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TROPICAL REFORESTATION AND FOREST REHABILITATION IN THE PERSPECTIVE OF LARGE SCALE IMPLEMENTATION

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Contents

Summary

Worldwide huge areas have been deforested, and even larger areas have been degraded to some extent. When forests are cut down or degraded and the functioning of such ecosystems is lost, this not only means that a lot of biodiversity is lost. It also involves large carbon emissions, the loss of ecosystem services and livelihoods of people who depend on forest resources. Reforestation and forest rehabilitation can sequester carbon, and return some of the biodiversity, ecosystem functioning and services. Moreover, reforestation and forest rehabilitation can reduce the need for harvesting forest resources from undisturbed forests by sustainably providing these resources in a more controlled environment.There are several ways in which reforestation and forest rehabilitation can take place. Here ecological reforestation and forest rehabilitation, agroforestry and silvopastoral systems, and cultivated tree plantations are the methods that are explored for their advantages and disadvantages. Since such large areas have been deforested or degraded in the past, these methods are discussed in the perspective of large scale implementation. It turns out that each of these methods has certain advantages and disadvantages when is comes to large scale implementation. Ecological reforestation and forest rehabilitation sequesters most carbon and is most beneficial for biodiversity and ecosystem function. However this method is costly and does not yield many direct financial benefits. Agroforests and sylvopastoral systems combine carbon sequestration with a larger amount of biodiversity and direct financial benefits. But this method is very labour intensive and therefore difficult to implement on a large scale. Lastly, commercial tree plantations generate quite a lot of direct financial benefits. But their contributions to biodiversity and carbon sequestration on the long term are much lower, as these plantations are eventually harvested. Therefore, to implement these methods on a large scale, these have to be combined in a landscape mosaic. In this way many of the individual goals can be achieved while reducing the risks and disadvantages involved with implementing each methods separately. Also these various methods can benefit from the services provided by the others. One last major difficulty that remains to be addressed, is the effect of climate change. As the climate is expected to change in many areas, it is highly recommended that people and organisations take this into account when engaging in reforestation or forest rehabilitation. In this way the future ecosystems can be made more resilient for the future.

1. Introduction

1.1. Forest cover changes

The greatest terrestrial biodiversity is found and potentially lost in tropical rainforests (Brooks *et al.*, 2002; Myers *et al.*, 2000; Pimm and Raven, 2000). For instance the Amazon is thought to contain some 16,000 species, for many of which their ecological importance has not yet been determined (ter Steege *et al.*, 2013). It is estimated that more than half of all terrestrial animal and plant species live in forests (Millennium Ecosystem Assessment, 2005). Presently, tropical forests worldwide are disappearing at alarming rates which poses an enormous threat to biodiversity and possibly leads to the extinction of many species that often have not even been described yet (Achard *et al.*, 2002).

This biodiversity is essential for the maintaining ecosystem functions, or the ecological processes that control the fluxes of water, energy, nutrients and organic matter in the environment (Cardinale *et al.*, 2012). The functioning of these tropical rainforest ecosystems is essential for securing many vital ecosystem services such as provisioning of food and clean water, medicine, flood amelioration and soil conservation (Laurance, 1999). Therefore tropical rainforests and the biodiversity their harbour represent an enormous natural capital (Constanza *et al.*, 1997).

Perhaps even more important on a global scale, tropical forests hold and sequester vast amounts of carbon and therefore have an enormous influence on climate (Zarin, 2012). Due to their high growth rates, forested areas in the wet tropics hold the potential to store carbon at rates and quantities not seen in other terrestrial ecosystems. Especially during the first 20 years of regrowth moist tropical rainforests sequester large amounts of carbon. As climate change is seen as one of the major threats to many existent lifeforms on earth, tropical rainforests are highly favourable assets for carbon sequestration and climate change mitigation (Silver *et al.*, 2000; Thomas *et al.*, 2004).

Throughout the tropics, there are a myriad of proximate and underlying causes of forest and land degradation and the severity of degradation such as timber extraction, extension of infrastructure, and agricultural expansion. Of these, agricultural expansion in the form of large monoculture crop cultivation and cattle ranching are most threatening because of the space they occupy. There is however one common ultimate cause for this degradation to happen. That is overexploitation of the various resources in these areas, as a result of increasing human population pressure, and activity related to economic development (Figure 1) (Geist and Lambin, 2002).

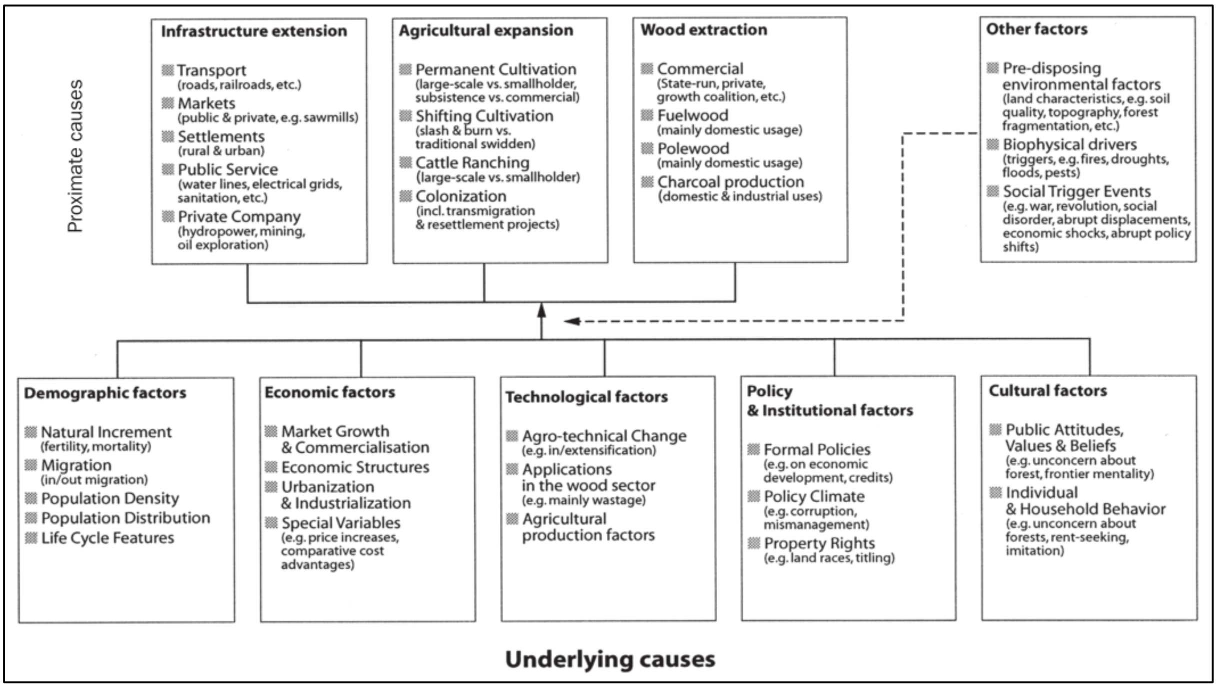

Figure 1: Causes for deforestation and forest degradation. Five broad clusters of underlying driving forces (or fundamental social processes) underpin the proximate causes of tropical deforestation, which are immediate human actions directly impacting forest cover (Geist and Lambin, 2002).

As the human population is expected to increase to over 9 billion individuals by 2050, combined with increased per capita demands, food production will need to be doubled or tripled by then. Also there will be a sharp rise in demand for other commodities provided by tropical rainforests (Godfray *et al.*, 2010; Smith *et al.*, 2010).

While many protective measures have been put into place, the human population and its demands are still rising, and ecosystems are still being degraded (Laurance *et al.*, 2012). For these reasons it is imperative that large-scale rehabilitation of degraded ecosystems is implemented in order to fulfil the needs of the future human population, and thereby decrease the need for clearing and degrading presently undisturbed forests. In order to implement such restoration efforts successfully, a key element is to limit the expansion of agricultural production to already cleared lands (Licker *et al.*, 2010; Phalan *et al.*, 2011).

A global assessment has revealed that more than 2 billion hectares of degraded land, including forests, is available for restoration worldwide. This is an area larger than China and the United States combined, and this area is still increasing in size (Figure 2) (World Resources Institute, 2012).

