Abstract

As the majority of Madagascar’s population continues to rely on wood and charcoal for cooking fuel, today, and as the production of charcoal to meet urban demand is linked to deforestation, plantation projects may offer an option to replace extraction from natural forests. This project aimed to gain insight into the status of plantation projects, in Madagascar, particularly in relation to fuelwood production. I conducted semi-structured interviews with representatives from four organizations that run active plantation projects in Madagascar, regarding project background, decision-making processes, management practices, sites, species, markets, and general thoughts about the role of plantations for fuelwood. Of these projects, two specialized in charcoal production specifically, although all of the organizations had implemented some type of intervention to improve fuelwood or supply chain efficiency. It seems that organizations may benefit from knowledge sharing regarding both approach to plantation as well as regarding technology such as improved-efficiency charcoal kilns. These projects still face numerous challenges as well, due to limitations from funding sources, lack of governmental support, and land tenure access. As most of these projects were recently launched, their impact and durability remain to be seen.

Comme la majorité de la population de Madagascar continue de utiliser le bois et le charbon de bois pour faire la cuisine aujourd’hui, et que la production de charbon de bois pour répondre à la demande urbaine est liée à la déforestation, des projets de plantation peuvent offrir une option pour remplacer l’extraction des forêts naturelles. Ce projet visait à mieux comprendre l’état des projets de plantation, à Madagascar, en particulier par rapport à la production de bois de chauffe. J’ai mené des entretiens semi-structurés avec des représentants de quatre organisations qui exécutent des projets de plantation actives à Madagascar, en ce qui concerne le contexte du projet, les processus décisionnels, les pratiques de gestion, les sites, les espèces, les marchés, et de réflexions générales sur le rôle des plantations de bois de chauffe. Parmi ces projets, deux étaient spécialisés dans la production de charbon spécifiquement, mais toutes les organisations avaient mis en œuvre un certain type d’intervention pour améliorer l’offre de bois de chauffe ou de l’efficacité de la chaîne de production. Il semble que les organisations peuvent bénéficier de partage des connaissances concernant à la fois l’approche de plantation ainsi que concernant la technologie tels que l’amélioration de l’efficacité d’un fours à charbon. Ces projets se heurtent encore à de nombreux défis et, en raison des limitations de sources de financement, le manque de soutien gouvernemental, et l’accès à la propriété foncière. Comme la plupart de ces projets ont été récemment lancé, leur impact et la durabilité restent à voir.

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Introduction

Madagascar is globally recognized as a biodiversity “hotspot” with over 80% of its plants and animals endemic to the island (Medley 2004, Marcus 2001). As with much of the world, Madagascar’s forests, flora and fauna are threatened by a range of anthropogenic activities, one of which is land clearing for charcoal production (Bergeron 2002).

Utilization of charcoal or wood for cooking is still commonplace in Madagascar, with more than 90% of the population relying on one or the other (Global Alliance for Clean Cookstoves 2014, Gade & Perkins-Belgram 1986, Bergeron 2002). Charcoal is the principal energy option for cooking in urban areas particularly, due to its efficiency, cost, and transportability compared to wood, kerosene, or electric power (Seidel 2008). In addition to the ecological problems linked to charcoal demand (Meyers et al. 2006, Van der Plas 1995), urban markets tend to be volatile, and the price of cooking fuel is becoming increasingly cost prohibitive for Malagasy citizens. Today in Madagascar, people may spend up to 10% of their annual income on fuel alone (Bergeron 2002). Demand for charcoal has tripled over the last 30 years, with high increases in urban population, and this demand is cited as a major cause of deforestation across the country (Indian Ocean Times 2014, Meyers et al. 2006, Van der Plas 1995, Bergeron 2002). While these challenges are commonly recognized, most rhetoric in conservation dialogues tends to focus on limiting deforestation via protected areas, rather than looking at alternative ways of meeting the fuelwood demand of citizens (Consiglio et al. 2006, Clayton 2011, Raik 2007).

