PRODUCTIVE LANDSCAPES (PROLAND)

RESTORING ABANDONED DEGRADED LAND FOR AGRICULTURE: A SYNTHESIS OF THE EVIDENCE AND A CASE STUDY FROM INDONESIA

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Increasing agricultural production and reducing deforestation are top priorities of the United Nations Sustainable Development Agenda and USAID's development assistance. Unfortunately, decades of unsustainable economic and agricultural policies and practices have undermined efforts to achieve these goals. Overexploitation of natural resources, especially soil and water, have caused close to one-quarter of the world's agricultural land to become degraded and unproductive. Such widespread degradation of agricultural land also undermines efforts to protect forests in many developing countries because farmers and large agricultural firms frequently respond by simply abandoning degraded land and moving to more productive forestland, which they clear and use for agriculture.

In this paper we consider a frequently recommended strategy to address these problems, namely, restoring abandoned degraded land and using it for agriculture. Evidence suggests that this strategy can produce numerous benefits for people and the environment, including sparing forests from agricultural conversion, but the benefits associated with restoring abandoned degraded land for agriculture will also be limited by constraints and trade-offs. We synthesize evidence from the scientific literature, and we illustrate key issues associated with this strategy by discussing a frequently proposed opportunity in Indonesia: restoring the degraded Imperata grasslands to grow oil palm. We also discuss resources and decision tools that practitioners can use to determine the suitability of the strategy, and to evaluate prospects for success, in different development contexts.

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RESTORING ABANDONED DEGRADED LAND FOR AGRICULTURE CAN PRODUCE NUMEROUS BENEFITS FOR PEOPLE AND THE ENVIRONMENT BUT ALSO COMES WITH CONSTRAINTS AND TRADEOFFS

Degraded land is both a pervasive global problem and a major opportunity for ecological restoration (IPBES, 2018). According to recent studies, there are at least two billion hectares of degraded land in the world—for example, deforested land, or land where the soil has been eroded or lost fertility—that could be restored to more productive landscapes[1] (Oldeman, Hakkeling, and Sombroek, 1991; Cai, Zhang, and Wang, 2011; Minnemeyer et al., 2011; Bastin et al., 2019). In developing countries, somewhere between 150 million (Field, Campbell, and Lobell, 2008; Nijsen et al., 2012) and 500 million hectares (Houghton, 1990; Houghton, Unruh, and Lefebvre, 1991; Hoogwijk et al., 2003) of former agricultural land have become so unproductive that people have essentially abandoned it.

Consequently, many scientists and development practitioners are now calling for a global movement to restore degraded land. There are numerous international initiatives. Principal among them are the United Nations (UN) Sustainable Development Agenda, especially Development Goal 15, which aims to "…halt and reverse land degradation…" (UN General Assembly, 2015); the UN Convention to Combat Desertification[2]; the UN Reduced Emissions from Deforestation and Forest Degradation (REDD and REDD+) programs[3]; the Center for International Forestry Research Global Landscapes Forum[4]; and the Bonn Challenge,[5] which was launched by the

> As of 2020, more than 50 countries have made Bonn Challenge commitments to restore over 170 million hectares of deforested and other degraded land.

[1] Most researchers define "degraded land" as land that has reduced biological productivity (Gibbs and Salmon, 2015).

[2] https://www.unccd.int/

[3] https://www.un-redd.org/

[4] https://www.globallandscapesforum.org/

[5] http://www.bonnchallenge.org/

Government of Germany and the International Union for Conservation of Nature (IUCN) and aims to restore 350 million hectares of the world's deforested and other degraded land by 2030.[6]

Underlying each of these initiatives is a holistic restoration approach known as Forest Landscape Restoration (FLR). FLR aims not only to restore natural landscapes by increasing their biological productivity but also to improve human well-being.[7] It is a stakeholder-driven approach that brings people together to identify, negotiate, and implement restoration activities[8] designed to achieve ecological, economic, and social benefits[9] by striking a balance between restoring natural ecosystems, enhancing ecosystem services, and supporting productive functions of land for agriculture. Because FLR promotes a range of restoration options to help produce multiple outcomes, including many that support the United Nations Sustainable Development Goals (FAO, 2018), numerous national governments, environmental research groups, and sustainable development organizations have joined forces in a Global Partnership on Forest Landscape Restoration (GPFLR)[10] to advance FLR practices.

FLR proponents do not necessarily distinguish between abandoned degraded land and land that is still in use, and, as we discuss below, the distinction is not always obvious. Nonetheless, some researchers suggest that abandoned degraded land presents a unique opportunity for restoration: If the land is abandoned, then it should be readily available for restoration to more productive landscapes, including agricultural landscapes, with minimal conflict over other potential land uses (Cramer and Hobbs, 2007; Campbell et al., 2008; Field, Campbell, and Lobell, 2008; Corley, 2009; Meyfroidt et al., 2016). One compelling argument for converting abandoned degraded land to agriculture, in particular, rests on three key points:

1. Global demand for new agricultural land is expected to increase sharply in the next 20 to 30 years (Alexandratos and Bruinsma, 2012; Searchinger et al., 2013; Valin et al., 2014);

2. Agricultural expansion has historically been a major driver of global deforestation (Millennium Ecosystem Assessment, 2005; FAO, 2018); and

3. Restoring abandoned degraded land for agriculture could help meet growing demand while sparing forests from agricultural conversion (Campbell et al., 2008; Field, Campbell, and Lobell, 2008; Corley, 2009; Meyfroidt et al., 2016; IPBES, 2018; IPCC, 2019).

