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CARBON, BIODIVERSITY, CLIMATE, AND PEOPLE

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ABSTRACT

The main objective of the paper is to analyze forces and barriers that have been influencing the development of agroforestry systems (AFS) in Brazil. In recent years such systems have been praised as a potential solution to combine food production, income generation, and environmental protection. In spite of many successful examples across the country, and the promising solutions associated with these land management systems, the adoption by farmers until present is very insignificant to cause the desirable impacts. Drawing upon the valuable lessons learned from both the experience of AFS and the numerous conservation projects that have quietly and successfully been working in Brazil the authors examine the main public policies that might affect the development of AFS. The document also intends to answer the following questions: How can government implement such initiatives without compromising public funds? How can we integrate the successes of demonstration projects into existing official mechanisms to promote a wiser approach to farming practices? What legal frameworks need to be modified or strengthened in order to promote our aims as the natural evolution of an already existent and functioning set of practices?

INTRODUCTION

For those who aware of global political trends, it should come as no surprise that Brazil is still in the throes of reconciling her increasing economic development with less-than-rapid poverty reduction strategies and environmental conservation. One answer to balancing this triad of national urgencies, Agroforestry Systems (AFS), has emerged as a promising alternative to the more unconscious and mechanized industrial farming systems that have, as their goal and process, employed mass production strategies to produce increasingly standardized farm commodities. AFS, in contrast, have been championed by environmental groups, NGO networks, and organizations representing family farmers, many of whom possess great potential for increasing the nation's food security while generating revenue for their families and communities.

Interestingly, but not surprisingly, at the same time the AFS alternative is meeting their own local needs, such alternative groups are also on the front line of providing key environmental services for their region. From hard data representing years of challenging work on the ground, it has become completely evident that AFS offers at least one key, in fact a very important key, in the effort to reduce the vulnerability of the family farm to crippling external factors beyond the control of traditional local solutions. Such threatening factors such as global market pressures, unpredictable and shifting governmental policies, and the very real effects of climate change, all have combined to confound the small family farmer. And while the Brazilian government has drafted a series of policies that directly and indirectly promote the development of organizations like AFS, these local farming communities still face significant barriers to implementing and maintaining that which will serve them in the face of the new global realities.

Our objective, then, is to examine these forces and barriers so as to give a voice to those we represent while providing policy alternatives by drawing upon the valuable lessons learned from both the experience of AFS and the numerous conservation projects that have quietly and successfully been working in Brazil. To this end, the document is divided in three sections:

Section I. It is an old saw, but in order to know where you are going, you have to first know where you've been. Another "oldie but goodie" is that if you wish to change something you must first find a way to measure it. In Sections I and II, we achieve both. First we provide a brief historical overview – information that has led to the formation of our adopted analytical framework. We provide a review of key concepts embraced by AFS that have contributed to its impressive trajectory in Brazil as a dynamic alternative land-use system.

Section II. Here we provide a more detailed context of Brazilian policies affecting agroforestry development. We look at the issues both driving and inhibiting much needed changes in public attitudes and organizational strategies. We examine the Brazilian family farmer and reveal the numbers that underscore his importance to Brazil's continued economic development.

Section III. In this section of our paper, realizing that mere numbers without human examples make for painful presentations, the authors present a number of representative case studies of successful projects based upon two significant and interrelated areas:

1. The relationship between agriculture, biodiversity conservation, and an increasing faith in carbon sequestration.

2. A clear focus on conservation and sustainable agricultural practices as part of an overall project strategy, and a functional methodology for adopting the successful elements derived from different projects developed in Brazil with a focus upon the environmental services and relief for the rural poor.

Conclusion. We conclude our discussion with a hopeful but pragmatic look toward the future of our mutual challenge in Brazil. It is here that we suggest additional policy changes needed to promote the development and practice of agroforestry and other farming approaches that protect and conserve that which we value. But an idea without the ability to implement is the hollow stuff of pipe dreams.

Thus, this final section also introduces a "how to" approach to implementing these policy changes on the national stage. Some of the questions addressed by the document are:

1. How can government implement such initiatives without compromising public funds?

2. How can we integrate the successes of demonstration projects into existing official mechanisms to promote a wiser approach to farming practices?

3. What legal frameworks need to be modified or strengthened in order to promote our aims as the natural evolution of an already existent and functioning set of practices?

SECTION I.

THE ANALYTICAL FRAMEWORK

The case studies examined by our present analysis represent territory in three Brazilian biomes: the southwestern Amazon (the northwestern portion of the state of Mato Grosso); an area along the Atlantic Rainforest from its southern limit at Rio Grande do Sul to the state of Ceará (remnants of a once flourishing tropical rain forest in the mountains as well as a portion in the humid semi-arid lowlands), and a section located in the Caatinga (also semi-arid and the only exclusively Brazilian biome). Our sources for these analyses include a review of the literature and technical reports, consultations with key figures possessing intimate knowledge about those included areas, and focus groups involving farmers participating in various demonstration projects. Reports generated by these efforts are the result of painstakingly gathered and synthesized data – information collated, analyzed, and written in such a way that it is easily accessible and understandable to the public.

The primary reference material is based upon a number of documents produced by various authors over the last few years. They range from project reports, academic papers, or even collections of private manuscripts. The basic materials however are: May and Vivan (2006); Vivan and Nunes (2008); Vivan et al. (2009); Vivan (2009 and 2010); Gonçalves (2008, 2010 and 2012), Tito et al. (2011).

I.1. A REFLECTION-IN-ACTION APPROACH

We wrote this paper from the privileged perspective of protagonists, for in order to help as well as learn, we played many roles in a wide number of these projects and were thus able to use them as common sources of information. The whole gamut of project activities, at the farm level, field implementation, political negotiations, to large scale project evaluation as a response to the demands of

international agencies, we had the opportunity to insinuate ourselves in the process. Not only were we performing roles that had direct bearing on the success of these activities, we also placed ourselves in a position to become more completely informed. Given this "dirt-under-the-fingernails" exposure, we probably do not have the necessary distance to be considered completely disinterested social scientists, so our results might seem more than slightly biased.

