PRODUCTIVE LANDSCAPES (PROLAND)

STIMULATING SMALLHOLDER TREE CULTIVATION FOR WOODFUEL: LEARNING FROM SUCCESS IN MADAGASCAR

ProLand Woodfuel Resources
Deforestation and forest degradation are common challenges for countries that rely heavily on woodfuel. To reduce damage to forests, governments undertake efforts to manage harvesting and increase the supply of trees. They promote alternative energy sources and energy-efficient stoves. They regulate actors in the value chain, confer forest stewardship to local institutions, and launch afforestation campaigns. They also, usually with less intentionality, create the conditions for commercial production of woodfuel by smallholders. In Madagascar, the government appears to have gone a long way in creating conditions that stimulate private-sector tree cultivation. Forest plantations, woodlots, and individually planted trees flourish on the island. In this case study, we examine the environment that enables tree cultivation in three regions of the country. To do so, we describe the production, governance, and business factors that either stimulate or hinder widespread smallholder tree cultivation supplying charcoal to urban centers. In the process, we identify opportunities for intervention applicable to Madagascar and other countries whose forests are threatened by the heavy dependence of their urban centers on woodfuel.

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SUSTAINABLE WOODFUEL PRODUCTION IN MADAGASCAR: A REMARKABLE ACHIEVEMENT

In the environmental arena, Madagascar is one of the world’s biodiversity hotspots, its rainforests hosting lemurs and other endemic and endangered wildlife being lost at alarming rates. So, it comes as a surprise to many to learn that the country’s capital city, Antananarivo, where three-quarters of the country’s charcoal is consumed, procures a remarkably large portion of its domestic woodfuel from sustainable sources, and that tree cover is actually increasing in some parts of the island (McConnell, Viña, Kull & Batko, 2015). While the populations of most urban centers in Africa cook with woodfuel harvested from natural forests, much of Madagascar’s supply comes from planted trees (see “Madagascar’s Woodfuel” text box). Almost all the charcoal used in Antananarivo comes from privately owned plantations of a size and number that far surpass most other African countries (see “ Origins of Charcoal in Antananarivo” and “Plantations, in Hectares by Country” text boxes).

This case study sets out to draw lessons from this rare achievement. It also seeks to assess why this success in providing renewable energy does not extend to other urban centers in the country where residents rely much more heavily on charcoal produced from natural woodlands. To understand these differences in sourcing woodfuel, we describe the production, governance, and business factors that stimulate and constrain tree cultivation for the woodfuel market in three regions of the country.

THE THREE STUDY AREAS AND HOW WE LEARN FROM THEM

We first explore the origins of the plantations in the Analamanga region, which supplies Antananarivo. In this region we present characteristics of a relatively mature woodfuel system. We then turn our attention to a more recent phenomenon, the growing popularity of farm tree cultivation in the hinterlands of secondary...
cities and towns in the Amoron’i Mania and Matsiatra Ambony regions of the southern highlands. Here we describe the conditions, some unrelated to woodfuel, that have led to this growth. Finally, we examine the situation in the Diana region in the far north of the island, where long-term intervention under challenging conditions has provided additional lessons on stimulating smallholder tree cultivation to supply urban demand for charcoal.

By understanding 1) the historical and geographic circumstances that have led to the plantations that cover the Analamanga region; 2) why smallholder farmers have taken up tree cultivation in the southern highlands despite history and geography being less favorable; and 3) how donors and government investments in the north have overcome production, government, and business constraints, we generate a suite of promising interventions to stimulate sustainable renewable woodfuel markets in Madagascar and other countries whose forests are threatened by the heavy dependence of their urban centers on woodfuel.