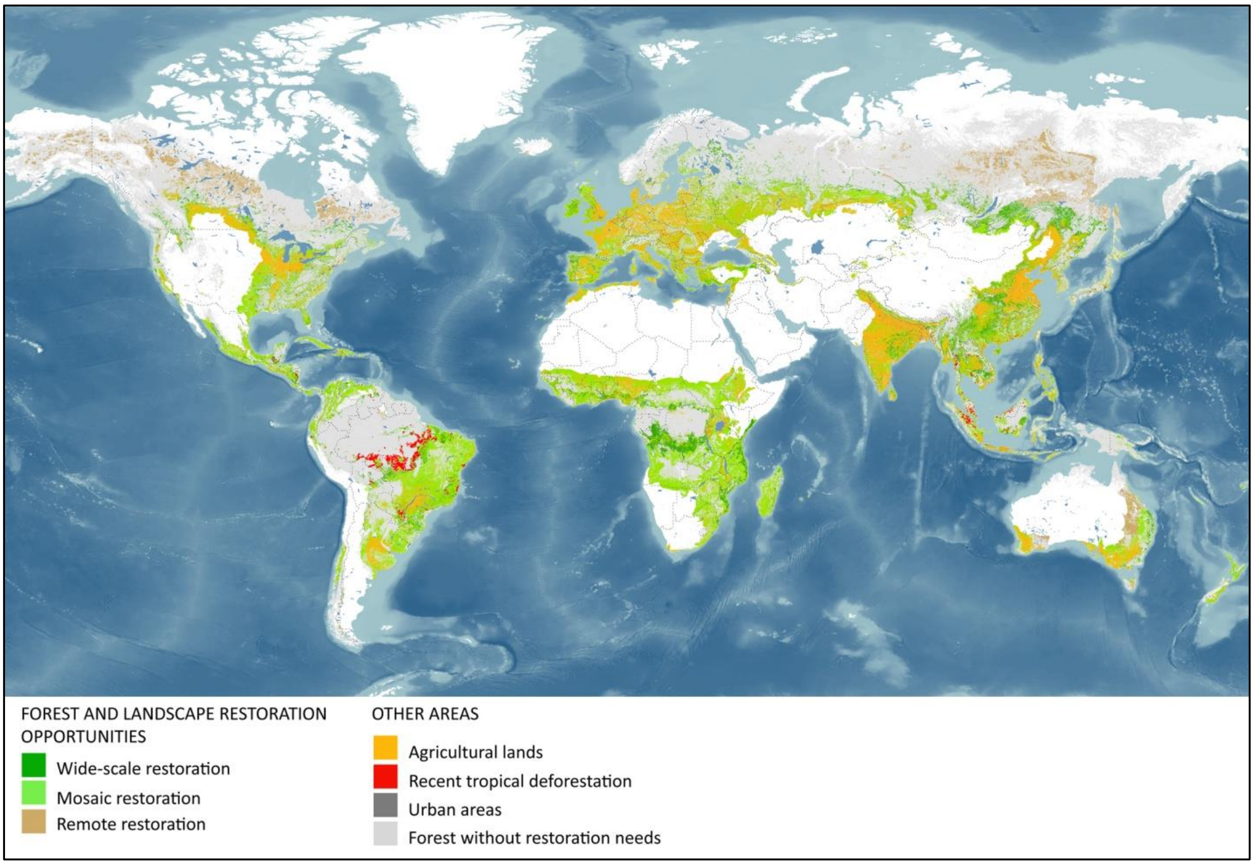

Figure 2: Global map of forest landscape restoration opportunities (World Resources Institute, 2011).

1.2. Reforestation and forest rehabilitation

Fortunately, over the past 15 years, ecosystem rehabilitation and reforestation have gained much momentum worldwide. It is now seen as one of the most prominent solutions to the environmental crisis the world is going through today (Aronson and Alexander 2013; Brancallion *et al.*, 2013; Chazdon, 2008; Chazdon, 2013; Hobbs and Harris, 2001).

Reforestation and forest rehabilitation are practices belonging to the discipline of restoration ecology and are both derived from insights into successional change (Chazdon, 2008). In general, reforestation is the practice of regaining forest cover in an area where it was previously removed. Forest rehabilitation is defined as the facilitation of recovery of forest that is still present, but has to some degree been degraded. Both reforestation and forest rehabilitation are being implemented worldwide in areas where causes of deforestation and forest degradation have ceased. In such areas new forest cover is desirable in order to either geophysically stabilize the landscape, to restore ecosystem services and/or to increase productivity of both timber and non-timber forest products. Restoration efforts are implemented when the ecosystem fails to recover naturally or when this process would otherwise take centuries to occur (Chazdon, 2003; Lamb, 1998; Lamb, 2005). Chazdon (2013) identified four ways in which reforestation and forest rehabilitation can take place:

1. A forest can spontaneously regenerate on former agricultural land.
2. Natural reforestation can be assisted (ecological reforestation of forest rehabilitation).
3. Agroforestry, silvopastoral systems and fallow management can be applied.
4. Reforestation can be the result of cultivated commercial tree plantations.

This thesis will focus on the latter three methods in which reforestation and forest rehabilitation can take place. These topics are chosen because there is an increasing demand for forest products and ecosystem services worldwide, while the actual forest cover is decreasing. As natural regeneration of tropical forests is generally slow, it is important to find ways to actively enhance the recovery of forests across the world. Therefore the latter three methods will be reflected upon using examples from scientific literature. This reflection will involve (1) implications of restoration to biodiversity and ecological functioning, (2) benefits to climate change mitigation, (3) financial or economic implications.

Finally, in the discussion, the lessons learned related from the three methods will be discussed. Also an outlook on future prospects of large scale reforestation and forest rehabilitation will be given. This will be done by discussing the way in which the characteristics of the three methods can contribute to large scale reforestation and forest rehabilitation. Reforestation and forest rehabilitation on a regional or landscape scale have the potential to contribute in countering the negative effects of deforestation, forest degradation and climate change on a global scale (Brancalion *et al.*, 2012). Putting these methods in a large scale perspective is especially relevant as they are presently not widely implemented in that way (Menz *et al.*, 2013).

In the last ten years, the private sector is increasingly involved in reforestation and rehabilitation practices. Also in the Netherlands this is the case. The Dutch government advocates that private institutions have to exercise corporate social responsibility and that sustainability of natural resource use should be achieved through private investments (Rijksoverheid, 2013a; Rijksoverheid, 2013b). Therefore some of the major points in this thesis will be supplemented with information gained from personal communications with representatives from five different Dutch private organisations that are to some extent actively involved in the field of reforestation and forest rehabilitation. The full list of questions that were asked and the stories that were told are provided in the appendix 6.1.

There are various incentives for reforesting an area or rehabilitating existing degraded forests. Reasons depend strongly on the stakeholders and their interests, the starting situation and size of the designated area and the desired outcome. The various different proximate incentives for reforestation or forest rehabilitation are based on ecological or economical benefits (Table 2). (Lamb, 2005).

Table 2: Four goals of reforestation or forest rehabilitation efforts. These situations are based on financial or ecological incentives, or a combination of these. On a large scale, the actual efforts may also involve a combination of these different types (modified from Hobbs and Norton, 1996).

	Category of benefits on which incentives are based	**Goal of reforestation or forest rehabilitation effort**
1.	Ecological	Land reclamation or the restoration of highly degraded but often localized sites such as abandoned mine sites, highly degraded pasture land, or other areas where favourable soil conditions are completely destroyed. Here the restoration often encompasses the amelioration of physical and chemical properties of the substrate and ensuring the return of vegetation cover.
2.	Financial	Improvement of the production capability of degraded production lands. Degradation of productive lands is increasing worldwide, leading to reduced agricultural, pasture or forest production. Here the aim of restoration is to return these systems to a sustainable level of production.
3.	Ecological	Enhancement of conservation values of protected landscapes. Areas dedicated to conservation worldwide are being reduced in their conservation value due to various forms of degradation. These include human encroachment, pollution, invasive species and fragmentation. A recent study by Laurance *et al.* (2012) showed that over half of the protected areas worldwide are suffering from degradation. In such cases restoration aims to reverse the impact of these degrading forces.
4.	Financial and ecological	Enhancement of conservation values in productive landscapes. Next to a need for restoration efforts within lands dedicated to conservation, an increase in area of natural or seminatural vegetation cover is needed in areas where habitat loss and fragmentation have been extensive. This is relevant as protected areas alone are likely to be unsufficient for conserving biodiversity in the long term. In this case some conservation value is returned to parts of a productive landscape, preferably by integrating production and conservation values.

1.3. The potential of large scale reforestation and forest rehabilitation

Small forest restoration projects exist almost everywhere in the world (Menz *et al.*, 2013). However in order to achieve more ambitious targets, many of them will eventually have to be combined into a common objective, integrated at the landscape level (Brancalion *et al.*, 2012). The United Nations Convention on Biological Diversity Aichi target of restoring 15% of all degraded land by 2020 is a prime example of how large scale ecosystem restoration, of which reforestation and forest rehabilitation can be a large part, is seen as a major solution to deal with the ever growing human population demands. Another major global initiative is the Bonn Challenge on Forests, Climate Change, and Biodiversity which aims to restore 150 million hectares before 2020. Although these are ambitious targets, 150 million hectares is still only a small fraction of the real opportunities for reforestation and forest rehabilitation (Jörgensen, 2013; Menz *et al.*, 2013).

Many major ecological, geophysical, cultural and economic challenges exist, especially in the tropics, that make reforestation and rehabilitation efforts difficult to apply successfully on a large scale (Kirilenko and Sedjo, 2007; Lamb, 2005). Many of these challenges, such as corruption, but also unsustainable economic development, also happen to be key drivers of tropical forest decline to this day (Laurance, 1999).

As reforestation requires considerable financial investments the most significant barrier towards large scale reforestation in the tropics is actually finding these investments. Opposed those in temperate forests, investments in tropical forests are seen as high risk investments. Market and investment risks here are high and difficult to estimate. Many tropical countries are therefore perceived as having a high or unclear risk profile. Important constraints for investments in tropical forestry are the limited physical and financial infrastructure, as well as local knowledge. Moreover there are often problems and a lack of clarity on tenure and governance. So countries that do not obide by their own laws and have high rates of deforestation, political instability and corruption are not very attractive to investors (van Dijk *et al.*, 2012). Not only is this corruption a barrier to investments in reforestation. It is also one of the main underlying causes of tropical deforestation and forest degradation (Laurance, 2004).

