Smallholder Agroforestry Programs: An Instrument for Mitigating Supply Chain Risk

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Executive Summary

Amidst increasingly globalized and competitive markets, many companies are recognizing that effective supply chain management requires monitoring and controlling the sustainability of their primary agricultural materials. This paper examines how three companies developed programs to improve the sustainability of agricultural inputs primarily through the promotion of agroforestry systems to smallholder farmers. Mars, Inc. worked to transform cocoa cultivation, Unilever introduced a new non-timber forest product called Allanblackia to the market, and the Western India Match Company convinced local farmers to integrate poplars with their existing crops. Their motivations for using agroforestry as a tool, the details of their project implementation, and the results of their endeavors will be deconstructed and compared to find common components that can serve as a general model for companies interested in similar initiatives.

Keywords: agroforestry; sustainability; supply chain; agriculture

Resumen Ejecutivo

En medio de mercados cada vez más globalizados y competitivos, muchas empresas reconocen que la gestión eficaz de la cadena de suministro requiere que se supervise y gobierne la sostenibilidad de sus materias primas agrícolas. Este artículo investiga como tres empresas desarrollaron programas para mejorar la sostenibilidad de recursos agrícolas principalmente usando la promoción de agroforestería a pequeños agricultores. Mars, Inc. trabajó para transformar la cultivación de cacao, Unilever introdujo un nuevo producto forestal no maderero, Allanblackia, al mercado, y Western India Match Company consiquió convencer a los agricultores locales incorporar los alamos con sus cosechas existente. Sus motivaciones para usar agroforestería como un herramiento, los detalles de la implementación de sus proyectos, y los resultados de sus esfuerzo serán deconstruídos y comparados para encontrar rasgos compartidos que pueden servir como un modelo general para empresas con iniciativas parecidas.

Palabras clave: agroforestería; sostenibilidad; cadena de suministro; agricultura

Manufacturers of processed agricultural products face numerous challenges in securing the supply of their primary agricultural materials originating on smallholder farms. These challenges range from increasing costs for agricultural inputs and environmental degradation of farmlands to economic instability that causes high rates of farm abandonment. This paper focuses on how three companies – Mars, Inc., Unilever, and Wimco – chose to confront the problem of supply chain risk by instituting large-scale agroforestry programs.

Since the concept of agroforestry is not particularly well-known, the first section of this paper will briefly review the nature of this practice and its advantages and disadvantages. Next, three case studies will provide concrete details of the agroforestry programs implemented by Mars for cocoa, by Unilever for Allanblackia, and by Wimco for poplar. The final section will compare these three programs and identify common features of the companies' motivations, methods, and results.

Agroforestry Overview

Agroforestry is the deliberate integration of woody perennials (trees and shrubs) into agriculturally productive landscapes. The practice encompasses a wide range of techniques and an equally broad array of intended goals. For example, alley cropping provides long-term and short-term investments by growing slow-maturing hardwoods or nut trees alongside annual agricultural crops. Riparian buffers protect waterways from adjacent land by absorbing excess fertilizer runoff, reducing bank erosion, and increasing biodiversity. Silvopasture uses trees and forage to provide shelter and high-protein fodder for livestock while simultaneously fertilizing and reducing weed competition for trees. These methods, among others, represent an increasingly important tool for low-input, productive agriculture that seeks to preserve land for future generations. However, it is important to recognize that agroforestry is not a panacea.

Although it is "widely practiced and demonstrably productive", other agricultural systems along the entire spectrum of high/low-energy input are still necessary to best use the available resources and provide the necessary products for our growing population (Kidd, 1992, p. 107). However, for many crops and in many regions of the world, agroforestry can prove to be a superior alternative to conventional large-scale, high-input farming systems.

The benefits of agroforestry can generally be divided into two main categories – social/economic and environmental – which may overlap at times. A brief review of these small-scale drivers for agroforestry will provide crucial background for later discussion. To start, many Green Revolution approaches to agriculture – widespread irrigation infrastructure, genetically improved seeds, synthetic fertilizers, pesticides – that have become widespread in the United States and elsewhere are not practical on the extremely heterogeneous and often marginal lands from which numerous agricultural products originate. Conventional techniques can be impractical on a farm for various reasons: "poor soil, slopes, and other marginal lands that preclude the use of large machinery; inadequate or poorly timed availability of water; farm size averaging less than a hectare; crops dependent on hand cultivation at all stages; and inadequate income" (Kidd, 1992, p. xi). In addition, standard methods of technology transfer, such as publications and extension services, often have little to no reach due to a lack of infrastructure, education, and funding (Franzel, 2002). For these reasons, practices such as agroforestry may be the only viable alternative for landowners seeking to achieve agricultural profitability. In some cases, it has been shown that "the small amounts of cash generated by selling AFTPs [agroforestry tree products] can allow farmers to purchase agriculture inputs, to achieve higher yields from their staple foods, and so create an opportunity for further advances into cash cropping," (Leakey, 2005, p. 18). This income diversification is a particularly important means to buffer farmers from the low or unstable prices that traditional crops normally fetch. Trees grown for "timber, fruit, energy, medicine, and seed" can provide short- or long-term income security and thereby prevent such extremes as farm abandonment due to unprofitability, which can exacerbate price instability in the market (Franzel, 2002, p.33; Clough, 2009). Agroforestry also has the potential to reduce costs, such as when trees with highly nutritious leaves, called fodder trees, are grown to substitute for expensive dairy feeds for the purpose of increasing milk yield and quality (Franzel, 2002).

Many see great value in agroforestry's potential for positive environmental effects. With a growing population and limited resources, the expansion of conventional agriculture is increasingly blamed for many of the world's environmental problems. Climate change, for example, can be strongly linked to farming practices on multiple levels: rice paddies and ruminant livestock release methane, mechanization and fertilizers rely heavily on fossil fuels, and land use change is a major cause of deforestation. Adding trees to farms increases carbon sequestration both above and below ground and decreases reliance on synthetic fertilizers and large machines. In areas of the world where soil quality is low and swidden or slash-and-burn agriculture is practiced, agroforestry can relieve pressure for decreased fallow periods by maintaining a high enough carbon content in the soil to prevent nutrient leaching. By allowing for decreased fallow periods, agroforestry limits the amount of forest land under rotation, mitigates the severity of fragmentation of forests, and accelerates regeneration time of forests that are part of a swidden rotation. In this sense, trees on farms can help manage healthier forests to fight climate change and to preserve biodiversity. As an example, the heavily-studied cocoa agroforests have served "as faunal refuges…[and] been noted to provide habitat and resources for plant and animal species and maintained connectivity between different land uses, particularly fragmented forests" (Asare, 2006, p.3-4).

Conservation of biodiversity is just one example of how the effects of agroforestry have more recently been recognized to include regional benefits. Attempts at watershed conservation and restoration, for instance, are often a response to pollution of waterways due to agricultural runoff in the form of sediment and excess nutrients. However, well-designed agroforestry systems can decrease soil erosion, increase flood resilience, and absorb fertilizer runoff, all of which contribute to a healthier watershed. This large-scale interconnectedness is one of the reasons agroforestry – and sustainable agriculture in general – hasn't become more widespread and consistent. Many smallholder farmers utilize some form of agroforestry to derive the on-farm benefits such as adding another source of income, but don't make decisions as a group even though many of the advantages of sustainable agriculture come from widespread adoption of these practices. Other challenges that NGOs such as the World Agroforestry Centre face in proliferating agroforestry methods include (1) the myopia of farmers when making investment decisions, (2) lack of infrastructure in developing countries that prevents extension services, (3) lack of funding, (4) weak documentation and experimentation, (5) poor distribution networks for dispensing germplasm and other resource, (6) lack of credit, and (7) farmer resistance to change due to high perceived transition costs. Corporations have the resources to overcome many of these obstacles, but convincing a company to invest in an agroforestry program requires proving that there are direct benefits to be gained. For industries sourcing primary agricultural materials from smallholder farmers in developing countries, these benefits normally take the shape of security of supply, although other advantages will be observed as well. The following three sections will examine the cases of Mars, Inc., Unilever, and Wimco, breaking down their agroforestry projects into the companies' primary motivations, the details of implementation, and the final results.