**CHARACTERISTICS OF THE WOODFUEL SYSTEM SUPPLYING THE CAPITAL**

**ORIGINS AND DYNAMICS OF THE MATURE WOODFUEL SECTOR IN ANALAMANGA**

The vast plains of the Analamanga region, located atop the island’s eastern escarpment, have historically lent themselves to intensive rice production, while the surrounding hills served as grazing lands for the
zebu cattle that provided the traction power necessary to work the heavy soils of the paddies and haul harvests. As elsewhere, the zebu were also a key means for investing the gains from a good harvest. Over the past 50 years, exotic tree plantations came to dominate large portions of these uplands, where between 64,000 and 120,000 ha of plantations are thought to be capable of producing between 300,000 and 600,000 m³ of wood per year (SRABE, 2019). The plantations are concentrated in the District of Manjakandriana, directly east of Antananarivo. In addition to the ever-growing woodfuel demand (the World Bank estimates a 2.7 percent annual population growth rate in the country), a set of key events and enabling conditions help to explain this phenomenon. These include the introduction of fast-growing trees, the availability of land with sufficiently secure tenure for forestry, and constraints on competition from other energy sources. We consider each in turn below.

The productivity of the exotic tree species introduced in the early 20th century. The emergence of artificial woodlots on the eastern flank of Antananarivo dates to the French colonial era. By the 1930s, the colonial government had administered the planting of over two million trees across the country through both forced labor and purchase from local producers. These trees were planted initially as a source of fuel and lumber ties for the steam-powered railway linking the highland capital with the main port some 350 km down the escarpment, and later for environmental reasons (Kull, Harimanana, Andrianoro, & Rajoelison, 2019). Fast-growing species from other parts of the world—primarily eucalyptus, pines, and acacia—prospered in the moist conditions, and woodlots continued to spread across the open hilltops of the plateau, known locally as tanety (Bertrand, 1999b) (see “A Tree Suited to Woodfuel Production” text box).

Colonial origins and land availability due to the contraction of the livestock sector. Following Madagascar’s independence from France, and particularly during the Deuxième République of the 1970s, colonial land holdings, including the extensive exotic tree plantations on the tanety, were ceded to Malagasy nationals. The legacy of this succession is key to understanding the way these resources are

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1 The wide range in estimates of the extent of Analamanga plantations is representative of the more general uncertainty surrounding forest cover estimates in Madagascar. A nationwide inventory conducted in 1996 has yet to be repeated.
managed today, as most of the owners of woodlots, several of whom were contacted during this study, have inherited former colonial land from their parents, along with knowledge of how to harvest the trees. While documentation of these transfers rarely exists, the long-standing control of these lands by the families to which they were originally ceded provides a level of security not seen in other parts of the country.

Other changes in land use have reinforced this dedication of the tanety to tree plantations. Due to their highly weathered soils the slopes of the tanety are poorly suited to agriculture, which is why they were traditionally dedicated to livestock grazing. This land use has diminished in recent decades, however, for a variety of reasons. First, the mechanization of paddy production has reduced the need for animal traction. At the same time, the spread of rural banking services (ATM machines are now found in even small towns), along with the threat of cattle rustling, have together reduced the traditional role of cattle in storing wealth. As a result, livestock production has become more intensive. Owners keep zebu confined more often in order to deter theft and feed them forage supplemented with agricultural residues. In this context, cultivating trees on the tanety has become a lucrative alternative to extensive livestock raising for generating income and for storing wealth (see “One Man Expanding on the Colonial Base” text box).

Limited competition from other sources of energy. Despite efforts by the government and its partners to promote the use of alternative fuels, woodfuels will remain key to meeting Antananarivo household energy needs for years to come. As it does in most of Africa and the Global South, the lack of affordable, reliable alternatives prevents Antananarivo’s 1.6 million inhabitants from “climbing the energy ladder” and switching from woodfuel to alternate forms of energy (Nansaor, Patanothai, Rambo, & Simaraks, 2011). The prices of kerosene, liquefied petroleum gas (LPG), and electricity far surpass the budgets of the vast majority of households (SRABE, 2019). It is also likely that some households simply prefer cooking with charcoal over other forms of energy (Zulu, 2010; Démurger & Fournier, 2011; Energypedia, 2018).