Moreover, the four ways in which reforestation or forest rehabilitation can take place, as formulated by Chazdon (2013), each have different ecological advantages and disadvantages that often cause these methods not to be viable to apply on a large scale. These will be discussed in chapter 2: Reforestation and forest rehabilitation methods.

2. Reforestation and forest rehabilitation methods

With regard to the latter three points of Chazdon's list (2013) of ways in which reforestation or forest rehabilitation can take place (chapter 1.2.), one of the factors strongly influencing the choice for a reforestation or forest rehabilitation method is the state of the land on which it is to be implemented. Different land use practices in the past result in different starting conditions. Of course the intensity and duration of past land use are key factors that influence the recovery to forest. Forest recovery is considerably slower after more severe disturbances to soil and aboveground vegetation. Often activities such as bulldozing, long-term or heavy grazing and fires have long lasting effects on species composition and succession. For example (surface) mining operations leave a completely barren land that, without additional support, will take a very long time to restore. On the other end, logged forests usually still have a large degree of vegetation cover, and much of the topsoil remains on site and relatively intact. Vegetation cover in the area is the result of ecological succession. Depending on the state of degradation of the land, the successional stage can vary from primary, to various stages of secondary succession. Of course the earlier successional stages usually require more intensive input, and therefore labour and funds, to restore or rehabilitate, and maintain the ecosystem (Figure 3) (Chazdon, 2003; Chazdon, 2008; Hobbs and Harris, 2001; Moran *et al.*, 2000).

Land reclamation (the restoration of land where everything, including the top soil is removed) is considerably more expensive and time consuming than the restoration of ecosystems that are to a lesser extent degraded (Lamb, 2005). The reason for this is that tropical forests usually grow on a very thin layer of nutrient containing top soil that rests on highly weathered and nutrient poor substrate. Tropical forest species have become highly adapted for capturing and recycling the limiting nutrients and many species of mainly the Fabaceae family have a capability of fixing nitrogen from the atmosphere. In soils that are too heavily degraded, or where top soil is removed entirely, mainly phosphate and other minerals become limiting and will have to be supplemented from another source such as fertilizers (Stoorvogel and Smaling, 1998; Vitousek, 1984). This increases costs significantly, therefore making restoration of such severely degraded areas less cost effective and therefore a less desirable investment.

Reforestation and forest rehabilitation programmes can work at various levels of scale, from local to regional or biome scale. Everywhere different ecological and socioeconomical scenarios are found. Therefore there is no singular recipe or method for reforestation or ecosystem rehabilitation and depending on the situation, one or more methods may be chosen (Brancallion *et al.*, 2013).

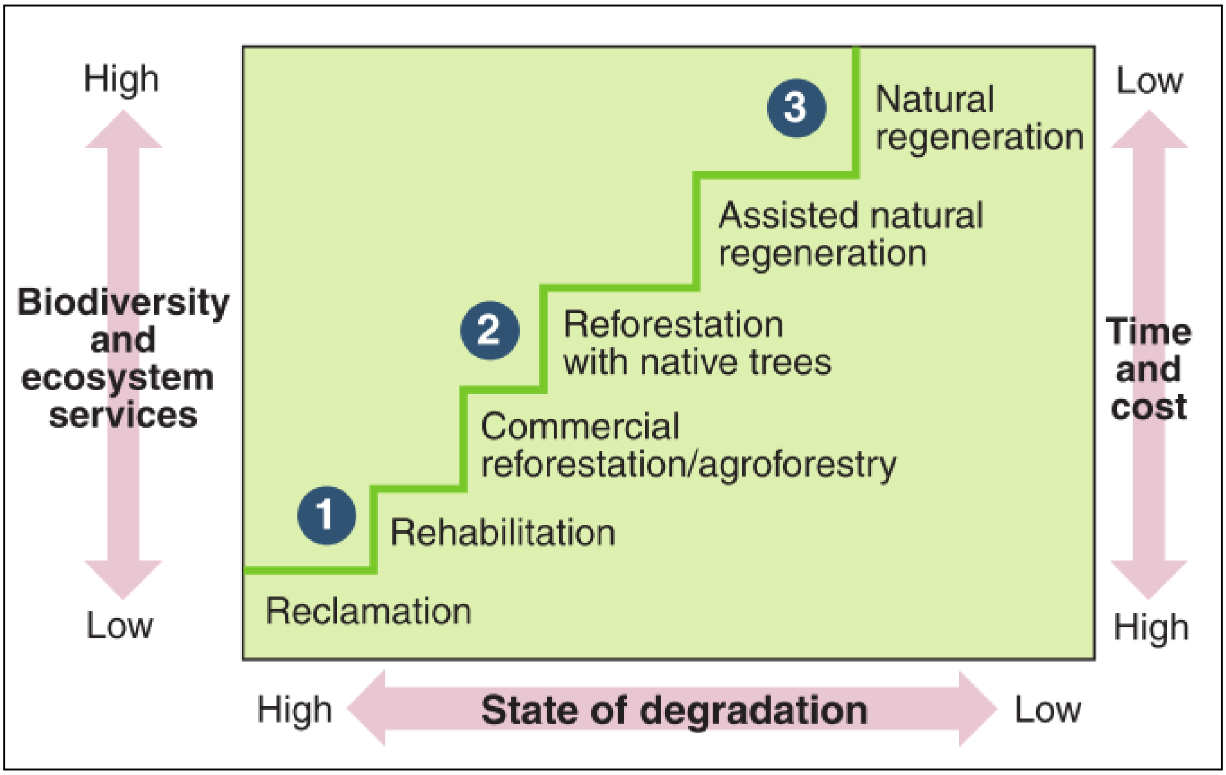

Figure 3: The restoration staircase. Depending on the state of degradation of an initially forested ecosystem, a range of management approaches can at least partially restore levels of biodiversity and ecosystem services given adequate time (years) and financial investment (capital, infrastructure, labour). Outcomes of particular restoration approaches are (1) restoration of soil fertility for agricultural or forestry use; (2) production of timber and nontimber forest products; (3) recovery of biodiversity and ecosystem services (retrieved from Chazdon, 2008).

2.1. Ecological reforestation or forest rehabilitation

Ecological reforestation and forest rehabilitation link back to point 2 of Chazdon's (2013) list of four ways in which reforestation and forest rehabilitation can take place. In ecological reforestation or forest rehabilitation, the ultimate goal is to restore a forest to a state of late secondary or a forest resembling its undisturbed condition. It is done by a practice named assistend natural regeneration, or actively replanting new forests and enrichment planting of degraded forests, followed by letting the vegetation cover regenerate by itself.

Here the main incentives are to return ecosystem function and biodiversity to a high degree and in many cases to sequester carbon. In some cases the forest is to remain undisturbed, while in other cases it is to be selectively logged in the future or used for production of NTFPs. In the latter two cases it is considered to be of high importance that the forest remains relatively healthy and retains the capability to regenerate naturally or to sustain the harvesting of NTFPs (Chazdon, 2008; Chazdon, 2013).

2.1.1. Implications for biodiversity and ecological functioning

Reforested areas or rehabilitated forests are in most cases unable to regain the amount of biodiversity or restore the range of ecosystem services that are present in undisturbed forests. However, ecological reforestation and forest rehabilitation offer the most potential for restoring and supporting biodiversity and ecological functioning (Benayas *et al.*, 2009; Hobbs *et al.*, 2006).

Ecological reforestation or forest rehabilitation promote the recovery of forests to a more or less natural state. Enrichment planting can speed up recovery where disturbances prohibit slow growing, shade tolerant species to emerge, because seedlings are absent, or die because of intense solar radiation and drought, or competition by weeds. Planting trees then allows these species to establish. Moreover, the planted trees can provide a seed bank of their own, speeding up forest recovery. Because many native species naturally establish under planted trees, a reasonable rich vegetation assemblage is created. Moreover, the increased vegetation and canopy density cause the forest to become more humid and causes ecosystem function and services to return relatively quickly (Omeja, 2011)

The more closed forest also provides a better habitat for many forest dwelling animal species. As these species are often very important for seed dispersal, their presence will increase the speed of recovery of the forest (Chapman, 1995).

2.1.2. Benefits to climate change mitigation

When it comes to climate change mitigation, forests play multiple roles. The most obvious benefit of tropical forests is that they contain and sequester vast amounts of carbon. However, forests also have a strong effect on climate through evapotranspiration and albedo, the reflective coefficient of the vegetation. Both evapotranspiration and albedo are much higher in closed canopy forests than in more open vegetation and pasture, thereby providing a considerable cooling effect (Da Rocha *et al.*, 2004; von Randow *et al.*, 2004).

Ecological reforestation and forest rehabilitation have the largest potential to sequester carbon, restore evapotranspiration and albedo, since these methods aim at to restore the forest to a state with the highest possible vegetation and canopy density. When compared to undisturbed forests, these factors are only moderately achieved, but this is likely due to the long time tropical forests take to fully recover from large disturbances (Bonan, 2008).

Still the relatively rapid accumulation of biodiversity and biomass causes this method to be the most favourable when it comes to both above ground and soil carbon sequestration. Biomass accumulation rates are the highest in assisted regeneration and the lack of disturbance afterwards ensures the retention of carbon in the system (Bunker *et al.*, 2005; Silver *et al.*, 2000).

The effect of carbon sequestration is of course highest when secondary forests are assisted in their recovery to mature forest. Abandoned agricultural fields are often fertilized and therefore also have to potential to gain biomass fast when trees are planted. Abanoned pasture and completely barren lands recover most slowly since these lands are often severely depleted of nutrients (Silver *et al.*, 2000). Here these nutrients will have to be supplemented some way or another, thereby increasing labour intensity and costs.