Nevertheless, over the last decade, working as we did on large scale projects and policy evaluations, we used our direct interaction in the manner conceptualized by Polsky and Ostrom (1999). We were the "outsiders" working in association with an "insider" to perceive a time-line and an intimate knowledge of events. Such proximity allows one to analyze people, their organizations, and their reactions to rules, stimuli, challenges, and confusing scenarios (also known as "action-situations"). And finally, direct involvement allows an acquisition of deep, hands-on understanding of certain patterns relating to invested efforts and achieved results of the policies under review.

From another perspective, we were both outsiders and insiders. We have more than 20 years in the field of AFS with relation with the phenomena studied. So the usual introductory work of, for instance, contacting leaderships, connecting with key institutions such as universities, research units, rural extension services, syndicates, farmers' organizations, and even our visiting rural communities all was done over a professional lifetime of reflection-in-action. The proximity allowed us to perform certain analyses and to gather kinds of information only accessible through a profound involvement with the local community. In fact, most of the findings confirmed what we already expected, so following the prescriptions of the scientific method was, frankly, more a strategy to verify prior empirical evidence.

This paradoxical situation of an inside practitioner who is also, to a great extent, an outsider investigator, has provided practical advantages with implications for insight leading to reflection. For example, the approach needs to be understood rather differently than in classically scientific terms (Uphoff, 1996), for you cannot be intimately involved in the creative birth and implementation of something while still remaining objectively committed to the purity of the data.

A concrete example of this comes in the form of employment for one of us (Gonçalves) who had the opportunity to observe, from the inside, the infrastructure and workings of a Brazilian NGO, *Centro Ecológico*, for almost 15 years. The perspective we have now from an external position, is that we were provided the chance to explore the local context through a virtual "macroscope" that focused and magnified those elements we considered important enough to investigate. Thus, in the first level of involvement we were consumed within the whirl of decision-making and adjustments to circumstances. In the second, we had time, in retrospect, to observe, consider, reflect, and judge what we were seeing.

Recognizing the limitations involved, we have currently left behind the unique challenges of the individual farmer and exchanged this level of complexity for the broader focus of community projects and aligned policy. Institutional and political dimensions, strategies and models for governance, participation, equity, rural extension, productive chains, and market promotion are now, necessarily, the

focus. The goal is to understand trends, search for patterns of success, and learn to more quickly identify system flaws. It is now our job to understand how things occur, how to replicate successes and avoid mistakes – it is how to adapt, change, grow, and then apply those bits of learning to new situations.

We believe that there is still hope, that we can do more than waste our time building higher fences to protect forests and animals from the threat of human activities. We believe that our role is to help those same human beings come to understand that more reasonable and conscious behavior will provide a richer future for a greater number of human beings as well as our less articulate living neighbors.

Pristine lands and forests are being transformed into deserts deprived of life. Cultivated land is being reduced to barren landscapes saturated with agrochemicals. Inequality and small holder marginalization is increasing in these industrial agriculture scenarios, all for the increase of GDP. But we have seen, read, and practiced enough to believe that change is possible. We are convinced it is still possible to address the ignorance, indifference, and apathy of those who still profit from the destruction and misery of the many for the profit and leisure of the few. Trees matter, animals matter, clean water and air matter, and AFS can have a significant role in making life worth living for all creatures of the world.

I.2. KEY CONCEPTS AND TRAJECTORY OF TREES IN AGROECOSYSTEMS

The idea of combining Environmental Services (ES) such as CO_2 sequestration, biodiversity enhancement, and soil conservation with that of improving living conditions for the rural poor were concepts embedded early on in a wide number of developmental demonstration projects. In fact, such programs have been funded in Brazil by international cooperation agencies since the beginning of the 1980's. Most of these projects were *rebel movements* of alternative agriculture under different umbrella concepts: Alternative, Biologic, Organic Agriculture, and more recently, Agroecology (Ehlers, 1999).

All these competing concepts have coexisted in Brazil since, again, the early 1980´s, and technicians were feeding their hunger for new strategies on sparsely available publications that related the occasional glimpse into what was happening worldwide. However, in the first decade, complex multistrata farming systems that included tree preservation, generically called Agroforestry Systems (AFS), were not an explicit part of the technical strategies of these movements. Most, following the tradition of Howard (1943), Edward H. Faulkner (Faulkner, 1945), and Biodynamic Agriculture put their emphasis upon soil conservation and the banning of agrochemicals from the farming systems.

An exception favoring trees in the first soil conservation strategies, and a rare reading amongst Brazilians, was the famous book of J.R. Smith Tree Crops (Smith, 1929). This classic work inspired the Permaculture movement (Mollisson and Holmgreen, 1978), which was influenced, too, by Masanobu Fukuoka (Fukuoka, 1978). The old sensei approach to a multistrata orchard (including fertilizing

trees even if planted in a small area) was inspirational for his followers all over the world.

More recently the International Center for Agroforestry Research coined the term "Evergreen Revolution" (ICRAF, 2010). It brings together the idea of more food and ES as a consequence of introducing, regenerating, or just retaining more trees in the productive landscape. The concept promoted the critical role of trees in redefining farming in the tropics and advancing a methodology that can effectively change the face of agriculture worldwide. The point is that AFS can contribute to improve agroecosystem's complementary role in promoting biodiversity and forest genetic conservation (Boshier, 2004; Negash et al, 2011), improve habitats and connectivity in agricultural landscapes (De Clerck, 2011), sequester CO_2 (Nunes and Rugnitz, 2011), and help to mitigate the impact of climate change by improving landscape resilience against disturbance (USDA, 2011). In short, AFS can provide a complementary role for protected areas by offering a full basket of ES, food for a pro-poor approach, and as relief for the pressure on Conservation Units. So, even while we have all these catchy concepts and well documented facts, why is AFS not yet promoted as a Brazilian mainstream policy 20 years after Rio+20?

Trees can endure, but so do political-economic paradigms

Cato "the Old", the Roman Empire expert in agriculture from the third century B.C., recommended arranging trees in the form of trellises to sustain the vineyards and reap the benefits from both soil conservation and firewood. Such systems were widely adopted in the following centuries, when forests (and firewood) had become scarce (Perlin, 1989). The tree supported vineyards can still be seen today in the Minho region of Portugal (Altieri and Nichols, 2002). But this reference from the Roman Empire is intended to illustrate the fact that institutions are very ponderous and slow moving beasts. They usually will not merely block innovation, but will adopt it only when it has just reached the edge of disaster (or just after it has occurred). Formal institutional behavior is typically built over centuries of either imposed or consensual behavior, and it usually translates into a kind of brittle resistance rather than resilience and adaptive thinking (Gunderson, 1995). In this sense, objectives like the ones proposed by the Evergreen Revolution (ICRAF) must deal with economic and cultural inertia, well established and rigid paradigms, and socio-economic arrangements with strong and complex political implications.