In the context of these challenges, this study aimed to gain an understanding of fuelwood plantations in Madagascar, via case studies of plantation projects. Historically, French colonial rule implemented eucalyptus plantations in the central highlands, whose remnants are still used today to meet fuelwood demand of the capital and surrounding cities (Gade & Perkins-Belgram 1986). To-day, however, plantations for fuelwood tend to be limited to certain regions and projects and are not widespread. Clear statistics of plantation projects throughout the country do not exist, but a number of past, present, and future projects were identified in the scope of this study. Four projects: Startle, Bararatata, Ecoformation, and GIZ PGM-E were reviewed as case studies for this study (Fig. 1).

Beyond the four projects investigated, past initiatives in Madagascar have included: (1) USAID sponsored Jariâla, which forested approximately 3,845 hectares in 6 communes surrounding Fort Dauphin, largely using varieties of Eucalyptus, in addition to Pinus keziya and Grevellia exul (Sibomana & Burren 2006), (2) CARMACODEC (Carbonisation améliorée et contrôle forestier decentralize à Madagascar) a project implemented in association with CITE and French Research Center CIRAD, for sustainable charcoal production for Mahajunga, in Northwest Madagascar (Montagne et al. 2010), and (3) World Wildlife Fund implemented fuelwood initiatives in the Southwest region, Toliara. Some examples of ongoing projects.

Fig. 1. Map of Madagascar, showing locations of the projects interviewed.
that are now in early stages of operation include: (1) Alamanga is a French nonprofit, launched in 2010, with broad objective of reforestation, including species to be used for fuelwood among other uses (http://www.alamanga.fr/alamanga/), (2) Honko, a Belgian nonprofit, who launched a nursery for a fuelwood plantation project in 2012, in aims of reducing pressures on mangrove forests in the Southwest (Honko 2013), and (3) a broad scale project, “Program to support Agroforestry around Antananarivo,” is presently being launched by the European Union, aiming to implement 13,000 hectares of fuelwood plantation, among work with other interventions (aquaculture and agriculture), over a 5 year period (ASA 2014). In addition, numerous nonprofits throughout the country, such as Association pour le Développement de l’Energie Solaire (ADES 2006), Zahana, and Azafady, among others, promote interventions such as improved-efficiency and solar cookstoves, in the aims of reducing charcoal consumption.

Methods

I conducted semi-structured interviews between May-June 2014 with four organizations that operate plantation projects. The organizations talked to were Start!e, a project based in Fort Dauphin using bamboo for charcoal production; Ecoformation, an organization implementing plantations for goals of reforestation in the Sofia Region; Bararata, focused on bamboo’s potential to replace traditional forest-dependent products, with projects in the central highlands surrounding Antananarivo; and plantations of the fuelwood production-focused branch of German-Malagasy Program for the Environment (GIZ PGM-E) in the Antsiranana region of Northern Madagascar (Fig. 1). I conducted interviews with individuals at the director or management level within each organization. I also visited selected nursery or plantation sites of Ecoformation, Bararata and GIZ PGM-E.

Interviews asked questions regarding project background, decision-making processes, management practices, sites, species, markets for products, and general reflections of the individuals who represent such projects.

Results

Overall Goals

The organizations interviewed had varied objectives, and as a result, varied approaches in terms of their choices of plant species, project management, plantation products, and other activities beyond the plantations themselves. The organizations Start!e and Bararata both focused specifically on using bamboo as a fast-growing alternative to trees, to reduce pressures on natural forests. Despite this similarity, Bararata aimed to focus on bamboo and bamboo products more generally, whereas Start!e held more interest in the ecological and social implications of current charcoal supply chains. GIZ PGM-E also aimed to produce charcoal to meet urban fuelwood demands and to reduce pressures on natural forests, although using more traditional plan-
Table 1. Summary of four plantation projects interviewed