Regulation also makes charcoal produced on plantations more competitive relative to woodfuel harvested illicitly from natural forests. The Malagasy government controls charcoal production and trade through a licensing system that requires permits to harvest, even for domestic use. Officially, all transportation of charcoal also requires permits, yet the reach of regulation has been limited. Across much of the country, value chain actors, even large-scale traders who consider regulation burdensome and costly, function informally for the most part (Minten, Sander, & Stifel, 2013). People transporting woodfuel into the capital city, however, face more effective regulation due to the bottlenecks in the road system and a concentration of government agents (Charpin, 2015).

Improved Regulation May Raise Prices

In field interviews, the district head of the forest service in Manjakandriana, a commune just east of the capital, credibly asserted that the ability to monitor transportation reduces competition from illicit supplies. The potential impact of this regulation was illustrated by one key informant who pointed out that a crackdown on illicit woodfuel exports to the nearby island of Mayotte resulted in a tripling of the market price of locally sourced woodfuel.
Legeay, Rabemanantsoa, & Richter, 2019; ASA, 2019). The overwhelming bulk of Antananarivo’s woodfuel supply arrives in large trucks via three main highways, the RN2, RN3 and RN7. Enforcement on these routes is characterized by corruption and may favor larger, politically connected merchants (Minten et al., 2013; Aubert, Karpe, Jaster, Rambinintsaoatra, & Montagne, 2015), yet the overall result appears to be reduced competition from suppliers who harvest in natural forests (see “Improved Regulation May Raise Prices” text box).

THREATS TO ANALAMANGA’S SUPPLY OF PLANTATION WOODFUEL

Madagascar’s remarkable achievement in providing renewable energy to its capital may be deteriorating. Production from plantations in the region currently falls short of demand, and the rate of charcoal consumption in the capital is double the rate of tree regrowth from all sources in the region—plantations, natural growth, and agricultural lands—combined (SRABE, 2019). Growing demand may be one reason plantation owners have shortened harvest cycles (Verhaegen et al., 2011). By harvesting earlier, smallholder owners meet short-term income needs but sacrifice greater income and production in the long term. Owners interviewed for this study reported harvesting their coppices after just three, or even two, years. During fieldwork, we also observed owners harvesting stumps. Overall trends in production for the region have not been studied, but if widespread, these behaviors will bring greater pressure on the island’s forests as plantation production declines. Early harvesting combined with a shortage of silviculture skills, a lack of diversity in tree stock, insufficiently secure tenure, and consolidation of the market threaten Madagascar’s most sustainable woodfuel market. We address each in turn below.

Limited technical skills. Reports of farmers establishing eucalyptus plantations through locally developed methods such as annual controlled burning and natural regeneration date back over a hundred years in some parts of Madagascar (Bertrand, 1999a; Verhaegen et al., 2011). However, owners do not appear to have successfully adapted these practices to today’s plantations. They report a lack of success in replacing lost trees, extending existing woodlots, and creating new ones. Interviewees complained of rates of success as low as 10 percent in transplanting volunteer seedlings from their woodlots.

Susceptibility of trees to pests and disease. A potentially more serious threat to the sustainability of the charcoal supply lies in the provenance of the seedstock. One expert at the French research organization CIRAD warned that Madagascar’s very popular Eucalyptus robusta stock appears to descend from fewer than a dozen individual trees. Investment in developing a more robust set of cultivars has been insufficient. This absence of diversity raises concerns about the population’s vulnerability to pests or disease, incidents of which have already been observed.

Unsettled nature of the owner’s rights in land. As mentioned above, it seems that families in Analamanga who benefited from the redistribution of colonial lands are generally recognized within their communities as holding stronger rights to that land than is true elsewhere in the country. Rights to the plantations in Analamanga are nevertheless contested. Owners interviewed for this study described the efforts of family members and others to claim rights in the land and explained that extending plantations to open land is still fraught with risk. In addition, interviewees unanimously reported their inability to secure formal title despite decades of attempts in some cases.