2.1.3. Financial or economic implications

While ecological reforestation and forest rehabilitation is highly favourable when it comes to the accumulation of biodiversity, aqcuiring the necessary funds can be challenging. If a forest is to remain undisturbed it does not provide any direct financial benefits (Omeja, 2011; Snoep, pers. comm.).

When it comes to provisioning goods such as timber and NTFPs, restored forests perform better than undisturbed forests. This is mostly due to specific enrichment planting of species that provide direct economic benefits (Benayas *et al.*, 2009). But the provisioning of economically beneficial products is usually less in restored forests than on degraded forest land. This can likely be attributed to the fact that undisturbed forests are not used, while degraded forest lands are often used for agricultural production or cattle ranching (Benayas *et al.*, 2009). Even though the economic production of degraded land is strongly dependent on the level of degradation, this does create a conflict between land use and ecological reforestation as the reforestation effort can reduce a much needed source of income for local communities. In that case the funding will have to be derived from charity, carbon credits, or payment for restored ecosystem services. In cases where it is allowed, the sustainable harvesting of timber and non-timber forest products is a major opportunity for increasing the financial viability of an ecological restoration project (Brancallion *et al.*, 2012).

There are a number of requirements for ecological reforestation or forest rehabilitation to succeed. Whether these requirements are met prior to engaging in reforestation or forest rehabilitation depends strongly on the level of degradation. The requirements that have to be met prior to, or during an ecological reforestation or rehabilitation programme in order to make the effort a success are formulated by Chazdon (2013):

1. Topsoil needs to remain onsite or be supplemented.
2. Forest fragments, preferably large and well-preserved, should be in close proximity to target site.
3. Resprouting native vegetation promotes rapid early growth and soil stabilization.
4. Seeds of early and late successional woody species are present in the seed bank and in seed rain.
5. Colonization of common and rare native species occurs on a long-term basis.
6. Weed suppression needs to happen rapidly after site abandonment.
7. A diversity of fauna (insects and vertebrates) serving as pollinators and seed dispersal agents are present in the landscape.
8. Protection against frequent fires that promote dominance of fire-resistant grasses.
9. Hunting and excessive harvesting of litter and forest products is prevented.
10. The site is protected from grazing and clearance for agricultural land use for at least 20 yr.

The extent to which these requirements are met prior to reforestation or rehabilitation have large financial implications. Should the land or remaining forest be more degraded, or a high rate of recovery is desired, then a stronger intervention is needed, thereby increasing the costs (Figure 4). The level of degradation, as well as the desired rate of recovery, can potentially cause ecological reforestation and forest rehabilitation to become very expensive, while in most cases the forest does not yield any short term financial returns. Initial sources of income will have to be derived from charity, state assigned funds, the carbon market or investments for future use of forest products (Aide *et al.*, 2001).

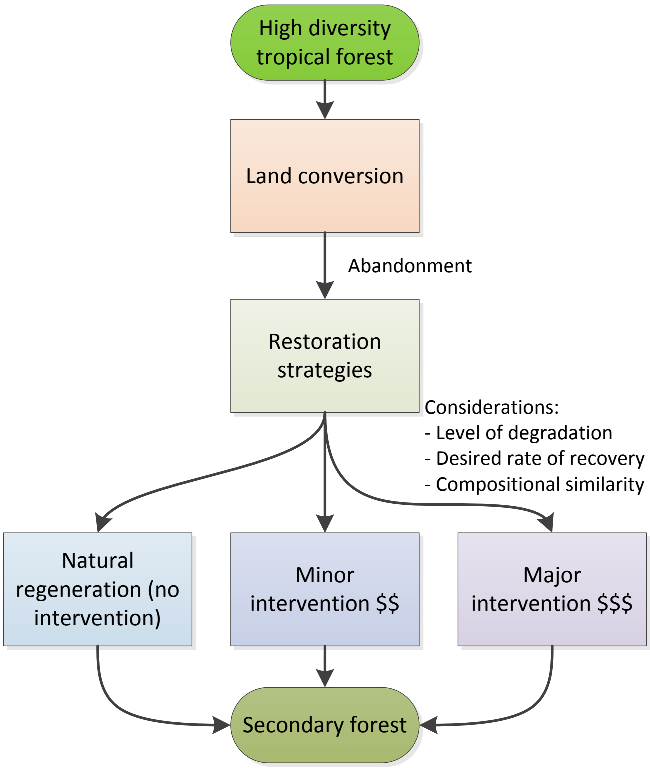

Figure 4: Management strategies for restoration of tropical forest following the abandonment of converted lands (modified from Aide *et al.*, 2001).

2.2. Agroforestry and silvopastoral systems

Agroforestry and silvopastoral systems link back to point 3 of Chazdon's (2013) list of four ways in which reforestation and forest rehabilitation can take place. Simply put, agroforestry is a combination of agriculture and tree growth. Silvopastoral systems encompass pastures on which domesticated animals are allowed to graze and trees are allowed to grow. In fact these are integrated approaches that combine and use the benefits of agriculture and animal grazing and forestry to create a more sustainable, diverse and productive system. It therefore serves both economical and ecological interests as both species diversity and productivy are key elements in the establishment of an agroforest (Alavalapati *et al.*, 2004).

2.2.1. Implications for biodiversity and ecological functioning

Agroforests hold the potential to produce various timber and non-timber forest products without depleting soil nutrients to the degree that traditional farming in many tropical countries does. In fact, agroforests with improved nutrient cycling can even lead to a net buildup of some soil nutrients, thereby increasing the fertility in some cases (Garrity, 2004; Jose, 2009; Montagnini and Nair, 2004)

However, one study in the Brazilian Amazon actually showed that long term smallholder agroforestry kept most soil nutrients stable over time, but found a strong decline in soil phosphorus. The researchers suggest that when this is not supplemented with fertilizers of manure, it will create an unsustainable situation in which the agroforests will no longer yield a sufficient amount of crops and new forest will have to be cleared (Alfaia *et al.*, 2004).

When it comes to supporting and conserving biodiversity, there are a number of major roles that agroforestry can play:

- Agroforests provide habitats for disturbance-tolerant species;
- They can help in preserving germplasm of sensitive species;
- Agroforestry provides a productive and sustainable alternative to traditional agriculture that may involve the clearing of previously undisturbed habitats, thereby reducing habitat conversion rates;
- Agroforests contribute to the connectivity between fragmented natural habitats by creating corridors for both flora and fauna;
- Agroforests help conserve biodiversity by providing ecosystem services such as erosion control and water regulation.

In all these ways, agroforestry provides a much better alternative to traditional agriculture in terms of biodiversity conservation. It does however require that the system is designed in a landscape context, meaning that other nearby systems have to be taken into account, and that agricultural activities are extensified (Harvey and Villalobos, 2007; Jose, 2009).

2.2.2. Benefits to climate change mitigation

In terms of carbon sequestration, agroforestry applied on a large scale can deliver a strong contribution. This gives agroforests the advantage of being able to tap into the global carbon market by making use of "carbon credits" for initial investments. Moreover, faster growing species, more species diversity and longer rotations can further increase the capability of sequestering carbon by agroforests. Agroforests grown on degraded lands can also contribute to conservation of primary forests as the need for clearing new land is decreased. The protection of primary forest should remain a top priority as the clearing of primary forest releases more carbon than any fast growing plantation or natural regrowth could recover in more than 25 years (Montagnini and Nair, 2004).

Another issue is that the promotion of rapid tree growth for the benefit of carbon sequestration can increase the abundance of fast-growing, disturbance-tolerant species that can potentially impact forest dynamics in nearby mature forest framents (Laurance *et al.*, 2006).

2.2.3. Financial or economic implications

When it comes to tree planting in general, regardless of location, trees sequester carbon. Therefore they may also be planted outside of the "forest" as defined by FAO, such as on farmland, rangeland and even in cities. Agroforestry is even seen as an essential component of global efforts to enhance rural livelyhoods and to mitigate climate change. Today more than 1 billion hectares of agricultural land has a tree cover of more than 10 percent. Farm forestry even contributes up to 40 percent of farm income though wood and non wood products. Trees can also provide benefits such as clean water, soil health and fertility, biodiversity and fodder for livestock. Therefore trees add both market and non-market value and natural capital to agricultural and rangelands (FAO, 2012; Pasicolan *et al.*, 1997).

One of the key factors in determining agroforestry adoption is the relative profitability of the practice in comparison with other land-use practices. Diverse agroforests are more labour intensive as they do not lend themselves to mechanisation. So in countries with abundant agricultural mechanisation, agroforests are much more labour demanding and therefore expensive than monocropping. However in tropical developing countries, this does in most cases not pose a barrier for implementing agroforestry. In developing countries capital is often scarce and labour costs are low.

Therefore there is usually already a low level of mechanisation and agroforestry even provides a more efficient means of harvesting crops (Filius, 1982).

In the tropics, labour is usually less productive than in temperate areas. Here agroforestry has the potential to increase productivity with the same amount of labour or by a change in labour requirements. For instance agroforests offer the potential to use barren or deteriorated soils, thereby increasing opportunities for production. Moreover, agroforests can avoid periods of peak labour demanding production by prolonging the availability of soil moisture and nutrients, and extending and spreading the ripening periods of diverse crops. Despite these advantages, the high labour intensity involved with maintaining agroforests is also a barrier towards implementation on a landscape or regional scale (Filius, 1982).