Mars, Inc. – Cocoa

Motivation

Mars, Incorporated has many reasons to be concerned about the sustainability of its cocoa supply, including a need to address growing complaints from environmental groups about destruction of rainforest wildlife. However, it is unlikely that the company would have invested such a broad effort in tackling the issue if it had not expected an impending threat to its supply of cocoa beans. Cocoa production has long been a boom and bust business on the regional and national scale, as Figure 1 illustrates. Brazil, Ghana, and Malaysia have all experienced massive changes in their relative importance in the global cocoa market. Mars, Incorporated, along with other chocolate manufacturers, worries that Côte d'Ivoire and Indonesia, the world's two largest producers today, may soon experience a similar crash in cocoa bean production. Due to the limited geographical zone in which cocoa trees can be cultivated (approximately 15˚-20˚ north and south of the equator), these localized fluctuations have a large potential impact on global cocoa production numbers. As shown in Figure 2, the result is that 17.4 million hectares of land have been converted to cocoa cultivation since 1961, but only about 10 million hectares are currently in production (FAOSTAT, 2012). This discrepancy means that each year, hundreds of thousands of hectares of cocoa trees are removed from production without being replaced. Over the past 100 years, demand for cocoa products has steadily grown at about 3% per year and is expected to grossly exceed supply by the year 2020. In response to these projections, the chocolate industry, and Mars in particular, has dedicated itself to determining how cocoa production can be improved and how the "boom-and-bust cycle" can be circumvented (Clough, 2009).

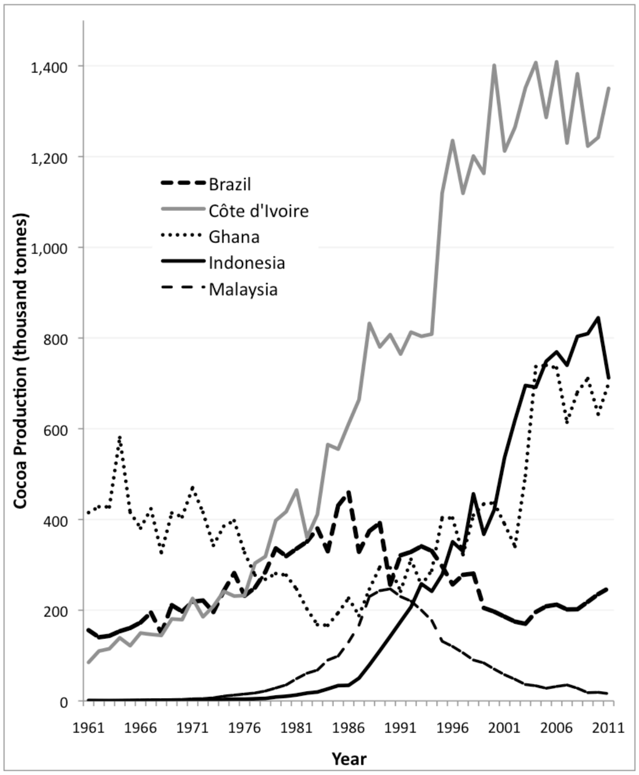

Figure 1
Source: FAOSTAT 2012
Yearly cocoa production in Brazil, Côte d'Ivoire, Ghana, Indonesia, and Malaysia. Production is often characterized by a boom-and-bust cycle that is extremely apparent on the regional scale, but still visible on the national level.

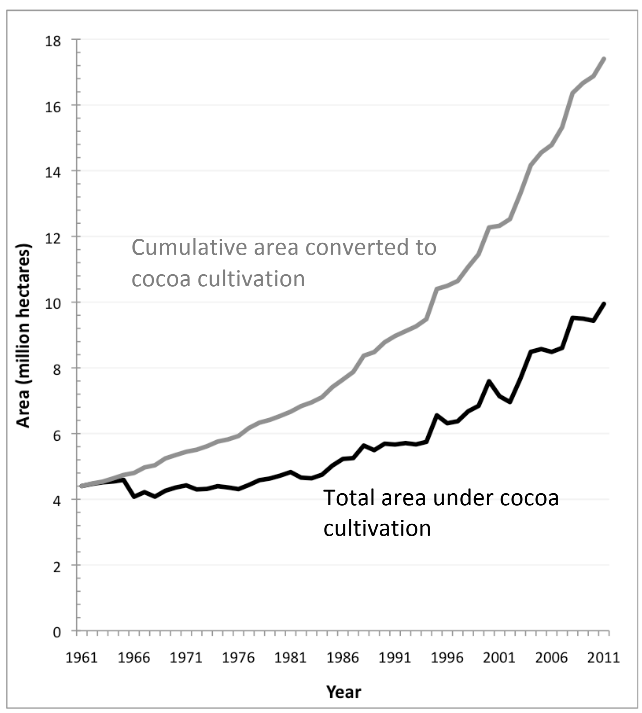

Figure 2
Source: FAOSTAT 2012
Since 1961, 17.4 million hectares of land have been converted to cocoa cultivation, but only about 10 million hectares are currently in production. This discrepancy signifies that each year thousands or hundreds of thousands of hectares of cocoa trees are removed from production and not replaced.

Unsurprisingly, it has been discovered that the sustained productivity of cocoa farms is largely dependent on the methods of cocoa cultivation employed by farmers. To start, it is important to understand that cocoa (*Theobroma cacao* L.) evolved as an understory forest tree in the Amazon and requires tropical climates to thrive. This means that cocoa cultivation is often in direct competition for land in tropical rainforests, and any attempt to create a controlled environment that favors cocoa proliferation will result in some degree of biodiversity reduction compared to the status quo of natural forest cover. In fact, cocoa cultivation has encroached on many diversity hotspots in the past, including the West Africa Guinea Forest, Sabah, Sarawak, and Sulawesi. However, the biology of the cocoa tree dictates the possibility for a middle ground in the trade-off between yield and biodiversity conservation. Young cocoa trees require shade to prevent the severe physiological stress that results from direct sun exposure. Consequently, cocoa is almost invariably started in some form of agroforestry system, whether the trees are planted into thinned forest or onto farms alongside other trees planted intentionally for shade. However, as plants mature, they can form a closed canopy and aren't as reliant on surrounding trees for shade. At this point, many farmers choose to remove shade trees and add fertilizer, which causes short-term yields to increase. In fact, for many decades agronomists from organizations such as the West Africa Cocoa Research Institute have advised cocoa growers to remove shade trees to increase yields. However, unshaded plantations are susceptible to much higher rates of pest attacks and tree death due to the physiological stress imposed on the trees and the sheer lack of biodiversity. Despite these conclusions in the scientific realm, many farmers are not aware of the risks of cultivating unshaded cocoa. As a result, the vast majority of cocoa is grown under ecologically unstable conditions that almost guarantee high crop losses to pests and disease, and expensive outlays for pesticides and fungicides (Clough, 2009).

In addition to false knowledge about the effects of shade removal, many farmers lack proper training in fertilizer application, pruning, tree spacing, and intercropping, all of which would reduce the threat of pests. Exacerbating the problem is the lack of quality germplasm and disease resistant varieties of cocoa trees. Many of these problems are self-perpetuating: as cocoa yields and quality drop due to pest attacks, disease, and aging trees, farmers are unable to reinvest in their plantations and subsequently leave the cocoa market. Then, in response to elevated prices caused by insufficient supply, a new generation of farmers with no experience enters the market and makes the same mistakes, often on a new swath of forested land. It has also been shown that after cocoa is abandoned in an area, the land does not normally return to a forested state, but rather is converted to intensive monocultures such as full-sun coffee or oil palm plantations.

The motivation for Mars's actions is apparent: a declining and unpredictable cocoa supply can have an enormous impact on profits. Only by identifying the original cause for the supply shortage did Mars have adequate incentive to invest in a solution. What has been shown thus far is a causal chain of events that links an uncertain cocoa supply to farmers' lack of knowledge and resources. This connection allowed Mars to develop a concrete strategy to improve the prospects for one of its key ingredients.

Execution

Addressing the issues mentioned above requires resources that many organizations simply do not have. Merely contacting a significant portion of cocoa farmers (approximately 5 million worldwide) is a massive challenge due to the lack of infrastructure in many cocoa-producing countries, low literacy rates that necessitate face-to-face interactions, and the sheer number of farms. In addition, the economic and political conditions of any given cocoa-growing country may not be conducive to the intervention of a transnational company such as Mars, due to increasing concerns about national sovereignty and anti-Westernism. These facts were important in shaping the strategy that Mars took and prompted the company to evaluate the opportunity for partnerships with organizations that might benefit from rehabilitating cocoa production. Luckily, many groups have a stake in cocoa: "the chocolate industry needs a stable supply of raw ingredients, environmental groups seek to preserve the wildlife habitats that cocoa creates, development groups aim to raise rural incomes, and governments look to support domestic agricultures" (Shapiro, 2004, p. 454). In fact, concerns about the habitats of migratory birds were the motivation for a conference held in Panama in 1992, which marked the beginning of Mars's unwavering contribution to sustainable cocoa production.

Since the Panama Conference, Mars has worked with the USDA/ARS to study integrated pest management systems for cocoa, partnered with IBM and the USDA to sequence the cocoa genome for public use, and more. In November 2008, Mars sponsored a conference at which various cocoa stakeholders, including fourteen West African and Central African countries, finalized the first ever sustainable cocoa farming plan for African nations, where 70% of the world's cocoa was grown at the time. The plan included a thirty-year vision of necessary steps, such as providing information channels for farmers to stay updated on market prices, government collaboration for sales taxes, and improving social services with the higher incomes generated from cocoa. However, the corporation's most recent and most impactful commitment was its announcement in April 2009 to source 100% sustainable and certified cocoa by 2020, worth more than one billion dollars, when at the time "only 2-3% of the cocoa market [could] be labeled as sustainable" (Hoeven, 2009, p. 19). In order to accomplish this, they have developed a farmer-centric strategy that consists of three main components: farmer training, stable prices, and certification.