SECTION II.

DRIVERS AND CONSTRAINTS OF AFS DEVELOPMENT[1]

Similarly, Brazil has praiseworthy environmental laws and regulations, such as the National Environmental Policy and the National System of Conservation Units, as well as a series of initiatives targeting what are known as "traditional communities" made up of riverine, quilombola (Afro-descendants of runaway slaves or maroons), artisanal fisherfolk, rubber tappers, and other forest-dwelling communities – a group that includes "family farmers." These social groups are eligible for low-interest loans ranging from 0.5% interest (for microloans) to 5.5% interest per annum and averaging approximately 2% for the bulk of loans – figures remarkably low by Brazilian standards. These loans often boast of comfortable grace periods and favorable payback plans as well. These groups are also eligible for other benefits under Brazilian federal programs, such as land regularization and technical assistance, as well as guaranteed prices, subsidized farm insurance, and tax exemptions for a range of products having origins in "sociobiodiversity."[2]

As a direct result of policies aimed at alleviating poverty and equitably distributing income, from 2004 to 2009, 26 million people have climbed out of poverty, and real wages have risen by 28% thereby allowing millions to climb the economic ladder into a steadily growing middle class (IPEA 2011). In 2003, former President Lula's administration instituted a sweeping and (now) globally recognized direct cash transfer program known as Family Stipend (*Bolsa Família*), targeting

1 Substantial parts of this section was extracted from the document *Policy lessons learned from Agroforesty Systems in Brazil: Insights based on five case studies* (A. Miccolis, J. L. Vivan, A. L. R. Gonçalves, M. Méier and R. Porro, 2011).

2 Sociobiodiversity is a concept coined in Brazil meaning, "The relationship between goods and services generated from natural resources and aimed at setting up chains of production that are in the interest of traditional peoples, communities and family farmers" (MDA 2011). Available at www.mda.gov.br/portal/saf/programas/Sociobiodiversidade/2291225. Last accessed on October 1, 2011.

millions of the poorest families. The conditions for receiving these funds include keeping their children in school and accepting regular visits by community health workers. Another renowned program, known as Zero Hunger, has set up innovative mechanisms for increasing food security for the poorest of the poor while also encouraging smallholders to market their goods through the Food Procurement Program. Thus, a dynamically developing AFS has a key role to play within this wider context in terms of its benefits for coordinating poverty alleviation with sustainable rural development polices – particularly, as we will see in the next section, those targeting smallholders.

II. 1. POLICY DRIVERS OF AFS DEVELOPMENT

Over the last 30 years, Brazil has seen a wide variety of agroforestry systems popping up throughout the country ranging from simple intercropping and crop-livestock integration to complex multistrata systems. While some medium-scale, commercially oriented systems, such as shaded coffee and timber production methods, have been gaining traction (especially in the Atlantic Rainforest and Amazon biomes) the vast majority of AFS in Brazil have been implemented by smallholders.

The importance of AFS in Brazil must be understood in the wider context of rural development, environmental protection, and poverty alleviation policies. Over the last two decades, the Brazilian government has drafted and implemented a wide range of sweeping policies aimed at reducing rural poverty, and others designed to protect sensitive ecosystems. For example, the federal Ministry for Agrarian Development (MDA), through the National Program for Strengthening Family Farming (PRONAF), has greatly increased low-interest rural credit for family farmers, including specific lines of credit for women, and youth, as well as for agroecological and forestry-oriented activities. In 2010, over BR$ 16 billion (Brazilian Reais) (roughly 8 billion US dollars) were earmarked for this program alone.

For the purposes of our analysis, drivers of policy may be defined as factors or forces in policies and programs that lead to the development of AFS, either directly or indirectly. Therefore, understanding policies aimed at developing AFS in Brazil requires first a discussion on those wider rural development policies targeting "family farmers," that account, in this country, for most of the implemented AFSs. Though this category of farmers might be loosely translated as "smallholders," in Brazil the concept of family farmers is defined by specific criteria: those who use family-based labor supplemented by temporary workers and a maximum of two full-time employees, farmers who possess a farm or a plot of land smaller than four "fiscal modules,"[3] who reside on the rural property or in a nearby rural settlement or town, and who earn more than 70% of their income from farm-based activities, fishing, or extractive pursuits (MDA 2010).

Indeed, because of the sheer numbers of people and properties and its overall share of food production, the importance of family farmers in Brazil cannot be overstated. While family farms in Brazil occupy only 24% of overall farmland, they

3 A fiscal module is a unit for measuring land for tax purposes that varies in size depending on the municipality and a series of parameters. In the Amazon it varies from 10 to 100 hectares but, on average, four fiscal modules is equivalent to 76 hectares.

produce 87% of all cassava, 70% of the beans, 46% of the corn, 38% of the coffee, 34% of all rice, 58% of the milk, 59% of the pork, 50% of all poultry, 30% of the cattle, 21% of the wheat, and 16% of all soybeans produced in Brazil (MDA 2010, PLANO SAFRA 2010/2011). Moreover, family farms account for 84.4% of all rural properties (MDA 2009). Despite the importance of family farms for food production, however, almost half of all people living in extreme poverty in Brazil (totaling 16 million human beings), still live in the countryside and are directly affected by food insecurity. This situation prompted former President Lula's administration to draft a series of polices aimed at fighting hunger – an edict that became the cornerstone of the federal government's poverty reduction programs and have since gained international notoriety. Below we present some recent policies or programs that have effectively contributed to agroforestry development in Brazil.