For stakeholders who wish to restore degraded land and use it for agriculture, FLR proponents primarily recommend agroforestry (whether the land is abandoned or not). Essentially agriculture with trees, agroforestry encompasses a broad array of techniques, including cultivating trees on farms and pastureland, farming in forests, and growing tree crops such as coffee or oil palm.[11] Founded on the understanding that trees are vital components of many natural ecosystems, agroforestry accords with the FLR approach to restoration because it has potential to produce numerous benefits for people and the environment. For example, restoring degraded land through agroforestry typically involves protecting the soil from erosion and improving soil fertility to increase agricultural production (Searchinger et al., 2013; Murthy et al., 2016; IPBES, 2018). This can help improve livelihoods, especially for the rural poor (Nair, 1993; Murthy et al., 2016). Increasing agricultural production on degraded land also can help reduce deforestation by sparing intact forests from agricultural conversion (Belsky and

[6] Progress to date has been slow. According to a 2019 assessment, Bonn Challenge commitments have resulted in only 27 million hectares of restored land (NYDF Assessment Partners, 2019).

[7] http://www.bonnchallenge.org/content/forest-landscape-restoration

[8] http://www.bonnchallenge.org/content/restoration-options

[9] http://www.bonnchallenge.org/content/restoration-benefits

[10] http://www.forestlandscaperestoration.org/

[11] https://www.worldagroforestry.org/about/agroforestry

Siebert, 2003; Gibbs et al., 2008; Koh and Wilcove, 2008; Fairhurst and McLaughlin, 2009; Searchinger et al., 2013). Reducing deforestation, in turn, conserves forest biodiversity and helps mitigate climate change because forests capture and store carbon dioxide from the atmosphere. In addition, trees cultivated as part of an agroforestry system can provide habitat for diverse species (Murthy et al., 2016; IPBES, 2018) and capture and store carbon dioxide in their own right (Albrecht and Kandji, 2003; Montagnini and Nair, 2004; Murthy et al., 2016; IPBES, 2018).

Of course, agroforestry is not the only way to restore degraded land for agriculture. Other options include restoring grassland systems, which can improve forage for livestock, and restoring wetlands, which can improve water quality and replenish groundwater essential for agriculture. But agroforestry has gained broad support among FLR proponents largely because agriculture has long been a primary cause of deforestation; deforestation is widely regarded as one of the world's greatest environmental challenges; and as noted above, agroforestry can help restore many ecosystem services that typically come from forests while increasing agricultural production. Ultimately, when evaluating restoration alternatives, people need to consider which restoration benefits they most value in the landscapes where they live and work as well as a suite of economic, environmental, and legal and social constraints and trade-offs.

Indeed, restoring abandoned degraded land for agriculture may be a compelling strategy in some landscapes—as in the case of Indonesia's Imperata grasslands, which we discuss below—but researchers have identified several potential constraints and trade-offs that practitioners should consider. For example, abandoned degraded land might be abandoned because it is severely degraded; consequently, restoring it could be prohibitively difficult and expensive (Rey Benayas, 2005; FAO, 2015; Gibbs and Salmon, 2015). The land also might be fragmented into small patches or far from transportation infrastructure, which could make it less useful for agriculture (Lambin et al., 2013), or it might be more profitably used for other types of development in some cases (Verdone, 2015). A related consideration is that the land might be so difficult to restore that some stakeholders would not consider restoration feasible (Rey Benayas, 2005; Lambin et al., 2013; Searchinger et al., 2013; Gibbs and Salmon, 2015). In addition, abandoned degraded land could be valuable for environmental conservation. For example, it might provide passive protection to forests by serving as a buffer zone that limits human activity in the forests (Gibbs and Salmon, 2015). If left alone, the land might revert to a more productive ecosystem that could provide wildlife habitat and help mitigate climate change (Campbell et al., 2008; Field, Campbell, and Lobell, 2008; Lambin et al., 2013; Searchinger et al., 2013), or the land could be actively restored as forest or some other productive ecosystem. Moreover, converting abandoned degraded land to agriculture might require inputs such as fertilizers or herbicides that could harm the environment (Campbell et al., 2008; Field, Campbell, and Lobell, 2008).

Practitioners evaluating a restoration project on abandoned degraded land should also consider whether the land is legally classified for agriculture (Stickler, 2012; Lambin et al., 2013; Rosenbarger et al., 2013; Sales et al., 2016); whether some people might have latent tenure claims to it (Tomich et al., 1996; Friday, Drilling, and Garrity, 1999; Ruysschaert et al., 2012; Lambin et al., 2013); and whether people might even still be using it, perhaps less intensively (Field, Campbell, and Lobell, 2008; Searchinger et al., 2013; IPBES, 2018). To avoid social conflict, those who restore abandoned degraded land for agriculture must have a clear right to do so (Ruysschaert et al., 2012; IPBES, 2018).

SUMMARY OF BENEFITS, CONSTRAINTS, AND TRADE-OFFS

Restoring degraded land can produce **BENEFITS** for people and the environment	Practitioners should also consider **CONSTRAINTS AND TRADE-OFFS**		
	ECONOMIC	ENVIRONMENTAL	LEGAL and SOCIAL
• Increase agricultural production • Improve livelihoods • Reduce deforestation • Conserve biodiversity • Improve water quality • Replenish groundwater • Mitigate climate change	• Cost of restoration • Utility of the land for agriculture • Opportunity costs, including other viable options for developing the land	• Ecological feasibility of restoration • Potential for the land to provide passive protection to forests • Potential for the land to revert or be restored to a more productive ecosystem, serve as wildlife habitat, or mitigate climate change • Possible environmental harms from restoration	• Legal classification of the land • Land tenure and land rights • Local peoples' interests in using the land