Growth of larger owners foregoing woodfuel production for timber. The woodfuel sector in Analamanga may be seeing increasing concentration that could lead to reduced overall woodfuel production. While some smaller owners overharvest their trees, interviews confirmed that more prosperous and well-connected owners are adding to their land holdings, increasing their tree stocks, and foregoing harvesting for woodfuel in favor of producing the more lucrative lumber. These owners often intend to leave mature trees to supply future family house-building or cash needs. When they
produce woodfuel they are also more likely to own the means of transport and the access to warehousing. This vertical integration enables them to capture more of the profits along the supply chain, particularly in light of their ability to time sales of woodfuel to exploit higher prices in the rainy season when production is more difficult in terms of labor availability and production efficiency, and transport is more challenging on unpaved roads (Charpin et al., 2019).

Overall, such consolidation of control over the market may result in a more efficient economic sector, but at the cost of social differentiation, as the number of owners shrinks and the number of wage laborers increases. If widespread, this shift towards consolidation by larger owners would lead to inequitable growth in Analamanga’s charcoal sector. It may also portend a loss in woodfuel production as ownership shifts from smallholders coppicing their trees for woodfuel to larger owners storing wealth in timber. Madagascar’s energy and transportation sectors are indisputably oligopolistic, and the woodfuel sector may be headed in the same direction.

**THE GROWING POPULARITY OF TREE CULTIVATION ELSEWHERE IN THE HIGHLANDS: AMORON’I MANIA AND MATSIATRA AMBONY**

**ORIGINS AND DYNAMICS OF SMALLHOLDER TREE CULTIVATION**

The tradition of private plantation ownership is less strong in the southern highlands. Although railway lines were constructed to connect the cities of this area with the capital and the coast, the region did not experience the same intensity of colonial plantations. Interviews confirmed that tree cultivation dates back more than a generation and includes major afforestation programs. But these efforts by the Malagasy government had a less dramatic impact than those of colonial administrators closer to the capital and did less to stimulate private tree cultivation. Beginning in the 1970s, the government established extensive pine plantations in the region, funded for a period with World Bank support. The most notable is the Haute-Matsiatra plantation on the outskirts of Fianarantsoa, covering more than 20,000 ha. Instead of being turned over to private tree cultivation like the colonial woodlots of Analamanga, the plantation remains government owned and has served as a source of resentment among the communities displaced for its creation (McConnell et al., 2015). Although subsequent efforts to promote local tree cultivation have engaged community members, they have been more limited. For example, in the 1990s, a World Bank-funded activity conducted largely in collaboration with farmer associations planted approximately 2,500 ha in eucalyptus.

The weaker tradition of farmer plantations, combined with demography and geography, led to weaker demand and undercut prospects for a robust, sustainable woodfuel market in this region. Like their counterparts in Antananarivo, the residents of the cities of Antsirabe, Ambositra, and Fianarantsoa largely rely on charcoal for cooking. Industrial enterprises, both large (e.g., the Cotona fabric mill in Antsirabe) and small (e.g., the rapidly proliferating essential oil distilleries) are also important consumers of woodfuel. At the same time, the lesser demand exerted by the residents and enterprises of these smaller cities is fed by woodfuel harvested from a proportionally far larger supply. This includes competition from remnant woodlands, such as the region’s groves of tapia trees and the natural forests of the eastern escarpment, all physically accessible sources of woodfuel.
People in the highlands south of the capital are nevertheless planting more trees. Despite a weaker tradition of tree plantation and smaller demand, the area covered by planted trees appears to be increasing. A recent study using satellite imagery documented an increase in tree cover between 1994 and 2014 (McConnell et al., 2015; also see Charpin et al., 2019). Fieldwork conducted in the regions of Amoron’i Mania and Matsiatra Ambony for this case study was able to confirm the remote sensing observations on the ground. Local farmers increasingly integrate trees into their agricultural systems to produce fruit and other products, including woodfuel for local markets.

Our fieldwork enabled us to identify some of the factors motivating farmers to cultivate trees, and some of the constraints they face. We address these below.