II.1.1. Food Procurement Program (PAA)

Instituted by Law No. 10.696 on 2 July 2003, the goal of this program was twofold: to encourage family farming by purchasing foodstuffs directly from smallholders and distributing them to people facing food insecurity, and bolstering staple food stockpiles. The program is divided up into two main mechanisms: one is called, Local Purchase with Simultaneous Donation, and is designed to increase food security by enabling farmers to sell foodstuffs directly to government institutions, such as food banks, "community kitchens" (which are akin to soup kitchens), and low-income restaurants, as well as to social assistance institutions. And the second mechanism, known as Stock Formation, is designed to stockpile certain staple foods purchased directly from family farmers. In both cases, procurement is exempt from complicated tenders so long as farmers meet some basic requirements. The suppliers must be eligible for the National Program for Strengthening Family Farming (PRONAF), which simply means being classified as family farmers, land reform settlers, or part of a traditional community.

Since 2003, the PAA has invested approximately US$ 3.5 billion to procure 3.1 million tons of foodstuffs from approximately 160 thousand farmers in over 2,300 municipalities. These foodstuffs supply 25 thousand institutions annually while directly benefiting 15 million people. The program's budget for 2011, a number supplied by the Ministry for Social Development (MDS) and MDA, is estimated at R$ 793 million (roughly US$ 470 million). Under this program, individual farmers are entitled to sell up to R$ 4,500 per year (roughly US$ 2,600) (MDS 2011). And although at first glance this amount may not seem all that substantial, given a national minimum wage of approximately US$ 320 per month, it actually means a sizeable source of income for many smallholders.

Despite its fledgling existence, this program emerges as a guaranteed source of income enabling farmers to make long-term investments in a diverse set of products that they might not ordinarily be able to easily market. Thus, this new institutional market, which pays farmers fair prices set at market rates, directly encourages the development of agroforestry and agroecological systems, which, by definition, tend to produce a wide variety of goods throughout the year.

II.1.2. The National School Feeding Program – PNAE

In addition to a purchasing guideline that prioritizes organic or agroecological products, a recent provision in PNAE, encourages the purchase of regional products (i.e. fruits, nuts, grains, vegetables, and roots that are either native to their region, traditionally cultivated or harvested from the wild, and/or are widely used in the regional cuisine). This program has had a series of positive impacts. First, it has led to a shifting of eating habits in schools by favoring locally-sourced (and therefore less processed), fresher, and more culturally appropriate foods. So, instead of school children in the Amazon eating oranges from São Paulo, apples from Southern Brazil, or imported foods from Argentina or Chile, children can now eat nutrient-rich local fruits, such as *açaí* (*Euterpe oleracea*), or Brazil nuts (*Bertholletia excelsa*), as well as locally produced fish and vegetables.

Though much more recent than PAA, the National School Feeding Program – PNAE, which only took on its current format in 2009, is already having a ripple effect throughout the country. While not directly targeting AFS, this program was mentioned in a number of case studies as having direct impact on developing AFS since it created a guaranteed local market for goods produced in these systems. The premise is that all public schools at both the municipal and state level must purchase at least 30% of foodstuffs used in public school lunches directly from family farmers – without intermediaries or complicated tenders (MDA 2010).

Besides the obvious socio-cultural advantages and an injection of capital that this new market dynamic provides for the local economy, these two programs also have provided numerous secondary benefits: first, by reducing the carbon footprint of the school lunch supply chain; and second, by increasing the self-esteem of smallholders, who feel elated at the prospect of supplying food directly to schoolchildren or to underprivileged people.

II.1.3. The National Program for Strengthening Family Farming - PRONAF

The PRONAF program provides low interest loans to family farmers (see definition above). The interest rate varies according to the size of the loan and type of activity. While the bulk of funding goes to investments and costing for all sorts of crops, there are also specific lines of credit for Agroecology and Forests, which includes Agroforestry, extracting products from the wild, as well as sustainable forestry and conservation-oriented activities (MDA 2011).

While these lines of credit are considered important steps in the right direction, the local case studies presented here report that the number of those making use of these lines of credit is still relatively low, and that procedures still need to be more suited to the reality of smallholders as well as the specificities of more complex cropping systems.

Despite this emergence of innovative programs, as we shall see in the next section, smallholders still face huge obstacles to gaining access to many of these benefits and implementing AFS programs.

While the Brazilian federal, state, and city municipal governments have instituted innovative policies designed to promote farming systems suited to the reality

of smallholders, the development of AFS, particularly among smallholders, also faces structural constraints. These barriers can be considered "structural" because they are longstanding and apparently ubiquitous conditions, although the degree to which they stifle the dissemination of more sustainable farming systems varies greatly depending on the region and local specificities.

The juxtaposition between these two extremes in policies – and their ripple effects on land use – cuts across the Brazilian landscape as vast monocultures of soybeans, cattle, sugarcane, and coffee (depending on the region) clash with land reform settlements, indigenous holdings, protected areas, and other traditional communities.

II.2. STRUCTURAL CONSTRAINTS

It first must be mentioned that many smallholders face daunting logistical barriers including poor road conditions and transporting goods long distances, as well as low access to public services such as: education, rural extension contacts, technical assistance, and financial credit. Moreover, smallholders are hard-pressed to meet basic requirements at every stage in the production chain, especially those concerning meeting environmental regulations, gaining access to credit, processing, and/or marketing.

Indeed, while many promising agroecology-oriented grassroots initiatives are springing up across the country, they have traditionally run up against the same barriers making it difficult to organize themselves formally through cooperatives and obtain official certification for their products. The culprits in this process are lengthy, complicated, and oftentimes confusing procedures – especially in light of their low schooling levels and the limited supply of skilled extension workers who could otherwise help them to overcome some of these hurdles. And these challenges are compounded, for rural technical assistance and extension services have been viewed as a burden, for public budgets, rather than an investment in sustainable development strategies (Caporal 2006), in Brazil since the early 1990s. As revealed in these case studies, existing and operating services lack preparation and proper understanding of the issues for agroforestry.

Contradictory policies

The stark contrast between rural development policies aimed at developing agribusiness, on the one hand, and policies targeting smallholders on the other, undoubtedly stands as one of the greatest barriers to sustaining and strengthening AFS. Nevertheless, while the Federal Government has greatly increased direct funding for family farming through the National Family Farming Program from approximately BR$ 2 billion in 2003 to BR$ 16 billion in 2010/2011 (MDIC 2010), this amount still pales in comparison to the BR$ 100 billion invested in rural credit for corporate farming during that same period.