REAPING BENEFITS IN INDONESIA: RESTORING IMPERATA GRASSLANDS TO GROW OIL PALM

One of the most frequently cited opportunities to restore abandoned degraded land for agriculture comes from Indonesia. In recent years, a number of development organizations promoting FLR, along with researchers and business groups, have proposed that farmers and agricultural firms in Indonesia should restore degraded landscapes currently dominated by the invasive grass species *Imperata cylindrica* by converting the land to oil palm (*Elaeis guineensis*) plantations for commercial palm oil production (Koh and Wilcove, 2008; Fairhurst and McLaughlin, 2009; Gingold, 2010; Gingold et al., 2012; Ruysschaert et al., 2012; Searchinger et al., 2013; Shahputra and Zen, 2018; Mutsaers, 2019). Here we discuss this proposal as a means to illustrate the potential for restoring abandoned degraded land and using it for agriculture to produce each of the benefits listed above.[12]

In 1997, researchers estimated that Imperata grasslands covered approximately 8.5 million hectares in Indonesia (Garrity et al., 1997). By 2018 the estimates were between 15 and 19 million hectares (Murniati, 2002; Lambin et al., 2013; Shahputra & Zen, 2018).

Imperata cylindrica (hereafter Imperata) is a highly invasive species that covers extensive areas in Indonesia. It reproduces rapidly, spreads quickly in landscapes that have been deforested, burned, or otherwise cleared of vegetation, and, once established, forms a thick mat of vegetation that can effectively prevent other plants from growing in the same area (Murniati, 2002; Mutsaers, 2019). Imperata is both flammable and fire-tolerant; its stems and leaves burn readily during dry-season fires while its roots typically survive, allowing the plants to quickly regenerate, and Imperata's tendency to catch fire also prevents other plants from growing nearby (Tomich et al., 1996; Friday, Drilling, and Garrity, 1999; Murniati, 2002). As people have cleared forests for timber in Indonesia and farmers have practiced slash-and-burn agriculture, Imperata has mounted an impressive invasion, now covering millions of hectares across the country (Murniati, 2002; Mutsaers, 2019).

Imperata grasslands are considered degraded landscapes because they have low productivity per unit area (Gingold et al., 2012; Ruysschaert et al., 2012); minimal species diversity (Tomich et al., 1996; Murniati, 2002; Gingold et al., 2012); and, frequently, low-fertility soils (Garrity et al., 1997; Mutsaers,

[12] We focus here on a *proposal* to restore Indonesia's Imperata grasslands to grow oil palm, rather on lessons from historical examples of FLR implementation, for two reasons: (i) although practitioners have not yet carried out large-scale restoration of *Imperata* grasslands to grow oil palm, researchers and practitioners have written extensively about the possibility of doing so and conducted substantial analysis to demonstrate potential benefits, constraints, and trade-offs; and (ii) to date, there are very few published analyses focused on benefits, constraints, and/or trade-offs associated specifically with restoring abandoned degraded land for agriculture.

2019). According to two productivity analyses, Imperata grasslands in Indonesia contain between 20 and 40 tons of carbon per hectare, compared to more than 200 tons per hectare in intact rainforests in Indonesia (Danielsen et al., 2008; Dewi et al., 2009).[13] Species diversity is low in the grasslands because Imperata successfully outcompetes other plants, and Imperata's dominance also blocks the development of a common ecological process known as succession, through which less diverse ecosystems generally become more diverse over time (Friday, Drilling, and Garrity, 1999; Murniati, 2002).

Indonesian farmers do occasionally use the Imperata grasslands to cultivate food or cash crops, harvest thatch, or graze animals, but farmers often abandon these areas after just a few harvests because growing annual crops in the Imperata grasslands is labor-intensive and costly; Imperata is very difficult to eradicate by tillage or other mechanical means; and, as noted above, soil fertility is often poor (Garrity et al., 1997; Friday, Drilling, and Garrity, 1999; Murniati, 2002; Searchinger et al., 2013; Mutsaers, 2019). Unfortunately, a common pattern for many of Indonesia's migrant and smallholder farmers who don't have access to fertilizer or sources of power that can make tillage easier is to abandon the Imperata-infested land and practice slash-and-burn agriculture in nearby forests (Garrity et al., 1997; Murniati, 2002; Ruysschaert et al., 2012; Mutsaers, 2019). It is possible to eradicate Imperata with a procedure that includes mechanical removal, herbicide applications, fertilizing the soil, and planting cover crops that prevent the grass from becoming reestablished, and larger agricultural firms could likely cover the costs of this procedure, but most migrant and smallholder farmers would need financial assistance to do it (Garrity et al., 1997; Murniati, 2002; Fairhurst and McLaughlin, 2009; Ruysschaert et al., 2012).

BENEFITS OF RESTORING INDONESIA'S IMPERATA GRASSLANDS TO GROW OIL PALM

Nonetheless, if the costs can be managed, then restoring Indonesia's Imperata grasslands to grow oil palm has potential to increase agricultural production, improve livelihoods for Indonesians, reduce deforestation, conserve biodiversity, and mitigate climate change.

Increasing Agricultural Production

Restoring Imperata grasslands to grow oil palm can help develop agricultural markets in Indonesia and meet increasing global demand for agricultural land and vegetable oil products. The oil palm is the world's most productive source of vegetable oil (Corley, 2009; Searchinger et al., 2013), and Indonesia is already the world's largest producer (Mutsaers, 2019). In the last two decades, the amount of area in Indonesia planted in oil palm has grown dramatically, from approximately 4 million hectares in 2000 to almost 12 million hectares today (GAPKI [Indonesian Palm Oil Producers Association], 2017). Although the amount of land in Indonesia that might be feasible to convert from Imperata grassland to oil palm will be limited by constraints and trade-offs, discussed in detail below, several researchers who take these considerations into account still argue that Indonesia's Imperata grasslands could supply a substantial amount of the land needed to meet expected increases in global demand for palm oil for many years to come (Corley, 2009; Gingold, 2010; Gingold et al., 2012; Searchinger et al., 2013).