A study in Kenya shows that smallholders will incrementally adopt agroforestry if it shows a clear benefit to their more traditional land use. For instance when natural resources and species become depleted due to overharvesting, it is in many cases beneficial to start cultivating these species, combined with traditional crops, in small community maintained agroforests (Scherr, 1995).

Ranchers in southern Florida, a rich area with high labour costs and high levels of mechanisation, are only willing to adopt silvopastoral systems if new incentives are offered. Silvopasture is more costly than traditional cattle pasture as it requires a larger initial investment and requires more manual maintenance, while the benefits are not very high in the American economic climate. Only if markets for environmental services on which ranchers can capitalize exist, the marginal benefits of allowing trees to grow would outweigh traditional ranching. Examples are payments for water quality improvement and carbon sequestration. Another way to stimulate ranchers in this area would be to increase taxes on for instance phosphorus runoff from cattle ranches. Due to increased expenses, it would be more attractive to grow trees that absorb part of the phosphorus (Alavalapati *et al.*, 2004)

2.3. Cultivated commercial tree plantations

Cultivated commercial tree plantations link back to point 4 of Chazdon's (2013) list of four ways in which reforestation and forest rehabilitation can take place. Commercial tree plantations are cultivated primarily for financial benefits and secondarily provide benefits to biodiversity and carbon sequestration (Lamb *et al.*, 2005). Cultivated commercial tree plantations can not be regarded as ecological reforestation or forest rehabilitation because in the long term they do not return a degraded area to something approaching its original condition (Lamb, 1998). Despite this, plantation forests can still contribute to species conservation because their undergrowth can in many cases support a wide floral and faunal diversity (Hartley, 2002; Kanowski *et al.*, 2005).

2.3.1. Implications for biodiversity and ecological functioning

Timber plantations are capable of sustaining high plant diversity in the undergrowth (Brockerhoff *et al.*, 2008). But this does require the plantations to be relatively small scale and to have high diversity forest nearby. Moreover, the undergrowth has to be left unmanaged so a high diversity and high biomass understory can develop (Sayer *et al.*, 2004). The accumulation of biodiversity can also be promoted by various plantation layouts and spatial, or species planting strategies (table 1). An obvious and major limitation is that this biodiversity in a singular plantation will not last because the plantation will eventually be harvested. The most obvious way for retention of biodiversity is then to implement selective harvesting cycles on a plantation, or between plantations on a landscape scale (Lamb, 1998; Lugo, 1992).

Major disadvantages of monoculture timber plantations in which the undergrowth is left unmanaged are that this facilitates the establishment of invasive species, and makes the trees more susceptible to pathogens. These invasive species can also rapidly colonize emerging forests nearby (Hobbs *et al.*, 2006). Timber plantations are also less effective at recycling nutrients than high diversity secondary forests. This is relevant in the tropics as nutrients are easily lost and often very limiting to plant growth (Vitousek 1984). The cycling of nutrients may be greatly improved by allowing the development of a high diversity understory (Lugo, 1992).

Table 1: Various options for improving biodiversity in timber plantations and their potential advantages, disadvantages and impediments to implementing each approach (Lamb, 1998)

Method	Advantages	Disadvantages	Impediments to adoption
Native species	Commercial value may be higher Social value may be higher Better adapted to environments	Slower growth Incomplete silvicultural knowledge Less Suited to degraded sites Less easily marketed	Ecological and silvicultural data often lacking
Buffer strips	Greater watershed protection Improved fire control	Reduced plantation area Source of pests	None
Species Mosaics	Improved overall productivity	Management more complicated More than one species less easily marketed	Inadequate site descriptions Inadequate knowledge of species-site relations
Mixtures	Reduced herbivory and disease Improved nutrition Earlier financial returns Social benefits from non-timber species	Management more complicated Reduced plantation productivity Marketing more complex	Finding complementary species Confirming benefits Developing silvicultural systems
Understory development	Reduced topsoil erosion Improved nutrient cycling May include socially useful plant species	Reduction in canopy tree growth Management more difficult	Developing methods for fostering understory at isolated sites Management of understories dominated by exotic weeds

2.3.2. Benefits to climate change mitigation

Plantation forests improve both above ground and soil carbon sequestration when compared to the degraded lands they replace (Hofer, 2010). Because in many cases fast growing tree species are chosen for cultivation, above ground carbon sequestration is often even faster than in natural forest regeneration under the same soil and climate conditions (Lugo, 1992).

A disadvantage of tree plantations is that the trees are eventually harvested. Much of the accumulated biomass will therefore be removed. Moreover, much of the undergrowth is also damaged or destroyed during harvesting. A large amount of the carbon stored in this biomass is then released to the atmosphere at an accelerated rate. This means that plantation forests do sequester carbon, but not in the quantities that agroforests, let alone natural forests do (Schroeder, 1992).

2.3.3. Financial or economic implications

Plantations do offer the potential for strong improvements in landscape biodiversity compared to naturally occurring vegetation cover in many degraded lands, and to most traditional plantation monocultures with exotic species. The cultivation of timber plantations addresses market demand combined with restoring some biodiversity and ecosystem function, and provides the means to harvest timber without having to log yet undisturbed forests (Lamb, 1998).

Past overexploitation of commercial timber species and an increase in demand for tropical timber have caused timber prices to rise. This has therefore created economically favourable conditions for cultivating (native) timber species. As native species are often more susceptible to natural pests that tamper their timber production in low diversity forests, it is favourable to plant a wide diversity of species to reduce risks. This then also aligns economical and ecological incentives for reforestation at a larger scale (Brancallion *et al.*, 2012; Rodriques *et al.*, 2009). It is however, more costly and labour intensive than planting non-native, less diverse timber plantations. Production and profits in monoculture non-native plantations are therefore often much higher. Despite that biodiversity is much lower in this case, still some biodiversity can be restored among the plantation trees. Moreover, the financial viability of a monoculture plantation is much higher than that of a mixed forest with native species (Lamb, 1998).

3. Discussion

3.1. Synthesis

Ideally reforestation and forest rehabilitation efforts would lead to a combination of high biodiversity, carbon sequestration, sustainable provisioning of ecosystem services, financial, and social benefits. In practice however, these often contradicting goals prove difficult to combine and are therefore in most cases implemented separately (Table 3) (Lamb *et al.*, 2005).

Moreover, reforestation is not a trivial one-time investment, it must be properly managed to ensure long-term success. The reason for this is that reforestation and forest rehabilitation require considerable long term investments to succeed. Therefore the choice for a particular approach is often based on ability of the restored area to generate income. Areas that are reforested or where forest is rehabilitated solely for the purpose of regaining a high level of biodiversity, are therefore more difficult to support financially. This causes tensions to remain between the objectives of biodiversity conservation and plantation productivity (Lindenmayer and Hobbs 2004).

Table 3: A summary of some of the different forms of reforestation that might be used when secondary forests are present or when some form of planting is needed. Any combination of these techniques could be used in degraded landscapes depending on ecological circumstances and on the goals of the land managers. To achieve large scale landscape goals, a viable option may be to implement multiple approaches in a landscape mosaic (retrieved from Lamb *et al.*, 2005)

Natural secondary forests	**Plantings and plantations**	
	To restore biodiversity	**To supply goods and ecological services**
Protect and manage natural regrowth: Potentially able to supply a variety of goods and services depending on the age and condition of the forest. Protect and manage natural regrowth plus enrichment with key species: Enrichment with commercially, socially, or ecologically useful species can improve the value of these forests to local communities or industry.	Restoration plantings using small number of short-lived nurse trees: Acquisition of further diversity dependent on colonization from nearby forest remnants. Primary benefit is ecological services although can supply some goods depending on species present. Restoration plantings using large number of species from later successional stages: Higher initial diversity that will also be supplemented by colonization from nearby forest remnants. Primary benefit is ecological services although can supply some goods depending on species used. Direct seeding: The number of species that can be established by direct seeding is limited by seed supply but the establishment cost can be lower. Direct seeding can be used to initiate reforestation in open fields under appropriate conditions but it may be most useful when used to enhance diversity once some tree cover is already present.	Tree plantation monoculture of exotic species: An efficient method of timber or food production for (mainly) industrial users; in most circumstances it is less successful in supplying many services. Tree plantation monoculture of native species: Useful to supply timbers of higher commercial value and other goods such as fruits, nuts etc.; the longer rotations normally used may facilitate an improved supply of ecological services such as watershed protection. Tree plantation used as a nurse crop with underplantings of native species not otherwise able to establish at the site: An initial fast-growing nurse crop supplying commercially useful timbers or other goods can facilitate (e.g., via nitrogen fixation and microclimate alterations) the subsequent establishment of more species-rich forests that supply a wider range of goods and services. Tree plantation mixtures of native species: Mixed-species plantations can, potentially, supply a wider range of goods and services than monocultures. Biodiversity gains are greater than in plantation monocultures but are mostly still modest (usually less than five planted species).

One option that is valid for (partially) funding all the different types of reforestation or forest rehabilitation project is to derive income from carbon credits by sequestering large amounts of carbon. However, carbon credit certification is relatively very expensive to achieve. And with decreasing values of carbon credits and rising costs involved reforesting, rehabilitating forests, and maintaining forests, carbon credits are becoming a relatively smaller source of income. Therefore, despite being one of the major results of increasing forest cover and being of major global importance, ironically, carbon sequestration is becoming a smaller financial incentive for organisations to engage in such efforts (Burgers, pers comm.; Snoep, pers. comm.; Sools, pers. comm.).