**GOVERNMENT SUPPORT AND NON-WOODFUEL USES MOTIVATE FARMERS TO CULTIVATE TREES IN THE SOUTHERN HIGHLANDS**

**Government afforestation efforts.** The local administration and civil society have undertaken afforestation initiatives in recent years. The Ambohimahasoa Cantonnement supports tree cultivation by conditioning charcoal permits on the planting of an equal area of new trees for each harvest, even in the case of coppicing. In addition, permit applicants are asked to provide seed to the Cantonnement, which is unable to procure sufficient supplies from the Silo National des Graines Forestières (SNGF). With greater access to seeds, the forest service at the Cantonnement level distributes eucalyptus and acacia seed to about 100 individual clients per month (100g minimum) and provides seedlings to village forestry projects sponsored by local associations, churches, and schools. The village activities plant up to 1,000 trees a year.

**The many non-woodfuel uses of trees.** Fieldwork also revealed that much of the tree cultivation in the southern highlands is motivated by reasons other than woodfuel production. As in Analamanga, lumber is much more lucrative than woodfuel, for those who can afford to wait until the trees mature. Farmers also plant orchards. Fruit production was spurred by the construction of a processing plant in the 1970s. It has since closed, but not before introducing many farmers to tree cultivation (see “The Many Roles of Trees in Leimavo” text box). Meanwhile, markets for other non-timber forest products, particularly honey and essential oils, also stimulate the cultivation of trees in this region. These trees cultivated for other products also contribute to the woodfuel supply.
The Many Roles of Trees in Leimavo

Farmers have long integrated trees into diverse production systems, including them as a source of firewood and charcoal for sale. The village of Leimavo lies some 15km from the town of Ambositra. Inhabitants recall tree-planting efforts as far back as the early 1960s, when Catholic missionaries established a eucalyptus nursery and the government paid farmers to plant pines. Later, the Association Nationale d’Actions Environnementales promoted the planting of trees used in the production of essential oils. More recently a small association planted trees on land previously used for grazing. Elsewhere, villagers have cultivated exotic acacias, which support apiculture and are thought to attract water from deep underground, thereby benefiting nearby crops. The village also boasts an array of fruit trees, including peach, guava, orange, and papaya. As in other places, association members intend the trees as an investment for future generations and confirm that the resource is sufficiently valuable to attract systematic pilferage of the fruit. Thieves are known to fell essential oil trees to steal their leaves or bark. Fire protection is crucial in this area, as wildfire is common.

SILVICULTURAL BARRIERS, THREATS TO PROPERTY, AND MARKET FACTORS LIMIT SMALLHOLDER TREE CULTIVATION

Limited technical skills and the susceptibility of trees to pests and disease. As elsewhere in Madagascar, though to a greater extent than in areas closer to the capital, thinly stretched government services and a highly localized nongovernmental organization (NGO) presence make technical assistance in the propagation and maintenance of trees difficult to obtain. In all areas visited, producers reported low rates of success in replacing or adding to their tree stocks. Challenges mentioned in interviews include seedling propagation (potting soil quality, type of container); selection for transplanting; root treatments (mechanical and chemical); the dimensions of the hole (size and shape); and fertilization. By far the most common request of interviewees was sound guidance on such issues.

Access to abundant quantities of high-quality seeds might mitigate the low success rate cultivating trees, yet local growers find viable seeds hard to obtain. Further, as with the eucalyptus supplying the capital, experts point out that the extremely homogeneous genetic makeup of the trees being cultivated leaves the sector highly vulnerable. In the southern highlands, as elsewhere, interviewees frequently reported pest and disease problems hindering tree cultivation.

Insecure land rights and threats from wildfire, theft, and vandalism. As in many other countries, a complex web of national and locally administered rules influences land rights in Madagascar. In recent decades, reforms have begun to deconcentrate land administration, and in 2005 the government withdrew state ownership of untitled, unoccupied land and conferred ownership on the occupants. With the reforms still far from complete, people attempting to assert rights in trees and land face an uneven and evolving tapestry of tenure rights and rules producing unpredictable outcomes.