> By 2050, global demand for vegetable oil will likely double (compared to 2009), and palm oil producers will need to plant an additional 12-28 million hectares of oil palm to meet demand (Corley, 2009; Fairhurst & McLaughlin, 2009).

Improving Livelihoods

Restoring Indonesia's Imperata grasslands to expand palm oil production could also help improve livelihoods for rural agricultural workers and smallholder farmers (Shahputra and Zen, 2018). Palm oil

[13] Productivity is measured as the total amount of carbon accumulated in aboveground plant tissues (e.g., stems and leaves).

production in Indonesia creates a relatively large number of jobs because it is typically labor intensive, and smallholder operations account for about 40 percent of the country's oil palm plantations (Kasryno, 2015; Mutsaers, 2019; Rochmyaningsih, 2019). As the industry has expanded over the last 20 years and employment opportunities have increased, palm oil production has contributed significantly to rural economic development (Kasryno, 2015; Shahputra and Zen, 2018). Although economic inequality is sometimes acute, with the bulk of revenues benefiting a small group of wealthy elites (Shahputra and Zen, 2018; Rochmyaningsih, 2019), palm oil industry growth has nonetheless been a major source of poverty alleviation for the rural poor (World Growth, 2011; Kasryno, 2015; Shahputra and Zen, 2018). According to the World Bank, there is a strong correlation between the expansion of palm oil production in Indonesia and poverty reduction, with more rapid poverty reduction in regions with more rapid expansion; poverty reduction effects are greatest for smallholders (World Bank, 2011).

> The dramatic expansion of oil palm plantations has made the palm oil industry one of Indonesia's most important sources of economic growth, providing jobs for approximately 4 million rural agricultural workers and smallholder farmers (World Growth, 2011; Kasryno, 2015; Shahputra and Zen, 2018).

Reducing Deforestation

Restoring Indonesia's Imperata grasslands by converting them to oil palm plantations could also help reduce deforestation (Koh and Wilcove, 2008; Corley, 2009; Fairhurst and McLaughlin, 2009; Gingold et al., 2012; Searchinger et al., 2013; Shahputra and Zen, 2018; Mutsaers, 2019). Historically, Indonesian farmers and agricultural firms have increased palm oil production largely by clearing rainforests to expand operations, and the recent rapid growth of oil palm in Indonesia has been a major driver of deforestation (Page et al., 2011; Miettinen et al., 2012; Shahputra and Zen, 2018; Mutsaers, 2019). One study finds that at least 56 percent of oil palm expansion in Indonesia between 1990 and 2005 can be attributed to forest conversion (Koh and Wilcove, 2008).

> Since about 1990, farmers and agricultural firms have converted approximately 6 million hectares of forest in Indonesia to oil palm plantations (Koh and Wilcove, 2008; Vijay et al., 2016).

Another study focused on Kalimantan, Indonesia, where many oil palm plantations are located, reports that 90 percent of land converted to oil palm between 1990 and 2010 had previously been forested (Carlson et al., 2012). Stakeholders around the world—including the Roundtable on Sustainable Palm Oil, which comprises thousands of growers, traders, manufacturing companies, and government and nongovernmental organizations—have responded by proposing to spare Indonesia's rainforests from additional oil palm expansion and instead develop new plantations on degraded land (Gingold, 2010; RSPO Indonesia National Interpretation Working Group, 2008).

Conserving Biodiversity

Modern oil palm plantations are usually planted as monocultures that support only a few other incidental species (Tomich et al., 1996; Murniati, 2002; Gingold et al., 2012), but the rainforests in Indonesia that farmers and agricultural firms have historically cleared and converted to oil palm are among the most biodiverse ecosystems in the world, with thousands of species that are found nowhere else on Earth (Koh and Wilcove, 2007; Laurance, 2007; Koh and Wilcove, 2008; Meijaard et al., 2018). Sparing these forests by directing new oil palm expansion to Indonesia's Imperata grasslands could help conserve the forests' uniquely rich biodiversity.

Restoring Indonesia's low-diversity Imperata grasslands to grow oil palm also presents an opportunity for farmers to create new habitats that could support greater species diversity in or adjacent to the oil palm plantations (Rochmyaningsih, 2019). For example, traditional agroforestry systems in West Africa that include oil palm also typically include other tree species, annual crops, and leguminous cover plants that help enrich the soil (Mutsaers, 2019). In Indonesia, some researchers are working with oil palm plantation owners to restore natural habitat buffer zones in 50-meter-wide strips along rivers running through the plantations to create habitat for native plants and animals; the restoration project is only a few years old, but early results show that native trees planted in the buffer strips are thriving (Rochmyaningsih, 2019).

Mitigating Climate Change

According to the Intergovernmental Panel on Climate Change, conserving forests that capture and store carbon dioxide from the atmosphere is one of the world's most effective strategies to mitigate climate change (IPCC, 2018). The rainforests in Indonesia that farmers and agricultural firms have historically cleared for oil palm are not only some of the most biodiverse ecosystems in the world, they are also among the most carbon-rich, especially Indonesia's peat swamp forests, whose soils have been accumulating carbon from the atmosphere for thousands of years (Page et al., 2011; Miettinen et al., 2012). Clearing these forests releases extraordinary amounts of carbon back to the atmosphere, from burning or decomposition of the cleared vegetation and through decomposition of organic matter in the soil (Danielsen et al., 2008; Page et al., 2011; Carlson et al., 2012). Sparing Indonesia's rainforests by directing new oil palm expansion to the Imperata grasslands could help preserve the forests' function as global carbon sinks and avoid future emissions that would exacerbate climate change.