Farmer training involves partnering with institutions such as the World Agroforestry Centre, UTZ and The Rainforest Alliance to transfer sustainable cocoa technology to farmers. They are using a 'hub-and-spoke' model to reach a greater number of farmers than would be possible with other methods (see Figure 3). The hub of each 'wheel' is a Mars Cocoa Development Center or CDC, that acts as a model farm where best practices are showcased, applied research is conducted, and individuals from government agencies, local organizations, and companies are trained to pass technology on to farmers. According to the Cocoa Sustainability page on Mars's website,

> "CDC locations are chosen with care to be highly visible sites in the heart of cocoa-producing communities. For maximum effect, roadside locations are planted with cocoa trees that demonstrate the benefits of good farming practices. Poorly maintained trees are grown next to well-maintained trees so farmers can see the difference for themselves." (Mars, 2012)

Branching out from each CDC are approximately twenty Village Cocoa Centers or VCCs, where local farmers can learn sustainable cocoa practices in their own village communities, purchase quality germplasm, acquire fertilizers, get advice, and even hire grafting experts to help rejuvenate their cocoa trees, addressing the issue of aging plantations. Farmers are encouraged to combine agroforestry techniques, quality genetic material, and other yield-improving methods to "produce more cocoa from fewer trees and to diversify their production so they can balance their income across the seasons" (Hoeven, 2009, p. 19). Research has been conducted portraying the benefits of combining cocoa cultivation with cashews, galip, safou, coconut, rubber, longan, and more, which can provide food and fuel resources to farmers or diversify their income with other cash crops. Each VCC serves about 100 farmers, and is monitored by its respective CDC for quality of service. Although Mars runs CDCs, VCCs are run independently by local farmers and are intended to be part of a long-term, self-sustaining system for farmer-run technology transfer.

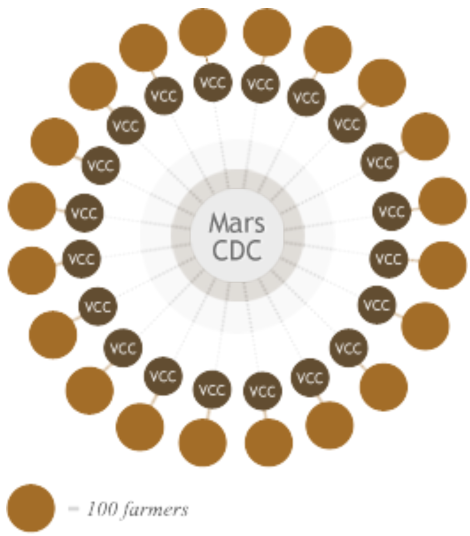

Figure 3
Source: Mars, 2012
"The hub-and-spoke model allows us to reach more farmers. A single CDC deals directly with around 20 VCCs. VCCs work directly with around 100 individual farmers."

The second component of Mars's plan is stabilization of cocoa prices to benefit both cocoa manufacturers and cocoa farmers. Price spikes in raw cocoa can cause the price of cocoa products to increase, which can affect sales. On the other hand, price drops cause farmers to switch to growing other crops that are more profitable. Unfortunately, the effects of price changes can be self-perpetuating due to the lag time of growing cocoa trees to maturity. Price stabilization is largely achieved as a side effect of increasing sustainability of cocoa farms, but Mars is approaching the issue from another direction as well. The company is persuading its largest competitors through collaboration and consumer pressure to purchase sustainable, certified cocoa as well. The intended effect is to make industry-wide improvements to the boom-and-bust cycle of cocoa production by maximizing demand of certified ingredients, and to reduce the price premium of certified cocoa with larger volumes. This demonstrates that Mars's ultimate goal with cocoa sustainability is not product differentiation, but rather supply chain management (Hoeven, 2009).

The third feature is certification of cocoa suppliers. In this instance, certification operates more as a means to an end than as a marketing tool. Mars is using the resources and local connections of organizations such as ISEAL Alliance, Rainforest Alliance, UTZ, Fairtrade International, and COSA to make its cocoa traceable and to incentivize farmers to use sustainable practices in exchange for a price premium (Hoeven, 2009). These independent cocoa certifiers offer their own training programs to farmers and audit farms to check for compliance. In exchange for certification, farmers receive higher prices for their cocoa, access to training and resources, and a guaranteed market. The standards for certification generally incorporate minimum wages, pest management systems, biodiversity requirements, water conservation, and more. Certification has the added benefit of monitoring for child slave labor on cocoa farms, which has been under scrutiny especially in Côte d'Ivoire.

These policies, in combination with its large investments in cocoa agronomy research and genome sequencing, have been instituted to support farmers financially, improve regional development, conserve and restore the environment, and ultimately meet projected future demand for cocoa products. Mars's commitment was announced after three years of global cocoa deficits, warnings about climate change's effect on cocoa yields, and evidence of greater demand for certified products. Although fewer than four years have passed, it is important to review the outcomes of Mars's investments.

Results

So far, Mars's efforts have been mostly concentrated in Côte d'Ivoire, which produces about 35% of the world's cocoa supply. In 2011, 10% of Mars's cocoa came from certified sources and they are on track to have 35% certified by 2014. As of then end of 2012, 17 Cocoa Development Centers had been built by Mars and its collaborators, with a goal of 75 by the year 2020. CDCs have proven to be successful, with many farmers' yields doubling or tripling after aging trees were replaced or used as the rootstock for grafting, in addition to other changes. This has had the effect of increasing farmer incomes by up to 500% in best case scenarios (Mars, 2012).[1] According to a survey conducted by GTZ in Côte d'Ivoire, "certified cocoa farmers who had received training in integrated crop and pest management, pruning of trees, seedling nurseries, and agroforestry, reported improved productivity by up to 30% and also increased awareness about post-harvest handling for quality" (Millard, 2011, p. 370). However, it is important to realize that most of these results are published by Mars and Mars affiliates and have the potential for a positive bias. Also, the metrics Mars uses for success (percentage of supply certified, and number of CDCs and VCCs established) does not necessarily reflect the more important impacts on farmers, such as average increases in profits or the degree of environmental improvement. For that reason, the following section covers some conclusions made by independent studies about the potential of transitioning to agroforestry-based cocoa systems and also some of the challenges to making such widespread changes.

Some agricultural scientists estimate that as much as 50% or more of the potential cocoa crop each year is lost to "aging trees, outdated farming techniques and plant disease" and conclude that reaching out to the 5 to 6 million small farmers that produce more than 90% of the world's cocoa could reverse this loss (Hoeven, 2009, p. 19). The capacity for agroforestry to

[1] Mars's ongoing achievements can be followed at this website: http://www.cocoasustainability.com/

make a boom-and-bust cycle into a long-term, sustainable, and profitable occupation is evidenced by places such as Bahia in Brazil, where cocoa has been grown in traditional cabruca agroforests for over a hundred years (Clough, 2009). In a collaborative study in 2011 about the multifunctional role of shade trees for cocoa and coffee, researchers found that cocoa trees in agroforestry systems suffer less from leaf herbivory and pests. With “a diverse layer of natural shade trees compared to just one species of planted shade trees,” pathogens such as black pod disease can be alleviated as well (Tscharntke, 2011, p. 619). Lower disease levels are likely a result of the greater microbial diversity in agroforests. However, without proper spacing, pruning and in some cases fungicide application, agroforests can still suffer from diseases such as witch’s broom. The same study found that cocoa agroforests are more resilient to droughts and extreme temperatures, require less water and fertilizer input, and have fewer weeds, which can act as “reservoirs of pests and diseases” (Tscharntke, 2011, p. 623).

Another study on the profitability of cocoa agroforestry collected input-output data from farmers over three seasons and combined it with data from traditional cocoa fields of various ages to conduct a discounted cash flow analysis comparing traditional varieties of unshaded cocoa, unshaded hybrid cocoa, and shaded hybrid cocoa. The results indicated that over an 80 year cycle, without including costs of fertilizers and pesticides, shaded hybrid cocoa had the highest net cash flow (Obiri, 2007). However, the limited amount of data collected in this study in addition to the large number of assumptions made, such as compliance with recommended rotation lengths, chemical costs, and timber value, might make this report difficult to extrapolate.