Another intitiative that combines many advantages of different reforestation and forest rehabilitation methods is analog forestry. Here a forest is actively replanted and all stage of succession are guided in the way that productive species are favoured. By carefull planning this will eventually lead to the growth of a high diversity, high biomass, closed canopy forest that resembles late secondary to primary forest, while all the way, providing sustainable economic productivity to the nearby communities that maintain it. Therefore this type of reforestation or forest rehabilitation combines many of the advantages of ecological reforestation and agroforestry (Becker and Goldman, 2001; Nijpels, pers. comm.). The major disadvantage of this system is the same as that of agroforestry, it cannot be implemented on a landscape level due to the required labour intensity.

3.2. Future prospects of large scale reforestation and forest rehabilitation

Large areas across the world that were previously covered by continuous stretches of forest have been deforested, fragmented and degraded. This has caused only scattered natural forest fragments to remain in a human-modified landscape (Myers *et al.*, 2000; Riitters *et al.*, 2000). The consequence is that the generation and maintenance of ecosystem services is very limited in these degraded ecosystems. Moreover, the low level of connectivity in fragmented landscapes limits the capacity to conserve many biological groups and the capacity for forests to recover after human land uses have ceased (Chazdon, 2013; Ribeiro *et al.*, 2009). Therefore, to be able to reduce the chance of species extinctions, to restore the sustainable and continueing provisioning of ecosystem services and to mitigate climate, it is highly favourable to reforest or rehabilitate forests on a large regional or landscape scale (Brancallion *et al.*, 2013).

The UNEP report "Towards a green economy: pathways to sustainable development and poverty eradication" (UNEP, 2011) calls for large investments in reforestation and forest rehabilitation of US$ 22 billion every year over the next 40 years. Carbon sequestration in woody biomass would most certainly be increased by such a level of reforestation. It may even be large enough to have a strong mitigating impact on climate change. However, there are some considerable hurdles that need to be overcome. There is no clarity on where the funds would originate, where the trees would eventually be planted, or how a global programme of this magnitude would be coordinated.

Nevertheless, planting trees is often the easiest and most effective way of producing new terrestrial biomass and to restore ecosystem function (de Ligt, pers comm.). This then helps to offset the loss of carbon resulting from deforestation or forest degradation elsewhere. Investing in reforestation and the resulting new carbon stocks has the potential to make a significant impact on climate change without requiring large political, cultural and economical reforms. Several countries, notably in Asia, have shown that replanting forests can reverse the trend towards deforestation and result in a net increase in forest area (FAO, 2012; Kosonen *et al.*, 1997; Niskanen, 1998).

A larger, more coordinated landscape approach may offer the possibility to address all the different stakeholder's interests and meet all the primary objectives. Different projects may exist alongside one another in a landscape mosaic and benefit from each other's function and services. Also a more large scale approach, supported my multiple stakeholders can have more significant impacts and could reduce risks of investment (Figure 5).

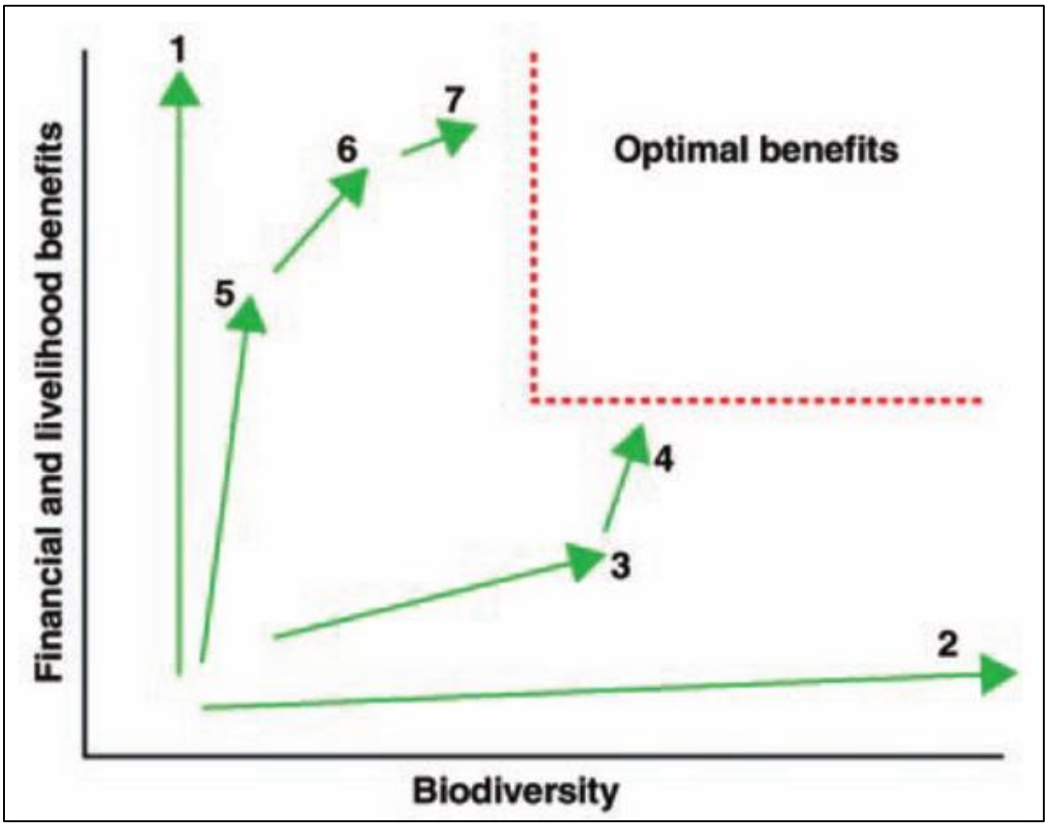

Figure 5: It is not easy to develop reforestation or forest rehabilitation methods at a particular site that both optimizes financial and livelihood benefits as wel as generates improvements in biodiversity (top right corner). Traditional monoculture plantations of exotic species (1) mostly generate just financial benefits, whereas methods that aim to enhance and maximise biodiversity (2) yield very few direct financial benefits to landowners, at least in the short term. The protection of forest regrowth (3) generates both biodiversity and livelihood improvements, but here the magnitude of the benefits dpends strongly on the density of commercially or socially important species; these can therefore be increased by enrichment planting with commercially attractive species (4). For reforestation or forest rehabilitation efforts in landscapes where poverty is common, it is necessary to attempt both objectives simultaneously. But in many situations it may be more desirable to give initial priority to forms of reforestation that improve financial benefits such as agroforests (5). In subsequent rotations, this balance might change over time (6), and could further be enhanced using a greater variety of species (7). On a landscape scale, many objectives and benefits may be achieved and shared by combining several options in a landscape mosaic (retrieved from Lamb *et al.*, 2005).

Simple as this may sound, organising and implementing various reforestation and forest rehabilitation methods in a landscape mosaic is far from trivial. It is not only challenging to unite the various stakeholders'goals and efforts. Tropical forests are highly diverse, complex ecosystems and the process of succession leading to a mature system is often nonlinear and unpredictable. The understanding of how succession leading to forest systems works is incomplete at best, and often practitioners of reforestation and forest rehabilitation have to learn as they go.

Next to this comes the added difficulty that the environment is changing at an unprecedented rate. As discussed in this thesis, a large number of reforestation and forest rehabilitation efforts focus on past ecosystems and seek to restore system's characteristics to their past states. This brings with it the notable complication that the past state of an ecosystem might not be an accurate indicator for the future. Therefore to try to bring back an ecosystem to its past state might in the face of environmental change be counterproductive in terms of achieving lasting outcomes.

Therefore the key element for everyone involved in reforestation and forest rehabilitation is to find a proper balance between rebuilding past systems and trying to build a resilient system for the future. Perhaps therefore in the future, it may be necessary to make way for emergent, functional, and designed ecosystems (Harris *et al.*, 2006; Higgs, 2003). Obviously this is a highly debatable subject since many practical, as well as ethical questions come to be involved. Therefore an open discussion and debate is required to answer the question of when traditional restoration will have to give way to future proof, functional and design driven goals.

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6. Appendix

6.1. Questionaire for Dutch private organisations

A list of topics addressed in the interviews with representatives of the organisations included in this thesis:

What is the main objective of your organisation?

What does your organisation want with the area that is to be reforested or rehabilitatied?

- Nature, biodiversity and ecosystem services
- Carbon sequestration
- Agricultural production
- Other

How are your goals implemented in the field?

- Soil: nutrients, structure, mycorrhiza, microfauna
- Stable hydrology
- Countering pollution
- Ensuring future sustainable land use

What is the role of local communities in your projects?

Do you hire external expertise?

Where do you get funding and how are these funds repaid?

What is the role of (local) governments in your projects?

What do you consider to be major success stories for your organisation?

Are there some unintended negative or troublesome sides to ongoing projects?

What is your organisation's future outlook?

- Upcoming projects
- Challenges ahead
- Expected successes

How do you envision the role of the Dutch private sector in tropical reforestation and forest rehabilitation in the future?

How do you envision the future of tropical reforestation and forest rehabilitation as a whole?