Restoring Imperata grasslands in Indonesia by converting them to oil palm will also achieve a net benefit for atmospheric carbon capture and storage on the restored land. As noted, the Imperata grasslands are considered degraded in part because they are low-carbon ecosystems—they capture and store only about 20 to 40 tons per hectare of carbon from the atmosphere. But an oil palm plantation can capture and store 30 to 40 tons per hectare of carbon just ten years after planting, and approximately 70 to 80 tons per hectare 20 years after planting (Danielsen et al., 2008; Gibbs et al., 2008; Dewi et al., 2009; Quezada et al., 2019). Thus, oil palm plantations established on Imperata grasslands can become carbon sinks in their own right.

ASSESSING CONSTRAINTS AND TRADE-OFFS

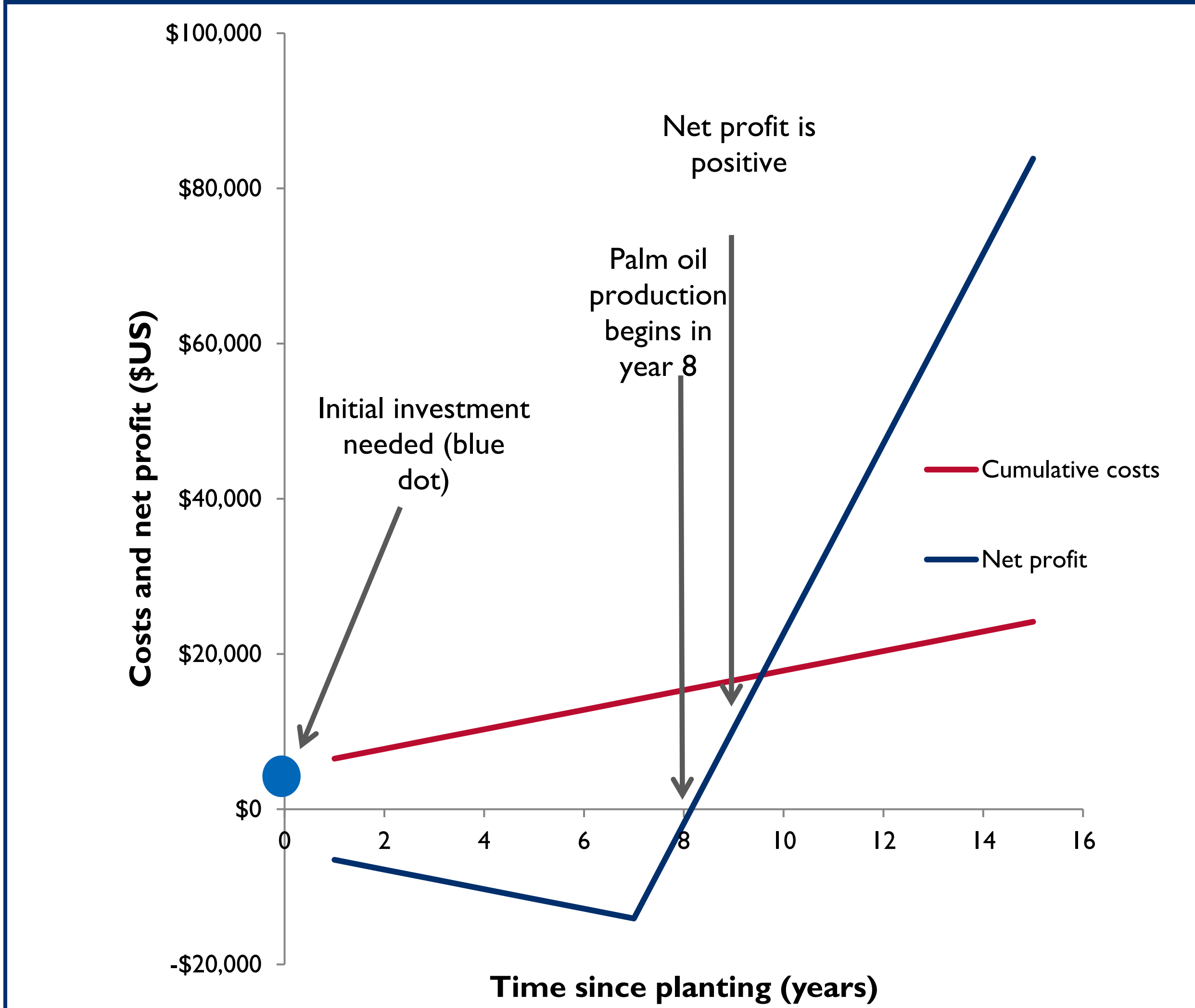
Despite its potential, researchers investigating the restoration of degraded land for agriculture have identified several possible constraints and trade-offs associated with this strategy; we can group these into economic, environmental, and legal and social considerations. Here we discuss these constraints and trade-offs in greater detail and provide additional context by referring again to the case of Indonesia's Imperata grasslands and palm oil industry.