It is now generally accepted that transitioning from unshaded cocoa farming to agroforestry-based systems has a positive effect on long-term yields and farmer income, and that additional gains can be made by providing training, quality germplasm, and fertilizer. The real challenge that Mars faces is convincing farmers to make the transition, and monitoring them for continued compliance. The latter is especially important since cocoa tree productivity often spans generations and because many of the benefits, such as environmental conservation and regional development, are long-term in nature. There are many constraints that might prevent widespread adoption and continued commitment. For example, even in regions with established CDCs and VCCs, many farmers would have to travel long distances using unreliable infrastructure to access resources and training. Also, many cocoa famers don't own their own land, which means there is less of an incentive to invest in the farm's improvement. In some countries, farmers don't have the right to cut down trees, so planting timber trees for shade would not provide additional income. Finally, access to credit is often nonexistent for small farmers in developing countries, resulting in insufficient capital to invest in new cocoa varieties or fertilizer, regardless of whether they are available (Millard, 2011).

On the positive side, since Mars is promoting agroforestry and farmer education as a risk management tool rather than as a marketing scheme, they are more likely to continue the program long past the year 2020. This will allow the company to iron out any kinks in their approach and to collect valuable data as to the success or failure of the program, which can serve as a resource for other companies attempting the same feat in their own supply chains. Also, rapid growth in consumer demand for "ethical" cocoa products does help offset some of the short-term costs of investing in cocoa sustainability. Although most of Mars's chocolate bars are not considered luxury brands, the general public is becoming increasingly aware of certification labels and making decisions with them in mind (Byers, 2008). In general, Mars's efforts should be seen as a success thus far, and it will be interesting to see whether or not they reach their goal of 100% certified cocoa within the decade.

Unilever - Allanblackia

Motivation

Similar to Mars, Unilever has dedicated itself to sourcing 100% of its agricultural raw materials sustainably by 2020. The reasoning the company gives is the following:

> "Agriculture and forestry are the largest contributors to global greenhouse gas emissions and are major drivers of climate change. Half of Unilever's raw materials come from either farms or forests. Given the scale of our footprint, sustainable agricultural sourcing is therefore a strategic priority for our business and brands. We are committed to sourcing sustainably all our agricultural raw materials by 2020. As well as protecting the planet's natural resources, sustainable sourcing helps us to manage a core business risk by ensuring security of supply for the long term." (Unilever, 2013)

Despite this, Unilever's support of agroforestry manifests itself in a very different form than that of Mars. While Mars sought to address potential severe shortages of a key ingredient by changing the way cocoa was being cultivated, Unilever seeks to introduce a completely new raw material to international markets by urging farmers to incorporate it onto existing farms. This crop, called Allanblackia, would be used to reformulate and improve existing Unilever products and possibly provide the foundation for entirely new creations.

Allanblackia is a tree genus consisting of 9 published species that grow in equatorial rainforests in West, Central, and East Africa. They are considered 'Cinderella' species, or potentially valuable crops that have been overlooked by science and industry and have not been well-domesticated or commercialized (Asaah, 2011, p. 390). Locals list the following uses for the tree: "timber and fuel wood, cooking oil from seed extraction, dried leaves are used as medicinal tea against chest pain, and heated oil is smeared on aching joints, rashes and wounds" (Meshack, 2004, p. 10). In 2002, a partnership was established between Unilever, The World Agroforestry Centre, The World Conservation Union, Netherlands Development Organisation, and various African governmental organizations and NGOs to launch the "Novella Africa" initiative aimed at developing Allanblackia on a commercial scale (Novella Africa Initiative). Unilever recognized the potential for Allanblackia in the seed's unique composition of stearic and oleic fatty acids, which give it a higher melting point and make it ideal for margarine, dairy cream alternatives, soaps, and detergents. Also, it is a potential substitute for oil palm because it is considered easier to cultivate in an environmentally friendly way and requires less chemical processing before use (Russell, 2009).

Looking at the FAO's projections for future diet shifts and average kilo-calorie requirements in developing countries may provide insight into another motivation behind Unilever's interest in Allanblackia. According to the FAO's World Agriculture Summary Report in 2002, two trends are emerging that would be potential motivators for Allanblackia development. First, developing countries are expected to have higher daily calorie requirements due to aging populations, since adults require more energy than children. Second, a larger portion of those calories is expected to come from vegetable oils due to shifting preferences (FAO, 2002). Perhaps in anticipation of these changes, Unilever hopes to diversify its supply of vegetable oils to increase its overall supply and reduce the potential damage of major crop losses in any one oil type.

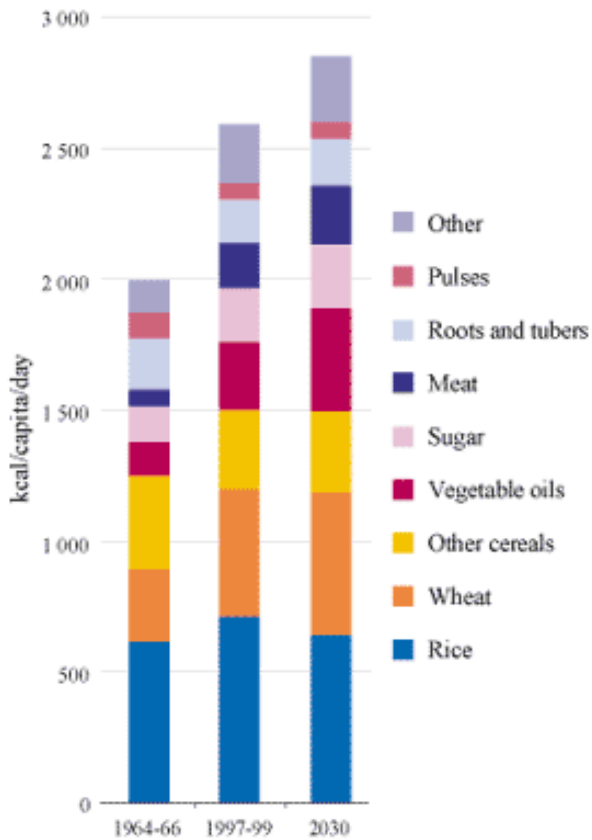

Figure 4

Source: FAO, 2002, p. 18

Dietary changes in developing countries from 1964-66 to 2030. Aging populations are increasing the average calorie requirement, and consumer preferences are shifting to include a greater percentage of vegetable oils.

Execution

The design of the Novella Project as public-private partnership allowed each party in the collaboration to contribute its own strengths and share resources efficiently. Unilever's role consisted mainly of project management and strategy planning, with a focus on developing the Allanblackia supply chain and providing resources to partnering NGOs. For example, "they set targets for the year, deploy resources for the purchase of seeds and resolve specific supply-chain issues with the support of other partners" (Attipoe, 2006, p. 182). As a whole, the Novella Partnership has several goals for the project, including the following:

- "Sensitization and encouragement of farmers to participate in Allanblackia domestication
- Range-wide germplasm collection, development of propagation methods (sexual and asexual) and gene conservation

- Studies on the ecology, abundance, sustainable harvesting and biodiversity conservation
- Integration of Allanblackia in agroforestry farming systems
- Facilitation and development of marketing networks and supply chains
- Development of poverty alleviation options in the rural areas through promotion of Allanblackia." (Ofori, 2011, p. 3)

Unilever and its partners piloted the project with a focus on wild harvesting of Allanblackia seeds by local farmers in Ghana, providing the incentive of a guaranteed purchaser at a guaranteed price. However, by 2004 a number of constraints forced the Novella Project's expansion to include domestication of primarily three species of the Allanblackia tree. The first of these constraints was that widespread deforestation due to land use change and logging meant that access to Allanblackia trees on public land was extremely limited, so "wild harvesting" often required farmers to travel long distances to forest reserves. Some individuals were able to gather the seeds from the few remaining trees on their own farmland, but that meant the crop wasn't available for local consumption. The issue of limited trees was exacerbated by the laborious nature of harvesting the large and clumsy fruits, the unpredictability of fruit ripeness, and scavenging by rodents. As a result, the potential market demand estimated for 2011 of 100,000 tons of Allanblackia oil/year could not be met by the wild harvesting of the three Allanblackia species that produce quality oil (*A. floribunda* in Nigeria, *A. parviflora* in Ghana, and *A. stuhlmannii* in Tanzania). Collectively, purchasers were only able to acquire about 200 tons of oil during the year from wild harvesting. Additionally, members of the Novella Partnership have been concerned that commercializing a tree that has already lost large swaths of habitat will lead to over-exploitation of the seed and a further decline in its abundance (Ofori, 2011).