6.2. Organisations from the Dutch private sector

Because the Dutch government advocates that private institutions should get more involved in the management of natural resources, some Dutch private institutions were interviewed for addional information. In this way a more accurate view on present day developments in reforestation and forest rehabilitation can be given. In some cases, scientific literature does not cover all the latest developments and some real life experience from people implementing various methods in the field can offer an invaluable addition to this thesis. In total, five organisations responded in time to be included in this thesis. The answers to questions that were asked to their representatives are incorporated in the texts below.

6.2.1. CO_2 Operate

Website: http://www.co2operate.nl/en/
The interview with founder Paul Burgers took place on November 27th, 2013.

CO_2 operate is a social enterprise that engages in rehabilitating degraded lands on the islands of Java and Sumatra, Indonesia. The main goal of the enterprise is to establish sustainable agroforests on hills that are presently covered by Imperata grasslands. These agroforests serve a number of purposes as they sequester carbon, provide local communities with a sustainable source of income based on carbon payments and agricultural tree products, NTFP's and in the long term timber.

The area in which the company operates was covered by tropical rainforest in the past. This forest was logged unsustainably by state forest enterprises after which a number of forest fires caused the area to become severely degraded. As demand for food rose, the land was converted into monoculture perennial agricultural croplands (clove trees). Agriculture continued until a major crop disease destroyed all crops and the land was abandoned in the 1970s. Imperata grass invaded, and dominated the landscape for 20 to 30 years. Animals moving through the grass deposited quite a large seed bank over the years. This contributed to the major success of the agroforest today. The only requirements to regain forest cover were to manually flatten the Imperata grass, and to mark and protect any possible tree saplings that were already growing between the grass. With the severe competition for light removed these seedlings started to grow rapidly and in three to five years the trees grew up to six metres tall. These trees provide shade and prevent the imperata grass from invading the land again. This simple technology was tested in the projects in collaboration with the Food and Agriculture Organisation. This technique is called Assisted Natural Regeneration. Although this does not provide enough incentive for the farmers to participate in such a programme, CO^2 Operate BV has been able to integrate this technology with the planting of some fruittrees, spices and timber trees in between the naturally occurring trees. These create substantial income sources for the local farmers, making it very interesting for them to participate in the project. Between the trees in some of the newly created agroforests, local farmers also grow a large variety of crops to improve their sustenance. In many cases, the boundaries of the individual fields are marked by planted rows of slow growing but valuable timber trees that serve as a savings account for their children.

Investments come mostly from Dutch companies who seek to compensate their unavoidable carbon emissions. As the projects are presently small in area (about 150 ha), it is not yet capable of attaining any certification, although this is a future goal. At the moment CO_2 Operate maintains close contact with the clients and provides them with frequent updates on the progress that is being made. Carbon stock measurements are regularly conducted by a specialist from the local branch of the World Bank in Jakarta. The local communities derive their income from increased and sustainable agricultural production and are very happy to have their land back into production after so many years. The local government also recognises this success and impact on the local economy and therefore provides some financial and legal assistance wherever needed. Moreover, the local university of Padang and the teacher's college in Padang (Geography) provide students and senior staff to aid in the manual flattening of Imperata grass, as well as for conducting vegetation surveys after the trees have started growing.

Presently a trial is being conducted to start importing teak from community forests on Java. Despite the depression of illegal logging of teak, the EU market demand has remained ever high, causing prices to have risen. Therefore this timber would be directly sold to Dutch timber companies and could greatly increase the revenues generated by CO_2 Operate. This increased income will help to finance expansion of future projects and lead to a possible Gold Standard certification as that is highly desirable but for the moment too expensive to pursue.

In the past major difficulties had to be overcome, as CO2 Operate followed existing regulations and local elites in identifying participants. This did not work out. After 2 years the farmers themselves protested against the local elite, and were able to re organise the projects themselves after the elite were forced to step out of the projects. Parts of the protests were linked to some severe and persistent local government corruption. But now that people see the benefits they have quickly adopted the new ways of sustainable agroforestry. Some challenges still lay ahead as the market for teak is very different from that of NTFPs. Also culture on different islands and in different regions of Indonesia is highly variable, causing the need for highly customized implementation of such projects that does take a lot of time. Future outlooks are very positive as CO_2 Operate is still growing and demand for sustainable timber and NTFPs in the Netherlands and the rest of Europe on the rise.

6.2.2. Rich Forests

Website: http://www.richforests.org/
The interview with founder Roos Nijpels took place on December 3rd, 2013.

Rich Forests is a Dutch NGO, situated in Amsterdam, which focuses on the development of local communities through sustainable forest use and reforestation of degraded lands. The role of Rich forests is that of a matchmaker; trying to find the right people in the right place with the right knowledge and experience.

With respect to reforestation and ecosystem rehabilitation, Rich Forests aims at agricultural lands or forests with a declining production due to overexploitation and a consistent overuse of pesticides. These land use practices are often enforced as a result of a tragedy of the commons problem caused by a lack of clarity and conflicts over land tenure. As crop yields on these lands are gradually declining, the people who depend on them have a more viable incentive to try new land use practices that are both sustainable and more profitable.

The general practice that Rich Forests advocates is Analog Forestry. This method bears characteristics of agroforestry and assisted natural regeneration. Here the aim is to develop a tailor made plan for the area in question which will first involve restoring favourable soil characteristics to some extent. This is then followed by regaining an increasing vegetation cover that will ultimately resemble a late secondary, to mature tropical rainforest. This methods facilitates the accumulation of biodiversity and the the return of ecosystem function and services, while maintaining sustainable agricultural and NTFP production at every stage of succession.

A major success story for Rich Forests is the establishment community tea plantations on Sri Lanka, where tea is now successfully and very productively grown in agroforests that are still developing. Other successes, not related to reforestation but still worth mentioning, are the sustainable harvesting of honey in Indonesia, and the establishment of forest corridors in Costa Rica. In Indonesia, the new method of honey harvesting insures bee communities are left intact. This then leads to the continued pollination of crops, and ability for local people to harvest honey from the same bee colony more than once. The corridors in Costa Rica facilitate the movement of wildlife and resulting seed dispersal. This increase in seed dispersal then leads to an increase in forest recovery after disturbance and a more rapid accumulation of biodiversity.

The success of these projects relies heavily on local involvement as it is mainly meant to improve living conditions of local communities. As communities see a decline in their agricultural production, their means of subsistence also comes under threat. Therefore local communities and farmers are trained in the methods of analog forestry and sustainable forest use. Once the project has started they will at first be guided to use the right methods and maintain a sustainable land use practice. It is also very important for people to experience the benefits of sustainable land use over traditional non-sustainable land use practices. As soon as the people start reaping the benefits of their new land use methods, they will most often freely adopt it and spread the word of their success to others. In this way analog forestry is a self propagating method with the potential to rapidly gain popularity among local communities.

Presently all projects established by Rich Forests are funded using seed capital provided by the development NGO Cordaid and some donations. As these sources of investments are slowly slowly drying up or inviable for the long term, new sources of income have to be found. Eventually the first projects will have to start generating enough of their own income so this can then be used to expand in the near vicinity.

For expansion in new areas, investments will involve trying to find long term credit at attractive rates. Banks are often hesitant to engage in such projects as time until the first return on investment is usually considered too long and investments in these areas are perceived as being too risky. Also carbon credits are not worth enough to cover all the costs of the initial enrichment planting and maintenance. This is particularly problematic as costs for sustained maintenance are rising worldwide.

Future outlooks however are positive as demand and prices for NTFPs and food products are rising worldwide. Therefore it is likely that more companies are going to be willing to invest in such projects in the future as they are looking to make their supply chain more sustainable. If analog forestry projects turn out to be a success in the long term, they are going to be an extremely viable investment product in themselves.

6.2.3. Face the Future

Website: http://www.face-thefuture.com/en/
Interview with senior carbon project manager Martijn Snoep took place on December 3rd, 2013.

Face the Future is a foundation that aims to mitigate climate change and conserve biodiversity. Therefore in reforestation, afforestation and forest recovery projects coordinated by Face the Future, the accumulation and recovery of biodiversity and carbon sequestration are the main goals.

Depending on the local context, specific targets are formulated for future use or protection of the forest. Examples are timber production, NTFPs, and the recovery of biodiversity. The role of Face the Future comprises funding and guidance for local management. By making specific agreements on the targets to be set, Face the Future can control the outcome to some extent, thereby increasing the chance for success.

Two large reforestation and forest recovery projects are considered major success stories for Face the Future. The first is a reforestation project in the Kibale National Park in Uganda. During the rule of past dictatorial regimes large parts of the national park became deforested or severly degraded. Since the establishment of a more stable government, the Uganda Wildlife Authority (UWA) has begun to look for ways to restore the damage done in the past. Here Face the Future has helped coordinating a major reforestation and forest recovery project in the National park since the beginning of the 1990s. The project is considered a major success as 90% of the original targets have been achieved. As the area was completely deforested, the restoration efforts had to be started by enrichment planting, followed by assisted natural regeneration. The first three to five years of a reforestation project require intensive maintenance for tree to be able outcompete the otherwise dominating grasses. For this maintenance, people from local communities are hired. This then creates a source of income for the local communities, further preventing them from using forest resources unsustainably.