II.3. BARRIERS TO AFS DEVELOPMENT

The main barriers to AFS development found across many case studies were: inadequate extension services, environmental restrictions curtailing the use of

areas protected by law, procedures for issuing processing permits, the weak role of local governments, and low access to rural credit.

II.3.1. Technical assistance

Shortcomings in extension services were frequently mentioned as key hurdles to the success of AFS, both in terms of quantity, quality, and lack of access. Since extension workers are few in numbers and, when available, are woefully unqualified to provide support to assist in the adoption of AFS technologies, the challenges for rural agriculture are magnified. In some cases, such as in Rio Grande do Sul, these services were considered "conservative," i.e. highly resistant, with regard to transferring more innovative farming systems to those who were in need of them, while in others areas they were simply not available or completely inadequate. Indeed, resistance to adopting more innovative farming systems is also strong among extension workers, whose technical training usually focuses on high-input, "green revolution" farming methods. But this attitude also persists even among some farmers. For instance, when public extension services are available, their effectiveness tends to be hindered by their lack of technical knowledge about (and practical experience with) agroecological systems. Among extension workers there also seems to be a lack of appropriate methodologies for transferring what they *do* know to smallholders. In other words, the methods used by extension workers rarely adopt a participatory approach to designing the best solutions that take into account not only technical but also sociocultural, environmental, and economic factors.

II.3.2. Environmental legislation

The most important law regulating land use in Brazil is undoubtedly the Forest Code, which is currently being hotly debated in the National Congress. Whatever emerges from this debate is bound to have a lasting effect on the public's access to natural resources as well as future land use options. Despite these pending restrictions, recent resolutions passed by the National Environmental Council allow farmers to plant using AFS techniques in protected areas (Permanent Preservation Areas and Legal Reserves) as well as upon private properties. Such resolutions are helpful by providing increased opportunities to farm legally on now-restricted portions of their land – so long as they abide by guidelines designed to ensure the preservation of native species and otherwise maintain ecological restraints. Nevertheless, since these new regulations are still not widely disseminated and are subject to different interpretations, farmers and technicians still tend to err on the side of caution.

These little known regulations should not be confused, however, with wider changes under discussion at the moment which, if approved, will greatly loosen environmental restrictions as a whole. Such regulations were initially designed to encourage smallholders to more actively preserve sensitive areas and to put into practice the social function of these lands by allowing AFS into these previously restricted areas. First, they will make smallholders exempt from preserving or recovering legal reserves altogether. Second, the decision determining the size of permanent preservation areas might be left to each state, which, along

with other measures, is likely to lead to greater deforestation. Thus, while some (including various organizations representing smallholders and the agribusiness sector alike) see loosening of environmental restrictions as potential opportunities, others consider them highly detrimental, not only to sensitive ecosystems and water resources, but also to those dependent upon rural livelihoods. In addition to these obstacles, smallholders also face a series of hurdles in gaining access to credit and marketing goods that are relevant do AFS, a situation we examine below.

II.3.3. Rural credit

Despite significant progress in targeted programs such as the National Family Farming Program (PRONAF), access to lines of credit tailored to the needs of AFS smallholders still emerges as a sizeable obstacle. Over the past few years, this program has gradually increased the volume of funds earmarked for family farmers through the Secretariat for Family Farming under the Ministry for Agrarian Development (SAF/MDA). The fund has been increased from 1.17 billion dollars in 2003 to over 9.4 billion dollars in 2011. Moreover, the program has created specific lines of credit such as PRONAF, Eco, Forests, and Agroecology. Unfortunately, however, the number of smallholders taking advantages of these lines of credit is still comparatively low.

This extremely insignificant use of available public funds might be attributable to the structural constraints mentioned above (low schooling among smallholders, weak extension services, etc.). But it might also be the result of the fact that the wider farm loan system and institutions have still not managed to embrace agroecological systems and still tend to remain inclined toward the more conventional farming systems that are easier and faster to draft and approve.

II.3.4. Processing

Processing and adding value to products is oftentimes a major challenge for smallholders wishing to market goods flowing out of AFS farms. The problem does not lie in processing per se, but in the struggle to obtain government licensing that would legalize their efforts and without which farmers are limited to local and informal markets (Miccolis 2008). In Brazil, most foodstuffs made from plants require a license or are subject to inspection from the Health Surveillance Agency (ANVISA). Animal products, on the other hand, are controlled by a different agency and can only be sold with a certificate issued by the Ministry of Agriculture. These licenses, which are hard to come by, since they involve cumbersome application procedures, often stand between family farming cooperatives and promising regional or national markets. Under these conditions, farmers are relegated to selling their goods in local markets where demand is limited and prices tend to be lower.

While the federal government's wide-reaching PRONAF program has provided low-interest loans for building small-scale processing facilities, it is quite common to find processing plants that are either temporarily idle or simply shut down because of their not meeting the federal technical standards. Farmers claim, however, that these standards are not suited the reality of their situation,

that the claims give rise to various interpretations, and that they are therefore subject to the whims of field inspectors. Other national and internationally-funded projects such as the Ministry of the Environment's Agroextractivism Secretariat and PDA/PPG7 have also provided numerous grants for smallholder processing plants, many of which still face similar barriers. In this region, these requirements are considered by key stakeholders as the single largest stumbling block for farmers to gain access to markets through formal channels. They are thus discouraged from investing in and adding value to AFS products such jams, jellies, dried fruits, nuts, or honey.

II.3.5. Role of local governments

An overarching constraint that touches all regions of Brazil, but especially affects the poorest regions the North and Northeast (where the Amazon and Semi-Arid Caatinga biomes are concentrated), is the lack of adequate basic services provided by local governments. Such services such as rural extension, technical assistance, access to credit, prohibitive licensing procedures, and regulatory enforcement are all issues that can, and do, act as barriers to those who need them most. While Brazil's 1988 Constitution instituted a decentralized approach to government thereby guaranteeing that basic services such as healthcare, education, and environmental licensing would be incumbent upon the local and state governments to provide, this new responsibility has not been matched with sufficient funding or human resources to enable effective implementation.