ECONOMIC CONSIDERATIONS

Many researchers have pointed out that agriculture on degraded land can be expensive compared to more productive landscapes when degraded land requires more costly inputs such as fertilizer, irrigation, labor, and herbicides to control weedy species (Rey Benayas, 2005; Gibbs et al., 2008; Lambin et al., 2013; Gibbs and Salmon, 2015). Restoring Indonesia's Imperata grasslands by converting them to oil palm is a case in point. As noted above, Imperata grasslands frequently have low-fertility soils, and eradicating Imperata is not only labor-intensive but also very difficult without herbicides. In addition, fire suppression is crucial when Imperata is pervasive in the area. Financial analysis indicates that restoring Imperata grasslands by converting them to oil palm can yield long-term profits if farmers and agricultural firms are able to afford the restoration and startup costs, but these expenses will likely deter poorer farmers from making the investments without assistance (Tomich et al., 1996; Garrity et al., 1997; Murniati, 2002; Fairhurst and McLaughlin, 2009; Ruysschaert et al., 2012).

CASH FLOW MODEL FOR RESTORING IMPERATA GRASSLANDS TO OIL PALM

The World Wildlife Fund developed a cash flow model to estimate the costs and potential profitability of restoring Imperata grasslands in Indonesia for oil palm. As detailed below, the researchers found that restoration would yield a positive return on investment, but it would take eight years for plantations to mature and begin producing palm oil and nine years to be profitable (Fairhurst and McLaughlin, 2009).



The utility of abandoned degraded land for agriculture will also be affected by its scale and proximity to needed infrastructure (Gingold et al., 2012; Lambin et al., 2013). In Indonesia, some agricultural firms engaged in palm oil production prefer to invest in plantations that are at least 5,000 hectares to take advantage of economies of scale (Gingold et al., 2012). Projects in remote areas with poor access to shipping routes or palm oil processing facilities will be less useful and attractive to farmers and agricultural investors (Friday, Drilling, and Garrity, 1999; Gingold et al., 2012; Lambin et al., 2013).

In addition, there might be significant opportunity costs. For example, if farmers and agricultural firms restore abandoned degraded land for agriculture instead of clearing forests, they lose the opportunity to produce and sell products such as timber or charcoal that they take from the forests. In Indonesia, selling timber from newly cleared forests has provided agricultural firms essential funding to establish oil palm plantations, which do not produce palm oil and thus do not generate revenue for several years after planting (Corley, 2009; Ruysschaert et al., 2012; Mutsaers, 2019). Other opportunity costs are associated with other viable options for developing the land (Verdone, 2015), for example, if the land has valuable mineral resources or might be a good location for wind- or solar-electricity production.

Developing Financial Incentives for Restoration

Because restoring degraded land by converting it to agriculture might be relatively expensive compared to agriculture on more productive land, proponents should consider developing financial incentives for farmers and agricultural firms (Corley, 2009; Delgado et al., 2015; Gibbs & Salmon, 2015). Researchers have described numerous options for government agencies, banks, nongovernmental organizations, and private companies and impact investors to take on or share costs (Corley, 2009; Ruysschaert et al., 2012; Delgado et al., 2015; FAO, 2015).

In the case of converting Indonesia's Imperata grasslands to oil palm production, one study found that a credit union supporting a cooperative of independent smallholder farmers could provide funding for restoration and startup costs, break even on its investment after seven years, and reasonably expect almost twenty more years of sustained revenue (Ruysschaert et al., 2012). The researchers who conducted this study also stressed the need to build capacity among smallholder farmers to take advantage of credit union financing and create enabling conditions for the credit union to achieve a potentially positive return on investment. According to the study, multiple stakeholders needed to invest substantial time and effort to build trust among the farmers; raise farmers' awareness about advantages of collective action; train farmers to carry out the collective's operations; and register the credit union with the local government to be eligible to obtain loans (Ruysschaert et al., 2012).

Other groups working in Indonesia have promoted payments for ecosystem services to help finance the development of oil palm on degraded land, with the ultimate goal of sparing rainforests from conversion, by assigning a price to the amount of atmospheric carbon that rainforests capture and store. In 2010, the Indonesian government agreed to this approach through a US$1 billion partnership with the government of Norway (World Bank, 2011). According to the agreement, Norway committed to pay Indonesia to reduce deforestation, and Indonesia committed to implement a variety of forest protection policies, including developing agriculture on degraded land instead of converted rainforest (WRI, 2019). In 2019, Norway agreed to make the first payment of approximately US$24 million after Indonesia achieved a 60 percent reduction in forest loss in 2017 compared to 2016. Notably, it took nine years for Indonesia to earn the first payment because Indonesia's government delayed implementing essential forest protection policies; delayed establishing a monitoring, reporting, and verification system necessary to document progress reducing deforestation; and engaged in lengthy negotiations with the government of Norway over what counts as deforestation (WRI, 2019). If Indonesia's government continues to comply with this agreement, it could use future payments from Norway to incentivize oil palm development in the Imperata grasslands.

ENVIRONMENTAL CONSIDERATIONS

Researchers have argued that practitioners should consider whether restoring abandoned degraded land for agriculture is the best use of the land or whether it might be more valuable for conserving biodiversity or mitigating climate change (Gingold et al., 2012; Lambin et al., 2013; Searchinger et al., 2013; Gibbs and Salmon, 2015). For example, as noted above, abandoned degraded land located near a forest might provide passive protection to the forest by serving as a buffer zone that has minimal human activity, and developing the land with agricultural infrastructure could weaken this protective function. In addition, stakeholders might prefer to restore the land as forest or some other productive ecosystem, or the land might revert to a more productive ecosystem on its own, thereby providing wildlife habitat and helping to mitigate climate change by capturing and storing carbon dioxide from the atmosphere (FAO, 2012; Gingold et al., 2012; Lambin et al., 2013; Searchinger et al., 2013). The fact that Indonesia's Imperata grasslands will not revert to a more biodiverse or carbon-rich system if left alone—because Imperata is dominant, and frequent fires prevent other plants from getting established—is one reason why many people support converting the grasslands to oil palm.