Tree owners here, farther from the capital, have a more difficult time formalizing tenure because they tend to be less wealthy and less well informed, and have fewer ties to people in authority than do owners in Analamanga. With no regional history of redistribution of colonial holdings, tapping into the informal sets of rights to secure planted trees on heretofore communal tanety is much more problematic. In Madagascar, tree cultivation has long been an informal yet accepted way to establish a claim to land and a viable alternative to the onerous process of securing formal title. Smallholders may create woodlots, or plant trees to delimit and assert rights in fields and later use the trees as a source of woodfuel (Bertrand, 1999b). However, such claims do not always go uncontested, with family members and neighbors seeking to share in benefits and, failing that, resorting to pilferage or even vandalism.

Fire and theft are additional threats to successful tree cultivation that the government has been unable to suppress. Fire is used throughout the southern highlands to rid pasture of plants unpalatable to cattle and to clear land for fields. Since the practice is illegal it is often conducted in clandestine fashion, raising the chances of fire escaping onto adjacent land (Kull, 2004). Protecting woodlots here thus requires
owners to invest in costly fire breaks and in ensuring community mobilization to extinguish out-of-control fires. Along with fire, incidents of theft or destruction of seedlings were widely reported to the ProLand field team. While the malefactors’ motives cannot be determined definitively, those interviewed suspect jealousy plays a role.

**Higher competition and poor transportation.** Lower returns on sustainable woodfuel dampen incentives for tree cultivation in the southern highlands because producers face greater competition and higher transportation costs. Arriving from multiple directions, larger-scale producers truck charcoal into the cities of the region, while smaller producers haul it in on foot, or with bicycles and carts. The forest service, with fewer staff and less operational resources (vehicles and fuel), face a greater relative challenge than they do closer to the capital and are less able to deter the supply of illicit woodfuel. The uncontrolled trade in naturally grown woodfuel lowers prices, while unpredictable transportation on poorly developed roads raises transportation costs for all charcoal producers.

**LONG-TERM ENGAGEMENT IN A DIFFICULT CONTEXT BRINGS PROGRESS: THE DIANA REGION**

While the goal of limiting woodfuel supply to cultivated trees faces formidable obstacles in the southern highlands, the challenge in the country’s more remote regions is magnified (see “The Impact of Charcoal Elsewhere” text box). The Diana region, at the far northern tip of the island, is a good example. With a population of around 100,000, the regional capital Antsirananana, also known as Diego Suarez, exerts a more modest demand for woodfuel on the surrounding countryside than is felt in the southern highlands. Nevertheless, by 1990 the ever-expanding clearance of natural woodlands began to threaten the region’s protected areas, particularly the Montagne d’Ambre National Park, prompting an enduring response by the national government and international actors.

Through decades of investment, donors and the government have improved the conditions for smallholder production for the woodfuel market. According to the head of the regional office of GIZ’s current project, the *Programme d’Appui à la Gestion de l’Environnement, Composante Bois-Energie* in Diego, there are signs that the organization’s accomplishments are spurring adoption beyond the people directly engaged by the project. He estimates that as much as a hundred hectares of woodlots have been established without project support, with farmers collecting their own seed and successfully propagating and transplanting seedlings. (For a summary of the project and early reported successes, see Etter et al., 2014.) We discuss the contributions GIZ, other donors, and the government have made to increase the sustainability of the woodfuel supply chain below.

**One donor’s strategies to address technical, motivation, and labor constraints.** Over the past two decades, GIZ has sponsored the creation of tree nurseries with the goal of disseminating seedlings throughout the Diana region but efforts achieved low levels of adoption. Efforts, such as the GREEN MAD project, had to overcome the legacy of
training in transplanting seedlings and techniques to maximize tree health and the production of wood. GIZ employed a farmer-to-farmer method in which skilled individuals are paid to train their neighbors. To address labor constraints, the project subsidized the use of tractors for field preparation.