Indeed, the utter absence a firm state presence at the local level often leaves smallholders to fend for themselves, resorting instead to NGOs, church institutions, and various projects to fill the void. There are exceptions, of course, where the local and/or state government has played a much more active and effective role in supporting smallholders and AFS. Strengthening the capacity of local government to support AFS development, especially when bolstered by significant funding from projects, seems to be a determining factor in all the success stories of which we are aware.

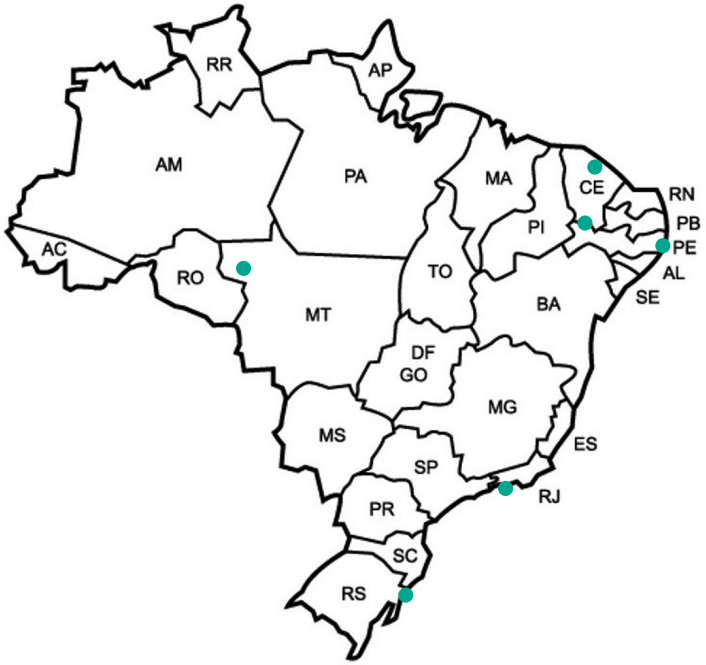
Indeed, there is potential power in the combination of supportive local government and institutions that provide adequate technical expertise, be it through NGOs, academic institutions or duly trained rural extension services. When such a combination is coupled with clear mechanisms for granting access to markets, all give rise to policy factors that can determine the success of AFS. However, according to local case studies examined for this paper, more often than not local governments and extension services seem incapable or unwilling to provide such crucial support to smallholders. Thus, while Brazil has taken significant strides in developing policies that are beneficial to smallholders and AFS, implementing these policies at the local level still poses daunting challenges for all involved.

SECTION III.

AGROFORESTRY SURVIVORS

As mentioned above, the information presented in this section comes from three specific case studies in the following biomes: Amazon, Caatinga, and the Atlantic Forest. Further, we cite one investigation related to land use systems and environmental services in which a number of situations where investigated in the Atlantic Forest. The figure below shows the location of those cases used in this document.

Figure 01. Distribution of cases used in this report. The Brazilian states in which the cases are located:



RS – Rio Grande do Sul;
RJ – Rio de Janeiro;
PE – Pernambuco;
CE – Ceará;
MT – Mato Grosso.

III. 1. RIO GRANDE DO SUL – ATLANTIC FOREST

The first case study, analyzed by André Gonçalves, focused on a region in the southernmost state of Brazil, Rio Grande do Sul, located in the surrounding countryside near Torres – nestled in hills originally covered by Atlantic Rainforest (*Mata Atlântica*). Considered one of the planet's biodiversity hotspots, this biome was one of the first in Brazil to be converted to urban settlements and other forms of land use because of its proximity to the coast and its human history dating back hundreds of years. As a result, only 2.7% of the original forest cover remains intact. And, in fact, most of this is located along the state's northern coastline, where this case study was conducted, and is being protected primarily in conservation units.

Comprised of eight municipalities, the region is mainly devoted to small-scale farming, with approximately 7,000 smallholdings averaging approximately 10 hectares of usable area. While most of these smallholders actually own their land and rely on farming for their livelihoods, many also depend on taking seasonal jobs in nearby towns. Banana cultivation is the main source of on-farm income, with roughly 10,000 hectares farmed by 5,000 families – many of whom have recently turned to modern farming techniques that include the use of chemical fertilizers and pesticides.

For the past two decades Centro Ecológico, an NGO, has been training farmers in agroecological and organic farming techniques, thereby leading to the adoption of agroforesty management strategies. This activity is occurring in what before were mono-crop banana plantations, the intercropping of several native species of timber, and organic gardening. Currently, over 200 families organized in several ecological farmers' associations are marketing their organic produce in local farmers' markets. Increasingly, farmers are intercropping within their banana plantations a native species of palm known as *juçara* (*Euterpe edulis*). Because of the highly prized pulp of the *juçara*, many farmers are now selling its product to local public schools through the federal PNAE program.

Their great dependence on banana cultivation and heavy dependence upon middlemen for selling their bananas, has rendered the farmers vulnerable to the high cost of chemical inputs as well as a limited access to consumer markets. This experience has shown that smallholders planting bananas using AFS methodologies tend to sell their products for a higher value through more responsive marketing channels, thereby offsetting lower yields that result from refusing to use chemical inputs. As mentioned above, some of these farmers are also earning additional income by selling *juçara* palm fruit and using their interspersed AFS timber for domestic purposes. Moreover, this case study highlights the benefits that AFS provides for biodiversity conservation and an ability to adapt to extreme climate events such as high winds and severe frosts.

As a general principle, production systems and agroforestry guidelines recommended by the Ecological Center (EC), especially for the conversion of banana monocultures that dominate the rural landscape of the region, are called the "Agroforestry Complex." These systems are composed of a variety of species, especially endemic native Atlantic Forest such as: "cedro" (*Cedrela fissilis*), "embaúba" (*Cecropia spp*), "sobragi" (*Colubrina glandulosa*), "louro" (*Cordia spp*), and

"canelas" (*spp Nectandra*, and *Ocotea spp*), among others. The areas are managed by introducing plants of economic interest and by selecting species available through spontaneous regeneration. After a few years of planting and maintenance, the systems are very similar to each other in form and structure – resembling, if you will, the natural vegetation. This process mirrors nature, thereby ensuring the resilience of the system and its sustainability both in environmental and economic terms. Some studies indicate that complex systems deployed by farmers in the Torres region are home to more than thirty species of endemic vascular plants, and promote the establishment of approximately 100 tons of $CO_2e.ha^{-1}$ over a period of ten years (Gonçalves, 2008). And such systems are more economically efficient compared to conventional banana plantations (Gonçalves, 2008).