To address these challenges, the partnership decided to use a participatory tree domestication approach in Phase II of the Novella Program in which agroforestry systems involving Allanblackia would be promoted on existing farms in Cameroon, Ghana, Nigeria, and Tanzania. Participatory tree domestication involves training farmers in appropriate techniques for collecting germplasm, selection of trees for collection, and techniques for vegetative propagation (Jamnadass, 2011). As an incentive, farmers received compensation for each new sapling that survived past the first year and again for those that survived a second year. Farmer participation allows for the integration of traditional knowledge into the domestication program and allows for a large number of specimens to be collected, which prevents extreme narrowing of the genetic base. It has also been shown to promote greater and more rapid adoption of agroforestry since communities feel empowered and farmers have a personal stake in the project. Allanblackia species in particular require more difficult propagation techniques due to their high degree of allelic diversity, low germination rates of seeds, relatively long delay until maturity, and the need to control sex ratios. It often takes three months for 50% of seeds to germinate, and ten months to achieve 75% germination under optimal conditions. Researchers in Ghana have been able to achieve 75% germination in ten weeks rather than ten months by "[removing] the seed coat and incubating the seeds in polythene bags at a temperature range of 23-23˚C", but many farmers don't have the resources for this kind of procedure and enhanced germination doesn't address the other issues associated with sexual propagation (Ofori, 2011, p. 4). Vegetative propagation is necessary to speed up the first flowering from approximately six years to one or two years, and to effectively manage the traits of trees for enhanced yield and quality. However, many methods of asexual propagation also have their limitations, such as slow rooting of cuttings and generally low success rates. Ongoing research shows that "grafting is a promising technique for the propagation of *A. floribunda* trees both in nursery and shaded in situ conditions. Five grafting methods were tested in two experiments and *A. floribunda* graft success was found to decline in the following order: side tongue 80%, side veneer 53%, top cleft 50%, whip-and-tongue 50% and budding 13%. Protecting scions from dehydration with non perforated translucent plastic was found to enhance success rates" (Asaah, 2011, p. 396). Marcotting or air layering has also had highly variable effectiveness. These discoveries show that effective communication with farmers is critical for increasing the number of trees in production, since very few methods of reproduction have acceptable success rates.

Allanblackia researchers interact with farmers through 'Rural Resource Centres' or RRCs, which function in a very similar fashion to Mars's Cocoa Development Centers. They act as hubs for experiments, technology diffusion, germplasm distribution, and more. RRCs "have their own tree nurseries, motherblocks and demonstration plots and train farmers in Allanblackia propagation and cultivation techniques" (Ofori, 2011, p. 1). These centers are also linked to private nurseries in local villages, equivalent to Village Cocoa Centers, from which remote farmers can be accessed. Because of the participatory domestication approach, though, research flows in both directions between trained agronomists and farmers. For example, local farmers in Tanzania experimented with various germination procedures, such as burying the whole fruit, and provided preliminary results for more formal testing at a nearby RRC. Rural Resource Centres have an advertising function as well. In order to increase the number of Allanblackia trees planted on farms, Unilever and its affiliates need to make farmers aware of the new and growing market for the crop and the potential financial and environmental benefits to be gained by interplanting it with their current crops or in fallow fields.

Some West African tree/shrub/liane species appropriate for growth in multi-strata agroforests and for domestication. Uses: 1 = Foods: fruits, nuts and vegetables, 2 = Medicinal products, 3 = Extractives and fibre, 4 = Timber, cane, etc.

	Use	Common names	Mature height (m)
Allanblackia parviflora	1,4	Tallow tree	35-45
Antrocaryon micraster	1	Aprokuma/onzabili	40-50
Calamus spp.	4	Rattan	35-45
Canarium schweinfurthii	3,4	Aiele/Incense tree	45-55
Chrysophyllum albidum	1	Star apple	30-40
Cola acuminata	1	Cola nut	15-25
Cola nitida	1	Cola nut	20-30
Coula edulis	1	Coula nut/African walnut	25-35
Entandrophragma spp	4	Sapele/tiama/utile/sipo	50-60
Garcinia kola	1,2,4	Bitter cola	20-30
Irvingia gabonensis	1	Bush mango/andok	20-30
Khaya spp	3,4	African mahogany	50-60
Milicia excelsa	4	Iroko/mvule/odum	45-55
Nauclea diderichii	4	Opepe/kusia/bilinga	35-45
Pentaclethra macrophylla	1	Oil bean tree/Mubala/Ebé	20-30
Raphia hookeri	4	Raphia palm	5-15
Ricinodendron heudelotii	1	Groundnut tree/nyangsang	40-50
Terminalia ivorensis	4	Idigbo	45-55
Terminalia superba	4	Afara/limba	45-55
Tetrapleura tetraptera	1	Prekese/Akpa	20-30
Treculia africana	1	African breadfruit/etoup	20-30
Triplochiton scleroxylon	1,4	Obeche/wawa	55-65
Vernonia amydalina	1	Bitter leaf	0-10

Figure 5

Source: Leakey, 1998, p. 255

Some West African tree/shrub/liane species appropriate for growth in multi-strata agroforests and for domestication.

Since Allanblackia is a newly commoditized crop, Unilever has had to build the entire supply chain from seed collectors to purchasers of processed oil. After local farmers and families collect the fruits, they remove and dry the seeds before taking them to a local "focal person" or buying agent for sale. Focal persons consolidate the seeds, which are then transported to a processing plant near Accra, the capital of Ghana. After processing, the oil is sold primarily to Unilever as an ingredient in various products, although the company has been motivating its fellow food processing companies to become buyers of the oil as well, in order to build a stronger international market. The company offers pre-set prices to all links in the supply chain, anticipating that this transparency and fairness will motivate "collectors, buyers, transporters and processors to feel adequately compensated for effort and resources invested in the market chain" (Attipoe, 2006, p. 182). NGOs play a supportive role in the supply chain, monitoring for adherence to developmental and environmental goals and providing information and resources to communities.

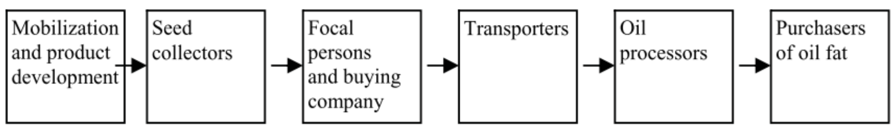

Figure 6
Source: Attipoe, 2006, p. 184
A represenation of the Allanblackia supply chain.

Results

The Novella Project has experienced many successes and failures, although it is still a very young venture. As of 2011, there were two active RRCs in Ghana and three in Tanzania, which had produced 48,000 plants and distributed them to more than 650 farmers (Ofori, 2011). Although nurseries may be able to provide Allanblackia saplings and grafts, farmers are often skeptical about planting the tree despite high levels of awareness about a guaranteed purchaser. Original surveys found that farmers would be willing to integrate Allanblackia into agroforestry systems providing the existence of a "ready market, attractive price, [and knowledge of] early bearing varieties and methods for propagation" (Ofori, 2006, p. 1). In fact, concerns about propagation and domestication were considered the major hurdles for the project. More recently, farmer resistance can be attributed to other factors as well. First, because the number of seeds collected in each community is still very small, the buying company does not have enough resources to deploy agents to each village. Similarly, many farmers who requested Allanblackia seedlings for their farms received significantly fewer than they asked for due to a lack of resources and poor distribution networks. This discrepancy between promises and reality undermines the trust that Unilever and its partners is attempting to establish in communities and often discourages participants from collecting seeds in future years. Second, feedback from farmers and other members of the supply chain revealed that prices offered by Unilever were not considered high enough to commit time and money to collecting wild seeds, planting Allanblackia trees, or acting as the focal person for a given village. Due to external market forces, Unilever cannot raise the price and instead must rely on “intensive education and persuasion” to convince participants that with time, Allanblackia can be developed to the extent of cocoa with increased demand and higher prices (Attipoe 2006). Also, since Allanblackia fruit production occurs during the lean season (when cocoa isn’t being collected), farmers usually don’t need to worry about high tradeoffs between Allanblackia and their other main cash crop. Some farmers have been swayed to plant Allanblackia after “seeing flowers on one to two years old grafts,” indicating that concerns about long payback horizons may be a factor in the decision to forego investment (Ofori, 2011, p. 4). Finally, some farmers resist keeping indigenous trees on their land because of ambiguous ownership rights in many countries. In some areas, timber companies can remove the trees without permission from the farmer, providing little to no compensation (Ofori, 2006).

Problem	**Sum of Ranks**	**Mean Rank**	**Ranks**
Low Price	270.0	2.62	1
Collection is laborious	419.5	4.07	2
Long distance	422.0	4.10	3
Rodents attack	432.0	4.19	4
Bias in sharing of incentives by buying agent	442.5	4.30	5
Delay in payment after sale	446.5	4.33	6
Low material incentives given to collectors	451.5	4.38	7
n (number of respondents)	103		

Figure 7

Source: Egyir, 2007, p. 30-31

Constraints in Allanblackia collection, according to survey conducted in five rural communities

On the positive side, many farmers appreciate Allanblackia trees for their unintrusive canopy and ease of integration with other crops. Even before the Novella Project, surveys indicated that they were often used as shade trees for cocoa and cardamom, and as a stake for climbing crops such as pepper vines (Meshack, 2004). They also attract animals, such as the giant pouched rat, bush tailed porcupine, thick-tailed galago, and blue monkey, which are drawn away from other agricultural crops or even trapped for bushmeat (Amanor, 2006). Despite these attractions, it is estimated that tens of millions of Allanblackia trees need to be planted to meet demand and that it could be 10 to 15 years before a self-sustaining market is established. In the meantime there are still concerns about the potential for Allanblackia development to be mismanaged. The genus grows in regions of high biodiversity that have already experienced alarming rates of deforestation, land use change, and habitat fragmentation. If individuals can be convinced that selling the seed is relatively profitable, then the establishment of monoculture plantations will likely undercut efforts to develop a sustainable agroforestry-based supply chain. Other tropical crops, such as rubber and oil palm, are perfect examples of a development path that the Novella Project is trying to avoid.