<table>
<thead>
<tr>
<th></th>
<th>Start!e</th>
<th>Bararata</th>
<th>Ecoformation</th>
<th>GIZ PGM-E</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year established</td>
<td>2011</td>
<td>2011</td>
<td>2011</td>
<td>1995</td>
</tr>
<tr>
<td>Location</td>
<td>Fort Dauphin</td>
<td>Antananarivo; Tamatave</td>
<td>Mampikony</td>
<td>Antsiranana</td>
</tr>
<tr>
<td>Objective</td>
<td>Produce charcoal to meet needs and supply sustainably grown charcoal in the region, environmental and social reasons</td>
<td>Encourage and increase bamboo as a substitution for wood/trees—for economical and environmental benefits</td>
<td>Reforestation to help protect Madagascar’s biodiversity, investment in carbon sequestration</td>
<td>Produce charcoal to meet demand &amp; reduce energy dependence on natural forests</td>
</tr>
<tr>
<td>Products</td>
<td>Charcoal</td>
<td>Furniture, construction material, charcoal, artisanal products</td>
<td>Charcoal</td>
<td>Charcoal</td>
</tr>
<tr>
<td>Current extent/Long-term planned extent</td>
<td>24 ha/1,000 ha</td>
<td>250 ha total</td>
<td>300 ha/ 5,000 ha</td>
<td>6,700 ha total</td>
</tr>
<tr>
<td>Species</td>
<td>Bambusa balooana, Oxytenanthera abyssinica</td>
<td>Dendrocalamus strictus, Dendrocalamus gundu, experimenting with others</td>
<td>Eucalyptus camaldulensis, Acacia auriculiformis, Terminalia mantaly</td>
<td>Eucalyptus camaldulensis</td>
</tr>
<tr>
<td>Land</td>
<td>Small-scale lease from private landowner + compensation to locals who were using the land parcel before the project</td>
<td>Voluntary participation in plantations: land must be shown as secure by legal recognition of land ownership, contract rights for the land, or communal ownership</td>
<td>Land that was previously used for zebu grazing, in 7,200 ha area (with areas used for agriculture left out)</td>
<td>Voluntary participation in plantations: communities commit to put in plantations, and technicians verify their suitability</td>
</tr>
<tr>
<td>Other activities</td>
<td>Improved carbonisation, supply chain intervention</td>
<td>Product construction &amp; commercialization, formation center</td>
<td>Technical training, improved cookstoves, product diversification (fruit, vegetables, hens)</td>
<td>Improved carbonization, supply chain intervention, improved cookstoves</td>
</tr>
<tr>
<td>Challenges</td>
<td>Land tenure &amp; project scale</td>
<td>Independence of project operations from funders; lack of collaboration with government</td>
<td>Limited funds &amp; equipment, poor planning, drought</td>
<td>Lack of supportive governmental framework for green fuelwood</td>
</tr>
</tbody>
</table>

Products produced

Closely linked to project objectives, the products produced by the different projects varied. Unsurprisingly, the main product from plantations that focused on fuelwood production was charcoal (Fig. 2). In the case of GIZ PGM-E, the majority of production was charcoal and only about 25% of wood grown on plantations was permitted for other uses, namely timber for local construction use. Start!e although still in early stages of the plantation production cycle, had a single expected product, bamboo charcoal.

Bararata another bamboo-oriented project focused more on a multitude of bamboo utilizations, rather than production of a single specific product. This organization aimed to make bamboo a commercially favorable product by working with artisans to encourage bamboo sourced furniture, buildings, construction materials, and artisanal products (Fig. 3). The organization was also exploring the potential of bamboo charcoal, but the bamboo species and size of plants produced by Bararata in the highlands does not produce large or hard...
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enough stems to make pure bamboo charcoal. Instead, they were mixing bamboo with charcoal from colonial-period eucalyptus plantations, to create a bamboo-supplemented “plantation-grown” charcoal product. Bararata also stated interest in potential of bamboo biomass for electricity, but this product remains an ideal at present.

On the other end of the spectrum compared to production-focused systems, Ecoformation’s approach was without specific products in mind. Instead, objectives of reforestation and carbon sequestration mean a lack of planned commercialization on the plantations that have been implemented. According to the interviewees at Ecoformation, once the plantations have been established for a greater period of time (they were established in 2013), their control and management would pass to the discretion of village-level cooperatives that could choose to utilize some wood for timber or fuelwood, as they see fit. Despite this option for local utilization, the organization expressed the opinion that the main objective was that of reforestation and vegetative cover, not specific products.