Making secure tenure more accessible.
Municipalities in the area have been able to establish a guichet foncier (local land office), resulting in documentation of semi-formal land tenure for participating producers (see “Guichet Foncier: Decentralized Land Certification” text box). The approach has shown promise incentivizing investment in resources that take years to mature, like trees, in remote areas otherwise rife with land conflicts and where formal land titles are virtually impossible to obtain. Unfortunately, the guichet foncier program suffered greatly from the withdrawal of Millennium Challenge Account support in the wake of the country’s 2009 political crisis. By 2019, the number of guichets fonciers in the region had shrunk from approximately 40 to perhaps a dozen.

Strengthening returns from renewable charcoal. A visit to the Ministère de l’Environnement, de l’Ecologie et des Forêts (MEEF) office in the Diego Cantonnement confirmed that the office is actively addressing the illicit charcoal trade and found quantities of confiscated charcoal on hand (see Figure 5). A recent university study cited by the Chef de Cantonnement estimated that 30 to 35 percent of the city’s charcoal is supplied under a valid permit. To further advantage renewably sourced charcoal, GIZ supported the establishment and operation of green energy cooperatives. The green energy cooperatives allow producers to reduce transportation fees by aggregating their produce and, because it operates within the law, avoid the heavy bribes inherent to illicit trade. Participating

Figure 5. Confiscated charcoal, far north
 producers can have their charcoal weighed, sorted, packaged, bulked for transport, and sold at a “green fuel depot” in Diego. A key part of the production process is the removal of fine pieces and dust during sorting. These are mixed with maize residues and made into briquettes with the aid of subsidized presses (see Figure 6). Participating producers also benefit from a price premium based on product quality and sustainability. They generate returns 20 to 30 percent higher than the informal channel (Etter et al., 2014; GIZ, 2020). Since the cooperatives are constituted by producers that comply with regulations, they can reliably assure the sustainable origins of their charcoal and thus command a premium.

LESSONS WE CAN DRAW FROM THE THREE REGIONS

Across continental Africa, governments have begun to realize that rather than vilifying woodfuel to protect their forests they must stimulate increased tree cultivation. Success will necessitate addressing some very stubborn problems. Widespread commercial production of woodfuel may require the provision of technical assistance to remote rural producers, upgrades to neglected transportation networks, and effective and inclusive systems of property rights and land tenure. Governments may also need to improve regulation, launch tree planting campaigns, and strengthen local stewardship of natural resources. The challenge will not stop there. Widespread progress on these fronts may result in the introduction of potentially invasive species that threaten natural ecosystems, and so protected area management will remain an ongoing concern. Stimulating widespread smallholder tree cultivation for woodfuel markets is not easy, but it is increasingly clear that in many countries this represents a vital component in sustainably meeting woodfuel demand.

This case study set out to understand the historical and geographic factors, and the current production, governance, and market conditions that have enabled Madagascar to meet a substantial portion of its energy needs with wood from cultivated trees. Historical experience with plantations, the availability of suitable land, and a policy environment conducive to scaling the successes of national agencies and international organizations in promoting tree cultivation have bolstered smallholder tree production. At the same time, the government and its partners are challenged to provide basic technical support, high-quality inputs, and secure and stable rights in trees and tree products (see “Challenges to Landscape Restoration” text box). More progress is also needed in creating well-regulated, cost-effective markets that prioritize sustainably produced charcoal. In our review of this mix of barriers and incentives we find opportunities in all three regions examined.

This is a crucial moment for the forestry sector in Madagascar. The government recently launched a

**Challenges to Landscape Restoration**

The Madagascar 2017 National Strategy for Forest Landscape Restoration and Green Infrastructure identifies four primary challenges to landscape restoration that may hinder the afforestation initiative: 1) weak management by the national government; 2) a lack of local governance capacity; 3) a shortage of technical skill; and 4) a lack of national and international financial support (MEDD, 2017).
major national afforestation initiative (Vyawahare & Rasolofomboahangy, 2020), an effort aimed at planting 40 million trees this year. While the strategy for achieving this objective—especially the source of the massive financial investment required—remains unclear, the political will is there, and it enjoys popular support. The initiative is aimed in part at meeting climate change mitigation targets established under international agreements. This same intention currently motivates the support of European research and development organizations, such as GIZ and CIRAD.