Only with close monitoring by NGOs can Allanblackia be used to help make current agricultural systems more sustainable. Unilever's intention is to promote Allanblackia as one component of a diverse cultivated ecosystem, so there is huge potential for the Novella Project to be promoted alongside other agroforestry projects. Cocoa and Allanblackia, for example, both grow in many of the same regions and often complement each other's needs. The similarities between Mars's CDCs and Unilever's RRCs hint toward possible sharing of resources in order to reach a greater number of farmers. Even though Mars has contributed funds to the Allanblackia domestication project, as of yet there is no indication that the two companies have worked collaboratively to accomplish common goals. This is perhaps due to the difficulty of coordinating between two large corporations, or because the focuses of the two projects are too different to reconcile. Despite this, for the Novella Project to be successful in the coming years, Unilever needs to continue its sensitization process, address concerns about low prices, and guarantee resources for plant distribution and seed collection in order to convince farmers to continue planting Allanblackia.

Wimco - Poplar

Motivation

Corporate interest in agroforestry hasn't been isolated to the last two decades or to tropical forests in Africa. The Western India Match Company, or Wimco, began promoting poplar-based agroforestry systems to local farmers starting in the late 1970s. Until that time, industries relying on wood as a primary raw material in India depended mainly on state forests in the Himalayas for their supply (Zomer, 2007). As is the case in most developing countries, local people also relied on trees for timber, fuel, and food, and the Indian government became concerned that the rapidly depleting forests could no longer support the needs of both industry and the community. As a result, logging for timber in state forests was banned and wood-based industries were forced to establish supply chains elsewhere. Even before this ban, Wimco faced acute shortages of wood for matches due to environmental restrictions and government funding given to its smaller competitors (Jain, 2000). The Indian government encouraged companies to develop tree plantations, but this route would not be feasible in some of the highly agrarian regions of the country. For example, in 2005 the Punjab state had 84% of its 5.04 million hectare area under "highly intensive technical and mechanical agriculture" (Kumar, 2005, p. 2). Since poplars, the softwood used to make Wimco's matches, grow in moist and fertile soil, they were in direct competition for India's agricultural lands. Converting fertile agricultural lands into forest would not be an option because of the demand for food production; the reason forest cover had declined so rapidly in the state originally was due to pressure from agriculture. Even though Punjab has only 1.5% of the country's area, it provides approximately half the rice and one-third of the wheat to India's central food reserve (Kumar, 2005).

As a result, Wimco decided to explore the option of contract farming poplar trees by developing and promoting agroforestry methods that would benefit both themselves and farmers. This system would address three disparate issues simultaneously: (1) provisions of poplar trees for Wimco manufacturing, (2) concerns that the Punjab state's forested region was far below the 20% recommended by the National Forest Policy resulting in low resiliency to natural disasters and climatic change, and (3) degradation of agricultural lands by the excessive use of agro-chemicals, monocultures, and other intensive practices.

Execution

Despite concerns that poplars wouldn't grow in India due to the climate, Wimco collected various poplar clones from around the world in 1970 and worked with the Uttar Pradesh Forestry Department to determine which would be most suited to the region. The following year, they convinced local farmers to start raising the most promising of those clones, providing saplings free of charge. Survival rates were only about 15 to 20% of those trees that were planted, which didn't include the many saplings that were delivered to farmers and not planted. In 1976, Wimco started a widespread publicity campaign and established a Forestry Extension Centre in Uttar Pradesh to promote poplar agroforestry. Successful farmers were used as demonstration plots and by 1979 the company started meeting a small part of its raw material requirements through agroforestry (Jain, 2000). Between 1980 and 1984, Wimco continued to conduct research on the most successful species, ideal spacing, and possible intercropping options. They also made two changes in sapling distribution during these years that increased the survival rates of trees enormously. In 1980, the company decided to stop delivering saplings and required farmers to pick them up for free at local nurseries. This caused the survival rate to increase to 55% of planted trees. Then, in 1982, they started charging farmers a nominal fee per plant, which brought the survival rate up to 85%. The idea was to make farmers feel ownership over their plants by requiring that they make an investment of time and energy into acquiring them. As a result, farmers started to take greater care of the poplars they planted and waste fewer saplings by not planting them (Deshpande, 2005).

This period of experimentation was successful enough to encourage Wimco's expansion of the program in 1984 to Western Uttar Pradesh, Haryana, and Punjab. The expansion was also prompted by further expected shortfalls in match production: "production in 1982 was 2.40 million cases of 7,200 match boxes each and the expected growth [was] 6 per cent annually. The requirement in 2000 was expected to be 6.85 million cases" (Deshpande, 2005, p. 39). A subsidiary called Wimco Seedlings Limited was established to conduct research and development on poplar agroforestry and provide extension services and resources to farmers participating in the program. The year 1984 was also when formal agreements were signed between Wimco, the National Bank for Agriculture and Rural Development (NABARD), and farmers for growing and selling back poplar trees. Each of these parties gained from the arrangement and had an important role in the program. For example, Wimco popularized poplar agroforestry, performed research on various aspects of poplar cultivation, provided extension and training services to farmers, supplied high-quality germplasm, and guaranteed the buy-back of poplars at pre-set prices. NABARD provided credit for farmers to finance the cost of planting and raising the trees.

Previously, Wimco had realized that many farmers wouldn't be able to afford waiting until poplar harvest for payment unless they had external financing. They subsequently approached several commercial banks to set up a customized loan system for poplar contract growing, but realized that the banks were uninterested in the eight-year time span it required, and preferred short-term crop loans. However, since NABARD is an apex development bank with an obligation to provide a stipulated percentage of its credit to achieving objectives such as 20% forest cover, it agreed to Wimco's proposal of offering loans to farmers through local banks. They launched a joint partnership in which Wimco would help farmers complete the documentation to mortgage their farmland in exchange for a loan made in installments to cover the expected annual costs of caring for poplars. Repayment would be due at the end of eight years, the recommended age for poplars to be harvested (Deshpande, 2005). The loan was intended to cover the costs of transplants, labor, irrigation, fertilizer, pesticides, technical advice, and insurance (Jain, 2000). Wimco's contract also included crop insurance for poplars damaged due to natural disasters, such as floods or fires.

The program was created to be relatively simple for farmers. Poplar saplings could be purchased at any nursery, although Wimco nurseries were known for providing high quality germplasm at a reasonable cost. It was recommended that the saplings be planted in December, January, or February at a spacing that allowed for an average of 200 poplars per acre. They then should be fertilized with urea one year after planting and irrigated with surrounding crops. Wimco also developed best practices for different regions, including advice for intercropping, pruning, watering etc. For the first few years, poplars could be grown alongside most other crops because of their limited foliage. In later years, more shade tolerant plants like turmeric were recommended. Extension staff were supposed to make monthly visits to farms to monitor progress and address concerns. It was determined that tree growth measured in diameter and height was fastest between years four and six, with trees tending to decline in quality and become more vulnerable to damage in storms beyond year twelve. Wimco recommended that trees be harvested after year eight before they reached maximum size.

As long as the tree was considered to be of "harvestable" quality, Wimco guaranteed buyback; however, the contract did not stipulate Wimco as the exclusive buyer. For a tree to be considered "harvestable", it needed to fulfill the following expectations:

> "[T]he tree shall be of good form, green, sound, cylindrical, of straight growth, and with the bark fully intact. The tree shall have good clean bole length with minimum of knots/knobs and free from twisted or spiral growth, cracks, bulges, and hollow, dry decayed, diseased, or damaged portions. The girth at breast height (1.37 m above ground level) shall not be less than 90 cm over bark at the time of its harvesting. To be harvestable, the tree should also yield a minimum of 0.4 cu m hoppus of peelable softwood, measured under bark and down to 50 cm girth over bark at the narrow end of the stem. On these considerations, the company shall decide whether a tree is harvestable or not, and that the company's assessment would be final and binding on the farmer, and the same shall not be contested by him/her." (Deshpande, 2005, p. 27)

Farmers benefitted from the program in various ways: diversified and low-risk long-term income, rehabilitation of agricultural lands, fuel wood from pruned branches that would allow dung to stay on the ground, and knowledge of poplar cultivation that could be applied outside the context of the contract for other wood-based markets like the plywood industry. By 1994, Wimco stopped offering contracts and financing for poplar growing and decided to focus exclusively on selling saplings from its established nurseries. Farmers could still acquire quality germplasm and sell their poplars back to Wimco, but by 2003 the last of the contracts for poplar agroforestry had been fulfilled. Examining the results of the program will give greater insight as to why this decision was made.