The second large success story is a forest rehabilitation project in Sabah, Malaysia. Here the dipterocarp forest has been logged unsustainably and consequently got degraded. The area is situated in a major logging concession that was to be consecutively logged, but is now dedicated to nature conservation. The logging company that still holds the concession will therefore no longer log the area, and has put funding aside for the recovery of the forest and its biodiversity. Since the area still maintains a certain degree of secondary forest cover with large gaps, and there are no nearby human communities, recovery here is much easier than in for instance Uganda. Here much of the soil remains intact, even containing many of the specific mycorrhiza fungi that dipterocarp tree require in order to grow. Also the presence of some forest cover means that it is much easier to return to late secondary to mature forest cover. The forest recovery practices here involve nursing and replanting of native, slow growing, shade tolerant, commercial tree species that were previously logged. The project was started in the early 1990s and is continuing to this day with over 50% of the targets achieved.

Another project that is still going on is the establishment and maintenance of timber plantations in Ecuador. These plantations are not considered as true forests as biodiversity is low when compared to natural or restored forests. However these plantations do sequester carbon to some degree and contribute to the protection of natural forests as the need for logging is reduced,. For all projects, the sequestration of carbon is measured by external organisations in the field and is certified by the Verified Carbon Standard.

Major obstacles in maintaining successes in reforestation and forest recovery projects arise from increasing maintenance costs. Labour and fuel costs have risen significantly since the start of the projects. And as there are no new sources of funding it is becoming increasingly difficult to maintain the project areas. This is also a concern for future projects as reforestation from completely degraded land is becoming too expensive. Moreover, income from for instance carbon credits is low as these are not worth enough to cover all costs. Also many investors are not willing to invest in such projects as time to return on investment is considered too long, profit margins are too low and risks are perceived as being too great. Another aspect here is that during times of financial recession, few companies are willing to pay for compensation of their carbon emissions. Therefore new sources of funding and income have to be found.

To address these difficulties Face the Future now has some pilot projects on agroforestry running in Senegal and Egypt to test the viability of this practice in these countries. If the pilot studies turn out to be successful and profitable, these could become major new projects for the future. These projects not only sequester carbon or accumulate biodiversity to some degree, but are also meant to yield direct sources of income, therefore making them a more viable target for investment.

6.2.4. Form International

Website: http://www.forminternational.nl/
Interview with senior forestry expert Rik Sools took place on December 10th, 2013.

Form International is a commercial forestry consultancy firm that has been active in the field of sustainable commercial forest exploitation sincs 1992. Originally Form International was active mostly in the FSC certification of the tropical forestry sector in Africa and Indonesia. This has now been elaborated with reforestation prorgammes in the form of sustainable timber plantations and agroforests with a timber production component. Also a pilot project is presently conducted to test the viability of cultivating *Allanblackia* in agroforests in Ghana. The main purpose of these projects is to generate market based income derived from sustainably cultivated forest products.

The main timber plantations that are presently being worked on are teak plantations in Ghana and Tanzania. Teak is the species of choice as its properties are well known and demand for it is high and rising. This makes it a commercially viable and low risk species for cultivation in plantations. For Form International, ecological, social and economic sustainability are top priorities. In Ghana, Form works with long term land lease agreements (50 years renewable) on land owned by traditional land owners and managed by the government (Forest Reserves). In Tanzania, Form works on privately owned land. In both countries, good relations with land owners, government and local communities are key to long term sustainability of the projects.

As teak trees demand reasonable to good soil quality in order to grow fast enough to meet commercial requirements, not all degraded areas are suitable for teak plantations. Form does not use fertilizers so before any teak plantation is started, first soil parameters in the designated areas are verified. True land reclamation areas could be used to establish plantations. But as the production potential in such areas is often very limited, this would generally be implemented as a compensatory, restoration or mitigating measure by a private organisation (company or NGO) or through government intervention.

Form International provides management and technical assistance to affiliate plantation companies, Form Ghana and Form Tanzania, that aim to reforest degraded lands in these African countries. In these plantations, Form International does strive to increase biodiversity and ecosystem function as much as possible within commercial parameters. Form has a voluntary commitment to plant 10% indigenous tree species, whereas FSC certification requires only 5%. Furthermore the plantations are only established in areas where they don't compete with agriculture. Local communities are not allowed to live in the area as it is designated as forest (Forest Reserves). In order to benefit both the client as well as the local communities, the local farmers are allowed, and even stimulated to grow their crops among the timber trees for the first few years of establishment (intercropping system). This allows the local communities to generate some income and is a useful tool for cheap and beneficial maintenance of the plantation. In all project phases, people from local communities are hired for maintenance of the plantations. Currently, Form Ghana employs around 300 permanent employees and 300 temporary employees.

In its projects, Form relies mostly on its own expertise, but for a number of services, e.g. soil and hydrological surveys, it is appropriate and efficient to hire external and/or local experts. Form has had some major reforestation successes in Cameroon and Ghana, but recognizes that working in this field and geographical area is sometimes difficult and risky. As lawful, sustainable and socially responsible operation are mandatory requirements for all operations, creativity, vigilance and sometimes a lot of patience are required. If a new project for some reason cannot meet all the requirements, another area has to be chosen for establishment.

As for future projects, Form will continue with its teak plantation operations. Also a pilot study for the upscaling of *Allanblackia* production for the Dutch/British multinational Unilever is being conducted and looks promising. For expansion of reforestation and ecosystem rehabilitation in all its forms on a large scale, much still has to be done. As enterprising in many tropical countries can be risky, at the moment not many potential investors are willing to invest here. Still Form International sees a positive future for reforestation and ecosystem rehabilitation as demand for sustainable forest products is rising. Another major way of increasing success rates of such enterprises in the tropics, would be to increase cooperation between different organisations and local stakeholders. Even though many organisations have different goals when it comes to reforestation, and might not agree with one another's methods, still a lot can be learned and gained from each other. More cooperating actors could help mature the reforestation and ecosystem rehabilitation sector and thereby reduce risks and increase mutual successes. Presently investments in this sector involve high risks and high rewards. This could then be turned to low risks and high rewards and thereby increase magnitude and scale of such enterprises.

6.2.5. Trees for All

Website: http://www.treesforall.info/
Interview with founder Sjaak de Ligt took place on december 13th, 2013.

Trees for All is a foundation and certified charity that focuses on protecting and restoring forests and supporting the use of renewable energy. When it comes to reforestation and forest rehabilitation the main goal is to restore biodiversity and ecosystem function. This is done mainly by planting native tree species where they had earlier been removed. Trees for All advertises mostly with CO_2 compensation and options for implementing corporate social responsibility. However CO_2 compensation is seen more as a tool for addressing a much wider range of issues involving reforestation and forest rehabilitation. Income is generated from both individuals and companies who seek to compensate their impact on the environment.

Trees for All is involved in two major reforestation and forest rehabilitation projects. The first is a major project in Sabah, Malaysian Borneo in cooperation with Face the Future. The projects takes place in a remote secondary dipterocarp forest that has been logged intensively. Here all commercial timber species have been logged and therefore large gaps have emerged. Most seed bearing commercial tree species have been cut and new seedlings often burn to death as a result of direct exposure to the sun. The logging company holding the concession wishes to selectively log the forest again in about 30 to 50 years from now and seeks to do this in a more sustainable manner. Therefore it has engaged in enrichment planting with native dipterocarp trees that are for a large part fruit bearing so native wildlife such as orangutans is also supported. New timber from this forest will have to be FSC certified so future practices will only involve reduced impact logging and again enrichment planting. The project is mostly funded by the logging company and is supported by the Sabah Foundation and thus the government. As there are no human communities present in the area, there is no need for additional protective methods. At this moment about 90% of the original replanting targets have been achieved so the project is considered a major success.

Another ongoing project involves the reforestation of a national park on Mt Malindang in the Philippines. Here human encroachment in the past has led to ongoing deforestation causing only a small fragment of the original forest to remain. All previously forested and now abandoned areas are dominated by grasslands. Here replanting is done entirely by local communities who derive a part of their income from it. Also the tree nursery is managed entirely by local communities. The Philippine forest management bureau is the project partner and coordinates the project in the field. It also funds about 25% of the project. The other 75% is funded by Trees for All and this income is derived from CSR and individual donations. To prevent future unsustainable use of the forest and to address the needs of the local communities, for every ten hectares planted, one hectare is attributed to the communities for their own use as they see fit. Also after 30 years, if no forest has been cut in violation of agreements, a fund will be made available to the local communities. In this project about 30 - 40% of replanting targets have been achieved.

Even though the projects in which Trees for All is presently engaged are going quite well, still some challenges and uncertainties lie ahead. The forests in Sabah are at the mercy of the goodwill of the logging company that presently manages it. Chances for it to happen are very slim, but should another company with a less sustainable agenda try to take over, all progress here may be lost. Also working in the Philippines requires a lot of patience as the working attitude there takes a lot of getting used to. Moreover, carbon credits are a declining source of income as their prices are falling. At this moment, carbon credits are worth less than 1 Euro per tonne of carbon emitted. This, combined with rising commodity prices worldwide makes it difficult to use carbon credits as a viable source of income.

Trees for All does see a bright future for reforestation however. As trees are a prime investment as they generate more than they cost in direct and non-direct economic value or natural capital. This with new methods of creating public awareness could potentially lead to a larger source of income from individuals in Europe. Also Trees for All sees a growing potential from CSR as more companies see the benefits of sustainable resource use. To make reforestation and forest rehabilitation efforts an even bigger success, there is a need for more cooperation between different stakeholders and companies in the field. If more different people with different agendas become involved and share their resources and knowledge, they could work more to each other’s benefit, risks could be reduced, and therefore much more could be achieved.