Researchers have also argued that abandoned degraded land might reach an ecological tipping point beyond which it is so degraded that at least some stakeholders would consider restoration infeasible. Examples include areas that have pervasive and persistent weedy species, very polluted soils, or extremely compacted soils due to intensive grazing (Rey Benayas, 2005; Lambin et al., 2013; Searchinger et al., 2013; Gibbs and Salmon, 2015). Indeed, such problems are common reasons why farmers and pastoralists abandon agricultural land and move to new areas (Lambin et al., 2013; Searchinger et al., 2013). But different stakeholders have different standards for the desirability or feasibility of ecological restoration, and if sufficient resources are available, even the worst examples of degraded land can be improved (Clewell and Aronson, 2007).

Another important environmental consideration is the risk that restoring abandoned degraded land by converting it to agriculture might ultimately pollute the land or nearby ecosystems (Rey Benayas, 2005; Gibbs and Salmon, 2015; Cowie et al., 2018). Again, Indonesia's Imperata grasslands provide a case in point. Because restoring the grasslands by converting them to oil palm typically requires fertilizer and herbicide, the process could pollute nearby water supplies (Gingold et al., 2012). Moreover, monoculture oil palm plantations are sensitive to pests and disease, which growers might control with chemical pesticides (Mutsaers, 2019).

Avoiding and Reducing Environmental Harms that Might be Associated with Restoration

Like all investments in agricultural productivity, restoration of abandoned degraded land for agriculture needs to follow environmental safeguards. This is not only the responsibility of farmers and agricultural firms; when governments and donors are investing, they also need to ensure that environmental harms are avoided when possible and mitigated when necessary.

Researchers promoting the restoration of Imperata grasslands to grow oil palm have suggested that farmers and agriculture firms should not establish new oil palm plantations in areas where surface water that can carry fertilizer or herbicide is likely to infiltrate ground water (Gingold et al., 2012); that plantations should have natural vegetation buffer zones adjacent to lakes and rivers (Gingold et al., 2012); and that oil palm growers should consider using integrated pest management practices to reduce the need for pesticides (Mutsaers, 2019; Rochmyaningsih, 2019).

LEGAL AND SOCIAL CONSIDERATIONS

Researchers have highlighted several legal and social issues that practitioners should consider when assessing opportunities to restore abandoned degraded land for agriculture. Principal among the legal issues is land-use classification. In some developing countries, degraded land that might be suitable for agriculture might not be zoned to permit it (Stickler, 2012; Lambin et al., 2013; Sales et al., 2016). For example, a study in Indonesia found more than 14 million hectares of degraded land, much of it Imperata grassland, that could be suitable for oil palm plantations, but government land-use classifications excluded more than five million hectares of the land from agricultural development; much of it was classified as "forest estate" (Rosenbarger et al., 2013). The researchers who conducted the study identified options for reclassifying the degraded land and described some of the key barriers to doing so, including lengthy and costly legal procedures and a lack of publicly available data and maps to help establish official land-use classifications (Rosenbarger et al., 2013).

In addition, there might be significant land tenure issues. For example, although degraded land might appear to be abandoned and available for development, in reality some people might claim ownership of it (Tomich et al., 1996; Friday, Drilling, and Garrity, 1999; Corley, 2009; Ruysschaert et al., 2012). This could be the case with many areas in Indonesia that are now Imperata grassland, if the people who cleared the land established a customary right to it, even if their claim to the land is not recognized as formal legal ownership (Tomich et al., 1996; Ruysschaert et al., 2012). Furthermore, it is possible that the land might not actually be abandoned, that people are still using it, but perhaps less intensively. Although farmers frequently abandon Indonesia's Imperata grasslands, people do sometimes use the grasslands, in particular for grazing animals (Friday, Drilling, and Garrity, 1999; Searchinger et al., 2013).

Planning Restoration Projects to Account for Legal and Social Issues

Latent tenure claims and failure to account for local people's rights and interests can hinder the success of a restoration project. To avoid conflicts over ownership, it is essential to clarify land rights before a project moves forward (Corley, 2009; Ruysschaert et al., 2012; IPBES, 2018). A study of farming communities in Indonesia noted that efforts to restore Imperata grasslands and convert them to more productive agroforestry systems failed to gain support from local farmers who did not own, or see clear benefits from protecting, the trees (Murniati, 2002). According to this study, collaborating with smallholder farmers who have secure tenure status is one of the most effective strategies for converting Imperata grasslands to productive agriculture (Murniati, 2002).

Researchers and development practitioners have also called for restoration proponents to implement social safeguards to protect local communities, especially if people are still using the land proposed for restoration (Lambin et al., 2013; Gibbs & Salmon, 2015; IPBES, 2018). For example, the Roundtable on Sustainable Palm Oil has a certification standard that requires developers to obtain local peoples' free, prior, and informed consent before establishing new oil palm plantations in their communities (Colchester et al., 2015). Following such requirements not only respects peoples' rights and interests but also may enhance restoration outcomes. Other researchers have noted that if restoration project developers fail to work with local communities, or push local people out of restored areas, those people might move to nearby forests and clear additional forestland for agriculture (Gibbs & Salmon, 2015).

RESOURCES AND DECISION TOOLS FOR PRACTITIONERS CONSIDERING RESTORING ABANDONED DEGRADED LAND FOR AGRICULTURE

FLR proponents have developed several resources and decision tools that practitioners can use to assess the benefits, constraints, and trade-offs associated with restoring abandoned degraded land for agriculture; to consider the likelihood that specific interventions will succeed and decide among alternatives; and to evaluate the implementation of restoration projects.