Land selection and local involvement

Two main approaches were adopted to access land for plantation projects. The first approach, used by Ecoformation and Start!e, employed preliminary studies to assess ideal sites for their projects, upon which they worked with village officials and documented land owners to obtain rights to land. Both Ecoformation and Start!e had central geographic areas of focus where the plantations were established and managed. In the case of Start!e, the current extent of the project is on land leased from an individual landowner with rights to the land. Local people had also been using the land for small-scale farming, so the organization offers compensation to them for lost profits. Start!e also involved the local community by receiving official blessing for the project from local officials and employing a number of local residents, aiming to employ the same number of men and women from the four neighboring village hamlets on the plantation. Ecoformation similarly involved local-level officials for permission to move forward with the project, and has hired local workers for nurseries and plantation parcels. The organization also aimed to incorporate villagers through outreach such as sanitary education, training youth as future nursery managers, and training people to operate their own nurseries, utilizing a micro-finance approach. For these nurseries, Ecoformation buys materials, gives them to individuals and at the end of the production period they buy back the seedlings produced, deducting the cost of the initial materials that were provided. By offering financial incentives for villager participation, Ecoformation aims to promote the concept and practice of plantations and dis-incentivize brush fires that threaten tree growth, which is a challenge to such projects throughout the country.

The second approach to land access, the approach of Bararata and GIZ PGM-E, was more decentralized. With these programs, the project was promoted by the organization, but then left to villages to voluntarily choose to participate, and identify land areas of their own to use for plantation parcels. In addition to identifying land areas, communes and villages are expected to manage the resulting plantations themselves. A key concept behind this approach, as mentioned by GIZ PGM-E, is to move away from people’s expectations of “handouts” from nonprofit projects.

Fig. 4. Bararata’s Dendrocalamus strictus demonstration plantation (left) and nursery (right) in Antananarivo.
In this sense, these projects operate without giving direct compensation to villagers, instead they are supported in the beginning plantation stages (planting, terrain preparation, original parent plant stock), and at the level of the supply chain at the end of the growth cycle. As rural land ownership (in the traditional sense) means small parcel sizes and more individual management, the geographic extent of these projects reach wider throughout regions of operation, and production is more dispersed.

Species choice

The different objectives of the organizations interviewed had a strong impact on the species selected for the various projects. Bararata and Start!e both focus on bamboo, but with different specific aims, the species of bamboo are different. Start!e, focused on charcoal production, uses species based on their thick-walled anatomy, the non-native *Bambusa balcooa* and *Oxytenanthera abyssinica*, which can be successfully converted to charcoal. Start!e introduced both of these species, working with Madagascar’s Department of Agriculture for importation and quarantine prior to their introduction. Additional considerations for Start!e’s species choice were bamboo’s fast growth, hardiness, and a lack of negative connotations from funders, where species such as *Eucalyptus* may be perceived as more invasive or negative environmentally. Bararata, while also concentrating on bamboo, has so far used species that had been previously introduced in the country, although it is also experimenting with other varieties of bamboo and the possible importation of species from China (Fig. 4).

Somewhat more “experimental” are the plantations of Ecoformation, which use principally *Eucalyptus camaldulensis*, and secondly *Khaya senegalensis* at present. The organization also listed *Acacia auriculiformis*, *Tectona grandis*, *Dalbergia sp.*, and *Terminalia mantaly* among the species used and is experimenting with mixed-species parcels. While the species most used by Ecoformation presently (*Eucalyptus camaldulensis* and *Khaya) are not native to Madagascar, the organization stated that they are aiming to find additional local species to use as well. With less production-focused objectives, this project seems to have more openness on species selection, although due to carbon credit funding, growth remained an important factor for financing the project. As a result it seems that fast-growing species have so far taken precedence over the “ideal” local ones.

Lastly, the longest established project, GIZ PGM-E, now mainly utilized *Eucalyptus camaldulensis* on their plantations. This project used experimental parcels in the beginning stages of the project, testing approximately 30 different species (Fig. 5). These experiments yielded *Eucalyptus camaldulensis* as the best choice, as most of the other species tested did not survive. Species of *Acacia (auriculiformis* and *mangium*) also survived, and was used in some of the project’s plantations sites, but proved to be highly invasive so the organization discontinued their use.