Results

Wimco's poplar agroforestry program faced many challenges during its existence. The most significant of those challenges were the following:

- As the project expanded in the late 1980s and early 1990s, Wimco started experiencing understaffing of extension agents, which led to some farmers complaining that the lack of support caused their trees to grow poorly and not be of "harvestable" quality.
- Often one poplar variety would become popular in a region as farmers saw its success on neighboring farms. Higher rates of pests and disease became an issue because of the lack of genetic variation in districts.
- Some local banks that offered financing for NABARD didn't have the experience to know which lands were not suitable for poplar cultivation, and so gave loans to farmers who were doomed to experience extremely low survival rates.
- Wimco's practice was to give saplings to interested farmers before they were approved for a loan because the loan process could easily continue past the recommended months for planting. This resulted in a significant number of farmers planting trees and then having loan requests rejected. Wimco lost money on these trees, and farmers who could not afford to maintain the poplars properly lost area on their farms that could be dedicated to other crops.
- Farmers who wished to make payments on their loan before it was due often confronted local banks that counted the payments toward interest rather than principal.
- Financing was phased out before contract growing officially ended, so in the final years that the contract was offered many farmers couldn't afford to follow the advice offered by extension agents. Since poplars are highly sensitive to input application, survival rates plummeted to less than 50% in many regions.

- As the plywood industry grew in the regions where contract farming was offered, market prices of poplar increased to as much as 200% of the price given by Wimco. Wimco eventually faced a shortage of poplars as farmers chose to sell to other buyers. This effect was exacerbated by two of Wimco's practices: (1) the company followed forestry norms and refused to harvest during the rainy season, and (2) Wimco's harvesting standards and procedures were a long and complicated process that could interfere with planting the next season's crops. Default rates also rose as Wimco couldn't ensure that banks were repaid if other entities purchased the poplar trees.
- Growing demand for poplar trees caused many new nurseries to enter the market, creating more competition for Wimco Seedlings. However, Wimco was still known for having the highest quality germplasm and many farmers opted to pay higher prices for it (Deshpande, 2005).

In spite of these complications, the program should definitely be considered a success. Wimco has established a healthy and competitive market for poplars that was previously non-existent. This market continues to increase the wealth of both farmers and industry today. Effective systems of poplar agroforestry have been developed with crops like sugarcane, potato, chilies, wheat, and vegetables. Wimco still provides high-performing clones to farmers and is constantly conducting research on new clones to prevent problems with pests and diseases. The program planted about 50,000 trees in 1984 and expanded to about 500,000 plants per year by 1988. Over 5000 farmers had been contract growers by 1989, and by 1991 over 11 million trees had been planted (Newman, 1996). Poplar growers who were under contract reported having about 25% more harvestable trees per acre compared to growers not under contract, implying that Wimco's extension services provided impactful advice that increased the quality and survivability of trees. Their expansion methods were also highly effective: agents originally contacted farmers through local seed companies and attempted to get adopters in as many regions as possible so information about the program would spread quickly by word of mouth (Deshpande, 2005).

Surveys conducted from 1993 to 1994 in Uttar Pradesh revealed that 24.7 percent of the total land was under poplar agroforestry, and that the average farm size for program participants was 5.8 hectares. Forty-seven percent of the land under agroforestry was on small farms of less than two hectares. More than half of farmers claimed that poplar cultivation had “no adverse impact on the quality of the land”, while about 45% reported that the poplars enriched their agricultural lands by increasing the carbon content of the soil (Jain, 2000, p. 270). Fewer than 5% of farmers stated that poplar agroforestry lowered the quality of the soil by removing nutrients and causing soil loss after harvest. More than 50% of the participants did not notice any change in the water table, and data collected from the state groundwater records in Uttar Pradesh confirmed that there had been no significant change in groundwater levels for the previous ten years (Zomer, 2007). As prunings from poplar trees replaced dung as the major source of fuel, it was determined that consumption of dung for fuel declined by more than 50% on relevant farms, indicating more effective nutrient cycling (Jain, 2000). Adoption rates were lower in Punjab than in Haryana and Uttar Pradesh, usually attributed to the higher cost of labor and lower awareness of Wimco’s offer in the area (Kumar, 2005).

To determine which socioeconomic classes benefitted from this program, we can examine the demographic information of the adopters. Fifty-seven percent of participants were considered part of the “average” socioeconomic class for farmers, while 41% were relatively wealthy. More than 50% of adopters had education past primary school. A study in 2001 found that adoption rates increased with increasing farm size, with basically all farmers on large farms participating in the program (Zomer, 2007). The program was profitable for farmers, as suggested by its widespread adoption. A comparative analysis of the profitability of poplar agroforestry showed that at a 12% discount rate it was more profitable than other common crop rotations, although paying for Wimco's technical assistance had a significant impact on earnings. Farmers that were already knowledgeable or had the resources to learn about poplar cultivation on their own could benefit much more than farmers requiring advice and financing. These facts signify that although Wimco's contract farming increased the income of a great number of small and marginalized farmers, it had greater potential to benefit wealthier farmers with more land. On the other hand, it also created many employment opportunities for local landless workers to prune and maintain trees during seasons when the job market was normally small (Jain, 2000). Additionally, many small farmers planted poplars in margins or in bunds – embankments on the periphery of farmlands to prevent run-off and reduce erosion – that increased their earnings without impacting crop yields.

Overall, surveys of farmers encountered high levels of participant satisfaction with the majority of contracts satisfied completely and any disputes resolved quickly. Farmers of various sizes proved to be responsive to the economic incentives offered by Wimco and willing to implement a more sustainable farming system with the promise of higher earnings. Wimco's very survival depended on the success of the program. Contract farming for timber is likely to become more common in the coming years as populations continue to grow and global demand for wood increases. WWF's Living Forests Report estimates that overall wood consumption may triple by the year 2050, putting forests in direct competition with agricultural lands. Agroforestry systems such as this may offer one way to reconcile the various demands that humans put on fertile lands for food, fiber, fuel, and ecosystem services.

Comparative Discussion

For the sake of simplicity, the discussion section will be structured in the same way as the case studies, with separate examinations of the motivation, execution, and results.

Motivation

Some companies view agroforestry promotion (or sustainable sourcing in general) as a value-adding practice, while others do not. There are two primary motivations for a company to invest in agroforestry: product diversification and supply chain management. However, it is very difficult to prove the benefits of product diversification through agroforestry because there exists no certification that focuses solely on the implementation of agroforestry practices and because the concept of agroforestry is very difficult to communicate to consumers. Agroforestry is not a term with which many consumers are familiar, and explaining the practice on product packaging is unrealistic. Ideas that have more resonance with the general public are more successful, which is why certification seals that tout “preserving forests” or “supporting farmers” like The Rainforest Alliance are used (Millard, 2011). For the sustainability message to be an effective marketing tool, consumers have to understand the relationship between the product they are purchasing and the environmental benefits that they are, in effect, supporting. The case of Allanblackia illustrates the difficulty in this: Unilever uses the oil from Allanblackia seeds as one ingredient among many in products ranging from margarine to detergent. Most products in the market consist of more than a dozen primary ingredients at the very least, so advertising the environmental benefits of one of those ingredients would just confuse potential buyers. Furthermore, the distinction between luxury goods and necessities is important because consumers of chocolate, for example, are much more likely to incorporate indicators of sustainability into their decision than are consumers of plywood or matches. In general, product differentiation might be an added benefit for some companies, but supply chain management is undoubtedly the driving force in a company's decision to sponsor agroforestry promotion.

Even within the three cases examined in this paper, there are numerous motivations stemming from the fundamental goal of supply chain management. The majority of them address current or anticipated supply shortages due to a variety of factors:

- Policy change: Wimco foresaw environmental restrictions that would prevent them from logging in local forests. Poplar cultivation required fertile, irrigated soil, so they were forced to either compete with or integrate with agricultural lands. As environmental regulation becomes stricter, especially in developing countries, more companies will have to address their sourcing practices in order to comply and avoid liability (Man, 2011).
- Ecological instability: Mars was experiencing the consequences of cultivating an understory rainforest crop in unshaded conditions, which caused catastrophic rates of pests and disease. Unilever wanted to prevent Allanblackia from developing in the same manner as oil palm, which is notorious for its role in rainforest destruction and wildlife endangerment.
- Financial insecurity of farmers: Mars experienced extremely high turnover of farmers because of yield and price instability that prevented them from investing in future crops. Unilever is attempting to make Allanblackia cultivation part of a profitable agroforestry system so more farmers will be persuaded to start growing it. Both companies acknowledged that farmers would have higher and more uninterrupted revenue streams if they were growing a diverse set of crops rather than just one, which would lower rates of farm abandonment and smooth the volatility of annual crop yields.

