion et al., 2020; Newton & Tejedor, 2011; Yirdaw & Luukkainen, 2003) if variables such as surrounding landscape structure, edaphic characteristics, species choice and local climate are duly considered.

The final phase is to monitor the restored landscape to ensure that FLR interventions are leading to the desired social and environmental outcomes, and adjust activities and strategies as needed, ideally in a participatory manner (Evans et al., 2018). There is a large literature on potential indicators to measure the impacts of social and ecological impacts of FLR interventions (e.g., Buckingham et al., 2019; Dudley et al., 2018). However, for fuelwood issues, the key aspects to track are the quantity of woodfuel harvesting and production, the percent of households using improved kilns and cookstoves, the sources of firewood and charcoal, the condition of tree and forest resources, the income and employment generated by fuelwood harvesting and sale, and the incidence of respiratory illnesses from woodfuel use. These statistics can then be used to determine whether the existing tree growing efforts are sufficient to meet local needs for consumption and sale, whether restrictions on harvesting from protected forests are working, whether the use of more efficient kilns and stoves is reducing woodfuel demand, and whether any adjustments are needed to improve woodfuel management within the landscape.

## 5 | POLICIES, FINANCIAL AND TECHNICAL NEEDS FOR GREATER CONSIDERATION OF WOODFUEL INTO FLR

Although systematically integrating sustainable woodfuel production and use into FLR initiatives is a vital step, these efforts will only be successful if the appropriate enabling conditions are also put in place. As with FLR in general (Chazdon, Wilson, Brondizio, Guariguata, & Herbohn, 2020), there is a need for more supportive and coherent policies, and associated legal frameworks, to promote and enforce sustainable woodfuel management.

Because the woodfuel sector is largely informal and crosses the domains of multiple government agencies, woodfuels are often overlooked in national and subnational policies (FAO, 2020; Sola et al., 2019). However, given their energy and environmental importance, it is critical that woodfuel production and use is addressed coherently across relevant government sectors. A wide range of policies could potentially support the transition towards more sustainable woodfuel management, including those that encourage the planting and growing of trees, promote natural regeneration of degraded lands, promote sustainable forest management, transfer forest management to local communities, transition farmers to more efficient charcoal kilns and more efficient stoves, and impose quotas, licenses, permits or taxation on woodfuel production (Arnold et al., 2006; FAO, 2020). That being said, there is great potential for FLR initiatives—which are typically implemented at the subnational level—to advance innovative models of woodfuel production and use that could be upscaled to other jurisdictions. Typically, FLR is an exercise in decentralized governance and enhancement of cross-sectoral cooperation (Chazdon, Wilson, et al., 2020). Its implementation could help in moving away from pervasive, national-level (top-down) approaches that typically focus on regulation, suffer from sectoral overlaps and pay little attention to sustainable management of woodfuels (Cerutti et al., 2015), towards a landscape-level and participatory approach that seeks to balance the diverse needs of multiple stakeholder groups and deliver both ecological and socioeconomic benefits.

Greater finance and investment are also needed as current levels of funding for woodfuel programs and research seems inadequate. For example, in Tanzania <1% of the budget for energy goes to biomass energy (Mendum & Njenga, 2018), despite the fact woodfuel is the primary energy source for most households. There is a need for much greater investment from both public and private sources in facilitating the development of more sustainable woodfuel sources, as well as in fostering research on woodfuels, especially on the cultural and technical factors affecting the adoption of more sustainable charcoal production methods and more efficient cookstoves (Mendum & Njenga, 2018; Sola et al., 2019). The enhancement of the caloric content of charcoal through the process of torrefaction is one potential technology that merits further investigation (e.g., Felfli, Luengo, Suárez, & Beatón, 2005). A mix of funding sources should be considered to support actions to enhance woodfuel sustainability, including climate finance, restoration funds, development cooperation, environmental funds, NGO funding, national budgets and resources and the private sector (Ding et al., 2017).

Finally, more detailed technical guidance and greater capacity is needed to successfully integrate woodfuel

issues into FLR initiatives. Guidance on FLR is needed to promote the value and importance of tackling woodfuel production and use and provide more details on how, when and where different types of woodfuel interventions could be integrated into FLR initiatives, and how to manage tradeoffs with other land uses and other FLR landscape goals (e.g., water provision, food production or biodiversity conservation; Woollen et al., 2016). This enhanced guidance should also include details on how to foster the adoption of efficient charcoal kilns and woodstoves and how to design strategies for preventing the unsustainable harvesting of native forests. To be successful, FLR initiatives should build on the existing knowledge and experience from previous efforts to design sustainable woodfuel interventions (Arnold et al., 2006; Mead, 2005; Sola et al., 2019) and use these insights to promote more sustainable and resilient landscapes.

## 6 | CONCLUSIONS

Forest landscape restoration initiatives can help address the ongoing demand for sustainable woodfuels by implementing three complementary actions: (a) improving the sustainability of woodfuel production through tree planting, natural regeneration and other restoration activities; (b) reducing woodfuel demand through the adoption of more efficient stoves and kilns, and (c) reducing the unsustainable harvesting of fuelwood from native forests. To be successful, all three strategies must be carefully considered and integrated into the design, planning, implementation and monitoring of FLR initiatives, and should be backed by supportive policies, technical capacity and financial resources. Raising the profile of woodfuel issues within FLR initiatives and systematically considering how to address the continued high demand for woodfuel, will not only enhance the sustainability of woodfuel production and use, but will also likely enhance the possibility that FLR initiatives are successful at restoring degraded landscapes and delivering the desired social and environmental outcomes.

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## CONFLICT OF INTEREST

The authors declare no conflicts of interest.

## AUTHOR CONTRIBUTIONS

Manuel R. Guariguata and Celia A. Harvey conceptualized the study. Celia A. Harvey wrote the first manuscript

draft with contributions from Manuel R. Guariguata. Both authors revised the manuscript after peer review and approved the final version.

## ETHICS STATEMENT

There was no interaction with human subjects.

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