For Madagascar this case study is timely, coinciding with the launch of the afforestation initiative, and its findings may inform this effort. Yet the challenges facing Madagascar are not unique. Other woodfuel-dependent countries that face similar technical, governance, and economic barriers may profit from a consideration of these recommendations.

RECOMMENDATIONS

LACK OF TECHNICAL SKILL
Smallholders are constrained by a lack of technical skill in tree propagation and maintenance. In all regions, producers reported very low rates of success in replacing or adding to their tree stocks. We recommend working with the government and experienced NGOs, such as ANAE (Association Nationale d’Actions Environnementales); the Tany Meva Foundation; and AIM (Action Intercooperation Madagascar) to:

- Identify and provide farmer-to-farmer extension of traditional methods of farmer-managed plantation creation
- Provide farmer-to-farmer extension on research-based methods of tree propagation, transplanting, and harvesting

RESTRICTED SUPPLY OF SEED STOCK
Smallholders are constrained by the limited availability of seeds and seedlings. This is especially pressing in the face of the ambitious national tree planting initiative currently underway. To address this, woodfuel actors should support:

- Increasing the capacity of SNGF to fulfill its mission
- Progressively transitioning from state monopoly to private sector seed distribution. This will require policy reform, after which NGOs would discontinue providing free seeds and help assure quality control and build smallholder capacity to collect, share and sell seeds and seedlings2

VULNERABILITY OF THE EXOTIC TREE STOCK TO PESTS AND DISEASE
The homogenous genetic makeup of the trees being cultivated allows for the spread of disease.

2 Recent years have seen new guidance regarding seed availability in response to national forest restoration efforts. For recommendations on assessing and meeting national needs see Jalonen, et al., 2018. For an overview of best practices for the collection and production of native seeds see Pedrini et al., 2020. The World Agroforestry Centre has developed extensive materials on tree seed production and distribution. Much is compiled in Kindt et al., 2006. For recommendations on transitioning to commercial seed supply, see Lillesø, et al., 2018.
• To counteract this, we recommend working with national partners, such as the forestry division of the École Supérieure des Sciences Agronomiques, Université d’Antananarivo (ESSA) to support applied research to diversify the genetic makeup of the woodfuel tree stock

COMPETITION FROM ILLICIT TRADE
The availability of illicitly harvested wood undermines forest protection efforts and weakens demand for sustainably produced wood. The current regulatory regime, while far from perfect, constitutes the best tool available to limit the supply of woodfuel from natural sources. To address this, woodfuel actors should:

• Support governmental efforts to monitor the supply chain and production trends
• Explore legislative and administrative alternatives to the current production and transport permitting system

CONTESTED RESOURCE ACCESS
Smallholders lack sufficient confidence they will control the returns on their (relatively long-term) investments in tree cultivation to divert resources from other agricultural investments. To address this, woodfuel actors should:

• Continue to reinvigorate the guichet foncier initiative to extend land certification more broadly
• Support enforcement and public education to reduce fire, theft, and vandalism

MARKET INCENTIVES
Revenues from woodfuel sales are insufficient to stimulate tree cultivation. To increase revenues, woodfuel actors should:

• Support the creation of producer cooperatives to reduce transformation, transportation, and marketing costs of sustainable charcoal produced by smallholders
• Support the diffusion of technologies that add value and justify higher prices by improving charcoal quality
• Support certification of charcoal producers using planted wood to encourage more efficient production and provide price premiums on sustainably produced charcoal

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3 For a review of the challenges governments face in woodfuel regulation and recommendations towards sustainable and decentralized woodfuel management see Miller, Dennison, and Faye, 2020.
REFERENCES CITED