- Expectations regarding climate change: Both Mars and Unilever are aware of the importance of trees in mitigating the effects of current and future climate change, and in the ability of trees to improve the resiliency of farms experiencing extreme weather events such as drought.
- Changing consumer preferences: Unilever predicted global consumers to consume a higher percentage of their calories through vegetable oils and sought to diversify its variety of vegetable oils to help meet that demand. Mars expected developed markets to start shifting preferences for chocolate products to those with higher cocoa contents, which would put greater pressure on cocoa-producing countries.
- Increased demand due to population growth or market expansion: All three companies recognized that untamed population growth around the world would only increase demand for their products, and that rising incomes in countries like China and India would disseminate the popularity of traditionally Western products across the globe.

However, other factors like crop quality and traceability also play a role. By participating in the domestication of crops such as cocoa, Allanblackia, and poplar, the respective companies could have greater control over the genetic basis of the trees. This allows them to (1) improve average plant morphology by selecting for qualities like large fruits or high oil content, (2) identify and proliferate strains with disease or pest resistance, and (3) prevent genetic narrowing in any given region by promoting inter-country and intra-country exchange of crop strains. Unilever went beyond improving the quality of its current ingredients by introducing an entirely new crop to the market. Many forest products that have been used by locals for generations but overlooked by the larger populace have the potential to provide substantial profits to whichever company chooses to develop them first. These “Cinderella” species are perfectly suitable for agroforestry systems because they have evolved, like cocoa, to flourish in a diverse forested ecosystem (Leakey 2005).

In terms of optimizing efficiency, traceability and data processing are an important part of any business. The trade of agricultural commodities is often characterized by a lack of traceability, in that nobody can point to a cocoa bean or a poplar and say from where exactly it came. However, as companies become more involved in the front-end of their supply chains, the potential for tracking ingredients becomes more realistic. Agroforestry programs often require working together with independent auditors, NGOs, local buyers, third-party certification companies, extension agents, transportation companies, and more, using each organization's competitive advantage to achieve a common goal. Greater communication among these entities would allow for more efficient processes to be developed and for market chains to become more transparent.

Alongside the various factors that might motivate interest in agroforestry exist a number of reasons why a company may want to avoid it. First, many companies prefer the buffer of purchasing agricultural inputs through trade or middlemen, because it allows them to acquire supplies without having employees or operations within politically unstable countries. This is an important strategy for two main reasons: it allows them to focus on their core competencies which most likely don't include agriculture, and it puts distance between their reputation and the political and economic atmosphere of a material's country of origin. However, as more corporations are held accountable to the public for the human rights violations and environmental degradation in their supply chains, they will most likely take a larger role in supervising their suppliers. Other reasons a company would find agroforestry intimidating are that the benefits are often long-term in nature, farmers can be very resistant to change, solutions must be customized so research is often necessary, and a large amount of resources are necessary to make the program successful. In addition to these challenges, awareness of agroforestry in the developed world is limited and not all crops are evolved to be natural fits for an agroforestry system like cocoa, coffee, or Allanblackia (Franzel 2002).

Another issue to consider is that these three cases represent very specific situations in which agroforestry is applicable: they all source primary agricultural materials from smallholder farmers in developing countries for use in manufacturing final products. These characteristics make sense for a few reasons. To start, agroforestry promotion is likely to have a larger effect on farmers from developing countries where subsistence agriculture is the norm and land for crop cultivation is in high demand. Farmers in these countries have an incentive to use vertical space to increase their income or meet household needs, such as their need for firewood or fruit. Also, labor costs are lower in developing countries, which is important for many agroforestry systems because diversity is the enemy of mechanization. Trees are especially laborious because most pruning must be done by hand and fertilizer can't be applied using a tractor. Third, developing countries will likely be hit hardest by temperature and hydrological changes associated with global warming, so farm resiliency will become increasingly important and will drive the use of more sustainable agricultural practices. Finally, in terms of building partnerships, locations that are considered biodiversity hotspots are more likely to garner support from external organizations to implement an agroforestry project because there will be more widespread interest in conservation and restoration measures. Countries where national policies support forest preservation will also have an advantage, as Wimco experienced in India. While agroforestry in developed countries isn't nonexistent, high incomes and low food and energy prices make farmers less likely to benefit from it directly.

Execution

The agroforestry programs implemented by Wimco, Unilever, and Mars can be characterized by a few key features that they have in common: public-private partnerships, infrastructure for resource distribution, research and development, and extension services. Each of these was important in determining the success of the program for distinct reasons.

Public-private partnerships were the foundation of each of these projects. Effective partners can vary widely in their goals. Mars and Unilever both collaborated with environmental groups, research organizations, local and national governments, development organizations, industry competitors, and other companies in their supply chains. Mars also worked with a number of certification companies, who functioned both as a means to acquire a price premium and as third-party auditors for farms. Wimco primarily worked with NABARD to provide farmers with access to credit, but also had support from local seed companies and nurseries. In general, partnerships are necessary for agroforestry programs to work because even the largest companies will be lacking in either manpower, resources, or experience interacting with farmers.

The developing countries where agroforestry programs are used can be plagued by a widespread lack of infrastructure, especially in rural areas. This can prevent farmers from accessing the resources they need, including fertilizer, seeds, and knowledge. It can also keep farmers from selling their goods or from being informed of the market price for their goods. For agroforestry, these inadequacies can be even more pronounced. The infrastructure for distributing crop seeds is much more evolved than that for agroforestry trees. Current networks in place for developing and selling quality tree germplasm were developed for industrial plantations and often don't cater to smallholder farmers. Mars and Unilever addressed this concern by establishing CDCs and RRCs where farmers could learn about agroforestry practices and acquire saplings, fertilizer, and more. Unilever also improved farmers' access to markets by working with the purchasing company in Accra to send out buying agents to surrounding communities. Since Northern India was already a highly developed agrarian region, Wimco focused on supplying tree saplings to farmers by creating a separate nursery business called Wimco Seedlings. Studies of other agroforestry projects highlighted the importance of technical resources and agricultural inputs when they found that abandonment of a program was often due to poor-quality plants and lack of technical support (Franzel 2002).

In order to provide quality plants and effective technical support, though, agroforestry programs need include investments in research and development. Without corporate involvement, there is often very little incentive or funding to conduct applicable research on agroforestry systems. Much of our knowledge comes from observation of existing agroforests or from projects intended to improve farmer incomes as part of larger development goals. The private sector can fill the gap between scientific knowledge and effective field application by giving researchers funding, support, and direction. Mars has a strong history of support for research, and was closely involved in sequencing the cocoa genome and collaboratively studying methods of integrated pest management for cocoa. Ongoing research takes place in its CDCs, where agronomists conduct field experiments with results that can be directly applied to local farms. Unilever's approach to research and development of Allanblackia is both participatory and collaborative. Local farmers work alongside trained researchers to improve methods of propagation and domesticate the crop for easier and more productive cultivation. Wimco's research on poplars was largely internal, although interactions between smallholders and extension agents provided valuable information that was incorporated into field guides for constant learning.

Extension services are the fourth common component of these agroforestry programs. All three companies used extension services as a two-way means of communication in which research was disseminated to farmers, who in exchange provided traditional knowledge, field experience, and anecdotal evidence to extension agents. This method had the effect of empowering farmers and making them feel more invested in the program. Extension services were also influential in persuading many farmers to participate in agroforestry programs. Many farmers were offered hands-on technical advice without having to leave their farms. In some cases, a small number of farmers from each community were trained by extension center staff to teach necessary skills or helpful practices to fellow farmers.

Results

Normally, determining the metrics for a program's success can be difficult. Direct measurement of a program's contribution to increased profitability is impossible, and calculating how much of a shortage would have occurred in the absence of a program requires a lot of guesswork. Unilever, though, has the ability to measure increases in yield over time because they introduced an entirely new crop into international markets and are currently the only company purchasing the processed oil. They were also able to count the number of nurseries and extension centers established, which can be indicators of how many farmers are reached. Success in research has been kept track of by recording improvements to propagation techniques, cultivation methods, and trait selection in experiments. Surveys of farmers allow the company to examine the farmer perceptions from a qualitative viewpoint.

Wimco was also very lucky in their analysis of success because poplars aren't endemic to the region and they can easily record the number of trees distributed, planted, and harvested on farms. Mars, though, has been forced to use some combination of estimates, indicators, and surveys to examine the effects of their efforts. Program success will also be determined by how long these practices stay in use after their introduction, and how effective the newly-established infrastructure will remain without constant support from industry. Wimco developed a market for poplars that continues providing softwood for matches and plywood to this day, even though contracts and financing ended over a decade ago. Mars's and Unilever's programs have not progressed far enough to compare. Even without the final results from Mars and Unilever, it is apparent that agroforestry can be an important element of corporate strategies aimed at mitigating supply chain risk.

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