Beyond the Plantation

Regardless of their goals, all of the organizations are committed to social intervention beyond the act of growing trees. In terms of fuelwood, in order for plantation-produced charcoal to be competitive with traditional charcoal from natural forests, which is produced at little cost from the perspective
of tree establishment, organizations are intervening in the market chain from plantation to urban market. According to one interview, in the supply chain going from village to urban consumers there is a series of middle-men charging a 100% mark-up for each resale, resulting in end-consumer prices that are up to six times the price of the sale at the village level. Additionally, charcoal prices fluctuate seasonally, going up in the rainy season compared to the dry season, although prices overall have increasingly risen over the years. In this, there is the opportunity for projects to organize collective transport of products to market, making plantation charcoal more financially competitive by cutting out middlemen. GIZ PGM-E has implemented “Rural Commercialization Centers of ‘Green’ Fuelwood,” to enable villagers to sell to centers rather than middlemen (Fig. 6). Charcoal is put into special bags demarcating their origin from GIZ PGM-E plantations, and shipped directly to urban areas where they are sold, cutting out some of the intermediaries found in the typical supply chain. The charcoal for GIZ PGM-E is marketed as “Green Charcoal,” and the specialized bags show that the charcoal’s plantation origin—that it has not destroyed natural forests. According to the interview, there is a considerable market for “green” fuelwood in urban areas, and they are sometimes not even able to meet demand. Bararata is planning to install specialized kiosks for selling a similar “green” fuelwood, which is derived from a mix of bamboo from their project, with plantation-eucalyptus charcoal. The organization Start!e has yet to implement commercialization of their products, but have plans to organize transport of charcoal from rural areas to town via wholesale transportation and sale, in order to keep prices low. Start!e also aims to combat the seasonal fluctuation of fuelwood prices by flooding the market with plantation-produced products at fixed prices when the rainy season starts, when prices typically go up.

For projects focused specifically on fuelwood production (GIZ PGM-E and Start!e), improved charcoal kilns were also used (or planned to be implemented) to improve efficiency of charcoal production. In 2007, GIZ PGM-E started introducing methods of improved carbonization for making charcoal, by installing sealed cement kilns, to help prevent escape of methane that occurs in traditional methods, making carbonization more efficient. Implementation of the furnace has been a trial and error experience. The original rectangular-shaped kilns cracked due to expansion and contraction of heating processes (Fig. 6). The most recent model of kiln is dome-shaped, which has been more supple and so far withstood 38 firings. Start!e has plans for a mobile design, with an improved efficiency-kiln built on a shipping platform, enabling it to be brought to the raw material for conversion to charcoal.

Fig. 6. Fuelwood interventions beyond the plantation implemented by GIZ PGM-E: (Clockwise from top left): Rural “Green Charcoal” supply depot; an older rectangular model of improved charcoal kiln, which cracked after a few firings; and the most recent dome-shaped improved kiln, which has withstood firings so far.

On the other side of the producer-to-consumer supply chain, three of these projects also have improved cookstove interventions, to reduce net use of charcoal by consumers. Elements of these stoves can be narrower mouths than traditional metal stoves to reduce heat loss, or ceramic stoves that
hold and maintain heat better. GIZ PGM-E works with local artisans to produce improved-efficiency metal stoves. They are also looking to import ceramic stoves from the central highlands (where clay and ceramic production is common). Ecoformation does not emphasize fuelwood or charcoal production with their plantations, but to encourage less deforestation they promote fuel-efficient stoves and solar stoves (Fig. 7). Bararata has encountered challenges specific to bamboo charcoal, in that it burns too hot and risks breaking pots while cooking. As a result, the organization has a contract with an artisan to construct stoves that allow more space for bamboo combustion, although they are still in the experimental stages of the process.

Fig. 7. Improved efficiency ceramic cookstove and solar cookstove—a part of Ecoformation’s outreach to lower deforestation.