The Global Partnership on Forest Landscape Restoration and Bonn Challenge websites have many resources describing FLR principles and practices.[14] The UN Food and Agriculture Organization Forest

[14] http://www.forestlandscaperestoration.org/; http://www.bonnchallenge.org/

Landscape Restoration Mechanism website[15] also has numerous publications, webinars, presentations, and links to other websites focused on assessing landscape degradation and restoration opportunities as well as monitoring and evaluating restoration projects.

One of the most comprehensive planning tools available to practitioners considering restoring abandoned degraded land for agriculture is the IUCN's Restoration Opportunity Assessment Methodology (ROAM)[16] (IUCN, 2014), which IUCN created to support the Bonn Challenge and related FLR initiatives. Accordingly, the ROAM recommends a variety of restoration options, including agroforestry interventions to increase agricultural production, and it encourages collaborative engagement with multiple stakeholders—including local communities, policymakers, technical analysts, and financial investors—to identify restoration options that can meet stakeholders' goals. Because different options will have different benefits, constraints, and trade-offs, the ROAM encourages stakeholders to prioritize and negotiate the benefits they aim to achieve as well as the constraints they will agree to manage and the trade-offs they are willing to accept.

Essentially, the ROAM provides guidelines for project designers to make a series of analyses to:

1. Identify priority geographic areas for restoration;
2. Develop a list of stakeholder goals and the most ecologically feasible restoration options in the priority geographic areas;
3. Conduct economic analyses to quantify costs and benefits of restoration options[17] (Verdone, 2015);
4. Conduct financial analyses to evaluate potential returns on investment and identify potential investors; and
5. Perform a "restoration diagnostic" to identify key factors that are likely to enable restoration success and develop strategies to overcome obstacles (Hanson et al., 2015).

The ROAM recommends establishing a team of specialists to coordinate and carry out the assessment, including participants who have expertise in environmental science, economics, finance, sociology, relevant local policy frameworks, and geographic information systems (GIS) mapping techniques.

Because IUCN developed the ROAM to support FLR initiatives, all the restoration options it recommends involve planting and cultivating trees or allowing trees to naturally regenerate. As noted previously, ecosystems that do not typically have many trees, such as grasslands and open wetlands, also may need restoration, but FLR initiatives do not explicitly consider them. For practitioners to develop restoration projects with a holistic landscape approach, they should consider all types of ecosystems in the landscapes where they live and work. The ROAM prescribes an inclusive and rigorous methodology that practitioners can use when working in landscapes that are ecologically suitable for trees, and the ROAM analytic process described above also may provide a general framework for all types of landscape restoration.

[15] http://www.fao.org/in-action/forest-landscape-restoration-mechanism/en/

[16] https://www.iucn.org/theme/forests/our-work/forest-landscape-restoration/restoration-opportunities-assessment-methodology-roam

[17] To help stakeholders conduct the economic analyses, IUCN has developed a *Cost-Benefit Framework for Analyzing Forest Landscape Restoration Decisions,* which provides detailed guidance on economic modeling and cost-benefit analysis (https://portals.iucn.org/library/node/45246).

The Restoration Diagnostic: Identifying Key Factors for Restoration Success

IUCN and the World Resources Institute (WRI) recently published a set of guidelines, called the *Restoration Diagnostic*, that is meant to help practitioners assess FLR interventions according to 31 "key success factors," or enabling conditions, and develop strategies to overcome obstacles if conditions are not yet in place. The *Restoration Diagnostic* is based on FLR case studies from around the world and a synthesis of peer-reviewed literature. In a nutshell, IUCN and WRI found three primary factors needed for FLR to succeed:

1. Multiple stakeholders are clearly motivated to carry out the restoration project;
2. The context in which the restoration takes place includes favorable economic, ecological, legal, and social conditions to enable the project; and
3. Capacity and resources are available to implement the restoration project on a sustained basis.

Although not focused specifically on restoring abandoned degraded land for agriculture, the *Restoration Diagnostic's* case studies and recommendations will be useful guidelines for practitioners who aim to achieve those goals. Consider again the case of restoring Indonesia's Imperata grasslands to grow oil palm—each of the enabling conditions listed above would need to be in place for the restoration to succeed and be sustained.

For more information, see: https://www.wri.org/publication/restoration-diagnostic

Once stakeholders have decided on a restoration project and it is underway, practitioners will also need to monitor and evaluate its performance. Because landscape restoration is usually a dynamic process that involves long-term interventions implemented on a large scale, with multiple stakeholders, researchers have recommended a "collaborative monitoring" approach that facilitates adaptive management by catalyzing active data collection, communication, and learning among stakeholders (Guariguata and Evans, 2019)[18]. These same researchers have also developed a "collaborative monitoring diagnostic," based on literature reviews and expert interviews, that identifies key factors needed for the collaborative monitoring and adaptive management that will allow practitioners to evaluate the success and ongoing suitability of a landscape restoration project (Guariguata and Evans, 2019).

The FLR resources given above, and especially the ROAM and its related decision tools, are valuable resources for stakeholders considering restoring abandoned degraded land for agriculture. There may be many possible uses for abandoned degraded land, and each restoration project will have its own unique context. As we have seen in the case of Indonesia's Imperata grasslands, there are a number of potential benefits, constraints, and trade-offs that stakeholders will need to assess. Using participatory decision-making, technical analyses that directly address stakeholders' goals and priorities, and collaborative monitoring and evaluation can help restoration proponents design and implement projects that have the broad support needed to increase the likelihood of success.

[18] Collaborative monitoring is similar to USAID's Collaborating, Learning, and Adapting (CLA) framework (https://usaidlearninglab.org/node/14633).

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