Currently, a species that has been gaining attention in the SAF managed by farmers and is promising great potential for expansion, is the above mentioned *juçara* palm (*Euterpe edulis*), also known by its most common name in the region – *ripeira*. Originally only used for the extraction of the stem (the heart of the tree) and a marginal use of its wood for making slats (hence the name *ripeira*), this plant found itself on the list of endangered species. Now, however, it has become more frequently introduced in banana production systems with an eye toward collecting its of fruit for the production of "*açaí de juçara*." This product is very similar to its counterpart in the North – the Amazonian *açaí* – and has excellent marketing appeal. It promises to represent an important source of income for thousands of farmers and traditional communities living in the Atlantic Forest biome. Some municipalities in the Torres region buy this product directly from farmers to supply *juçara* pulp for school meals. Today, as a result of growing interest in the food, the production of pulp does not meet the growing demand. Thus, the success of *açaí juçara* supports one of the major thrusts of this paper, and that is to study the main causes that are preventing the expansion of AFSs in the region, and to search for concrete alternatives that might combine food production, income generation for farmers, and the promotion of proven environmental benefits and agroforestry systems.

Several factors point to agroforestry as an imperative for the promotion of sustainable rural development on the northern coast of Rio Grande do Sul. As reported, the banana accounts for the livelihood of thousands of families in the region. The sale of this product is accomplished largely through intermediaries who in turn sell to wholesalers or directly to supermarkets. The consumer demand is for high-quality produce, and this requires farmers to use increasing amounts of chemicals despite the environmental contamination, to misuse these inputs, and results in an increase in the overall cost of production which is inevitably passed on to the consumer. This reduction in the profit margin of farmers is exacerbated by the classification system that selects the fruit. This system is imposed by middlemen who often devalue the product and even rule out a significant amount of product that could be sold through other marketing channels.

Farmers who grow bananas through AFS management can generally access those marketing channels in which the product is more highly valued. An expected reduction in productivity because of the non-use of chemical inputs (such as pesticides) can often be offset by lower prices and the opportunity to sell the entire

production. Moreover, alternative sources of income, such as the production of *juçara* intercropped with bananas (again, for producing "*açaí juçara*") are gaining prominence. In the long term, the hardwoods such as cedar, laurel, and sobragi may increasingly become important sources of income for the families of small farmers. Some producers, who have deployed the system for some time, already use wood produced in SAFs for domestic consumption.

In a context of global warming and climate uncertainty – unseasonable rains, high winds, excessive heat or cold – it is necessary to design systems adapted to the new conditions, and even more so when they have the potential to mitigate greenhouse gases. Empirical data show that in March 2004, when the region was ravaged by Hurricane Catarina, a phenomenon occurred hitherto unheard for Brazil. Those banana trees managed by agroforestry techniques resisted the force of the winds. The other trees that make up the totality of the system ensured the protection of the bananas.

Recent studies in the region show that the AFS deployed by many farmers have a key role in biodiversity conservation. In an area surrounded by several preservation initiatives such as parks, biological reserves, and environmental preservation areas (APA), and classified by the Ministry of Environment – MMA as a priority for conservation, these systems can be an important addition, together with instruments of command and control to contain the spread of environmental degradation.

Lessons learned

One of the factors to be considered with projects designed to support the development of agroforestry practices refers to the wide range of systems that can actually be classified as agroforestry. Within a spectrum of infinite possibilities, following a gradient that goes from a simple consortium of woody plants up to planting more complex though naturally occurring species – and that, in fact, replicates the specific biological ecosystem – we propose a flexible use of the term to encourage more farmers to incorporate the practices in their cultivation. This more flexible approach may also contribute to technicians and extension agents who are increasingly more open to include the use of agroforestry practices. On the other hand, the non-standardization of cropping systems may serve as a barrier to agricultural credit concepts, whereas the encouraging policies follow pre-established models.

The organization of farmers into structures such as informal groups, associations, and even small local and regional cooperatives is also one of the success factors for the development of agroforestry practices. On the one hand, within the comfort of such organizations, farmers feel more empowered to adopt farming practices uncommon in their rural communities. Second, they can see that the scale of production is critical to establishing marketing channels thus ensuring their economic return on investment. In the Torres region, one of the success factors is precisely the reality that all farmers who adopt agroforestry practices participate in some form of organization. More recently, the local cooperative – *ECONATIVA* – has played a key role in enabling more farmers to convert their production systems.

The Food Procurement Program (PAA), designed under the Zero Hunger statute, was essential for farmers adopting more sustainable agroecological practices. With a relatively stable market, and without the pressure imposed by conventional markets to use chemical inputs to reach "production quality," farmers are encouraged toward the employment of agroecological management. More importantly, these initiatives are designed to reach the local market thereby creating what we term, "virtuous cycles of production and consumption" that encourage the resources to remain in the region in which they were produced.

Finally, one of the factors contributing to success, growth, and taking on more and more significance, are the initiatives of the Environmental Education (EE) program instituted in schools throughout the region. These initiatives have served an important purpose in creating awareness in farmers of the role of AFS especially through school lunch programs. In rural communities where schools work with EE there is a tendency for farmers to adopt a more practical attitude toward conservation of our natural resources.

III.2. CAATINGA – SEMI-ARID

The second case study, which was also examined by André Gonçalves, focused on a region with completely different physical characteristics. Known as the *Caatinga* biome, the vast Brazilian Semi-Arid zone is home to 21 million people spread across nine states that serve to make up most of northeastern Brazil. Unique to the country, this ecoregion is one of the most densely populated and biologically diverse drylands in the world, encompassing xeric shrublands, dry forests, enclaves of Savanna and humid forest vegetation. The rural population in this region is among the poorest in Brazil, with human development indices in some municipalities analogous to those in Sub-Saharan Africa.