Reflections and Challenges
At the end of each interview, questions were posed regarding challenges the projects have faced, and the interviewee’s view on the role of plantations more broadly in Madagascar. The main challenges highlighted included limited funds, limitations due to funder expectations, lack of governmental framework supporting plantation projects, and challenges surrounding access to land and land tenure.

Opinions on the role of plantation projects more broadly in Madagascar might meet fuelwood demand were quite varied among the four projects. Ecoformation, whose objectives were focused more on reforestation than product production, stated a greater importance in increasing vegetative cover in Madagascar, and that exploration of alternative sources of energy (solar ovens, biogas, improved efficiency stoves, etc.) is imperative. Bararata, also less focused on charcoal-specific production, stated that in the case of bamboo, the profitability of plantations is most important, and that charcoal-only production would not pay for the cost of bamboo production. Speaking most favorably of the potential of plantations for fuelwood in Madagascar, Start!e stated that “plantations are completely necessary”, as current forest and natural fuelwood sources are not going to meet demand in the next 20-50 years. Despite this, Start!e expressed caution against being overly optimistic due to challenges of successful community management of such projects and barriers, such as land tenure, that make these efforts on a broad scale much more difficult. GIZ PGM-E stated similar perspectives as Ecoformation, as to the importance of looking for alternative energy sources, but expressed the reality that wood-based charcoal will remain a major energy source for populations in Madagascar for the foreseeable future. GIZ PGM-E aims to streamline production from production to consumption to reduce overall demand, expressing that “we need to think in a combined manner to address the problem at hand”.

Discussion
Many active plantation projects in Madagascar are relatively new, and the sustainability and overall impact of these projects remain to be seen. Charcoal will likely to continue to be a major source of energy for cooking for a large part of the Malagasy population, and a cause of deforestation in Madagascar in the near future, making it all the more important to understand and learn from plantation projects. While the goals of projects can vary widely, there are areas where organizations can collaborate and learn from one another.

There was a common underlying theme of in-
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interest in conserving natural forests, biodiversity, and addressing environmental concerns (such as erosion) among the projects interviewed. It seems that while organizations or individuals may value the use of local species, exotics such as eucalyptus or introduced bamboos have the faster growth rates needed to make managed plantations financially feasible and provide more rapid harvest and return. Two main approaches were taken in terms of local involvement and land acquisition. Two of the organizations had plantation parcels that are widely dispersed based on voluntary village-level participation in the projects, and the other approach was a more centralized one, with land concentrated in a given area. In the latter case, ownership of plantations remained with the organization, although there was some discussion of a transfer of management sometime in the future. It may be valuable for future studies to examine the different strategies of land acquisition and their impact on the long-term success of plantation projects.

The challenges faced by these organizations also yielded areas of common interest and possible collaboration. For example, the organization GIZ PGM-E has already achieved a “green” charcoal market, with significant demand in the Antsiranana region. This concept could be of interest to other organizations making plantation-produced charcoal; for instance Bararata expressed interest in marketing “green charcoal” products, but with fears that clients won’t be interested in the Antananarivo region. Similarly, Startle’s planned approach to seasonal fluctuation of charcoal prices by flooding the market to even-out seasonal price surges could be an interesting application to other projects as well. Lastly, as all of these organizations aim to minimize deforestation and maximize fuel efficiency, coming together over improved technology such as high-efficiency cook stoves and improved carbonization may prove to be essential. For instance, GIZ PGM-E has undergone several trials of improved efficiency charcoal kilns before finding a sustainable model that withstood firings. Sharing knowledge and innovations among organizations aiming to improve the efficiency of the charcoal supply chain from plantation to cookstove may help to reduce unnecessary trial-and-error and the costs associated with it.

In addition to improved communication among organizations, governmental-level and policy support for alternative fuelwood, silvicultural research and improved land tenure access are needed to address additional challenges faced by plantation projects. While the government has implemented a licensing system aiming to regulate charcoal trade in Madagascar, in reality few charcoal producers obtain the necessary permits, and unregulated charcoal trade is commonplace (Minten et al. 2013). Overall, the challenges and considerations in regards to all levels including production, trade, and regulations will likely need to be integrated in order to make sustainable fuelwood production in Madagascar a reality.

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