The main environmental vulnerabilities faced by the people living in the Caatinga are: low annual rainfall (ranging from 300-800 mm) concentrated in just a few months of the year, and the widespread loss of native vegetation used mainly for producing charcoal that feeds the energy needs of local industries and households alike. Despite a series of public policies historically aimed at "combating" the drought through large irrigation projects, in recent years this approach has clearly shifted to one of learning to co-exist with the drought through integrated water resources management at both the property and watershed level. This new approach has placed greater emphasis on adopting livelihood strategies that enable rural communities to cope with the effects of the drought while also tapping into and leveraging the wealth of existing natural resources.

The Caatinga is generally little known and undiscovered, if compared to other Brazilian biomes. This wide-spread ignorance, coupled with a jaundiced view of poverty and desolation, feeds a vicious cycle characterized by welfare policies and a lack of investment (public or private) in strategic sectors for promoting sustainable development in the region. There is also, consequently, a lack of prospects for creating virtuous cycles of production and consumption. However, the region is rich in strategic opportunities that, if properly managed, might be incorporated into vectors of important social and economic dynamism.

The change in approach to "combat drought coping with drought" is undoubtedly an important advance in the direction of creative solutions, reacting as it does to a characteristic of the semi-arid drought during certain periods of the year. The drought is not an intrinsic problem suggesting that the system should be supplanted at any cost, and this conceptual and attitudinal change involves very large operational implications. From the idea that you can live with the climate, which is marked by periods of low water availability, it is possible to establish appropriate forms of production despite this severe contingency. Working with agroforestry systems in the Caatinga, there is a somewhat innovative production strategy that reflects this logic of coexistence. Complex systems, multi-diverse with a predominance of species typical of the region, are more efficient in the production of food and fodder for livestock and maintenance of the existing water. Any increase in organic soil matter also contributes to moisture retention. This naturally based strategy helps prevent the semi-arid region becoming a desert.

An initial element that justifies the development of complex agroforestry systems in the context of semi-arid conservation is itself biome-oriented. According to Leal et al. (2005), there are many reasons for conservation and systematic study of the Caatinga. The first refers to the uniqueness of this biome which, according to the authors, only exists solely in Brazil. Despite its importance, it is proportionally the least studied large natural region in this country in which the majority of scientific research is restricted to those few areas usually closer to major cities. Besides being sparsely studied, it is also the region less environmentally protected, for less than 2% of its territory has implemented conservation units. Because of these issues, the accelerated environmental degradation that has occurred over the past few years continues to jeopardize its integrity. Loss of endemic species, reduction or even elimination of key ecological processes, and the formation of extensive areas prone to "desertification" are just some of the consequences associated with the process of environmental deterioration.

As noted above, the extraction of firewood is a major cause of the deforestation and destruction of the Caatinga. According to the technicians and farmers interviewed, the practice of scouring the bush to remove firewood is the main source of income for thousands of small farming families. In the region of Ouricuri (PE), for example, various processing industries produce gypsum wallboard using wood obtained through this process as an energy source. A similar situation occurs in the region of Crato (CE), the Araripe, where the main energy source for pottery making is wood from native forests.

Potentially, AFSs are highly important for producing firewood both to feed small industries and to incorporate into domestic use. A monitoring study coordinated by the Association of Christian Base (ACB), a local NGO, demonstrated the superior ability of agroforestry systems in biomass production and carbon sequestration. The survey demonstrated that an area of environmental remediation – and riparian areas degraded – using a population of 12,500 plant species typical of Caatinga, was able to accumulate approximately 30 tons of carbon dioxide over a period of five years.

Focusing on biomass production and biodiversity conservation, our study has demonstrated that AFS techniques have had a high biomass production capac-

ity and carbon sequestration potential,[4] and have thereby greatly increased the soil's water retention capacity. The study also concluded that these farming systems increased farmers' adaptability to the effects of prolonged droughts by providing fodder for animals and while promoting the emergence of greater biodiversity as compared to conventional systems.

Another important reason that justifies the development of agroforestry systems in the context of Caatinga, refers to food production and income generation. In particular, the northeast region of Brazil is the one that suffers most from food insecurity. The data from the National Household Sample Survey – PNAD – conducted in 2004 shows that 7,240,852 households were threatened by serious food insecurity in the Northeast. This translates to 14.4% of the population of this region, while the national average is 7.7%. However, in the states of Ceará, Rio Grande do Norte, and Paraíba, these numbers tend to be higher: reporting at least 15.0% of all households.

The Northeast is also the region most completely affected by the major cash transfer program in Brazil, the Bolsa Família (the Family Purse). In total, the region receives 58.91% of an almost R$ 290 million program budget to meet the needs of 2.354 million families enrolled. Only the states of Ceará and Bahia receive more than 25% of the sum of the Bolsa Família, and serve more than 1 million families covered by the program (UNDP 2011).

Finally, farmers interviewed in our study indicated one of the main reasons for deploying agroforestry systems was the opportunity to work in harmony with nature. According to the interviews, the appeal of life in the system, manifested by plants, insects, birds, and even small mammals, indicates that they are contributing to the preservation of the planet. They also reported that even in longer drought periods they can provide their animals with fodder produced in the system, while many of their non-AFS neighbors have to buy feed.

III.3. THE NORTHWESTERN CORNER OF MATO GROSSO

The third case study was one generated by Jorge Vivan in the Northwestern corner of the State of Mato Grosso, located in what has been dubbed the "Arc of Deforestation" because of the high deforestation rates that have ravaged this southern edge of the Amazon. Comprised of six municipalities, this region spans 109,000 km^2 and contains 12 indigenous lands (38,600 km^2) and seven Conservation Units. This area is also home to 13 land reform settlements occupied by 4,500 families as well as a mosaic of rubber tappers, loggers, and rancher landholdings.

While 80% of the region is still covered by forest, the high deforestation rates over the past few decades, caused mainly by logging and extensive ranching activities, have led to the establishment of several projects aimed at conserving the region's phenomenal biodiversity. The most notable of these is the Pilot Program for the Protection of the Brazilian Rainforest (PPG7), as well as a project

4 Measurements taken in ten separate systems showed an average of 24.16 tons of above ground tree biomass and 11.72 tons of carbon per hectare, although some systems reached over 20 tons of carbon per hectare.

funded by the Global Environmental Facility (GEF) and managed by the United Nations Development Program (UNDP).

The Amazon biome is typically characterized by a cover of either dense or open moist tropical forest formations, often located over low fertility oxisols. In some areas they occupy a forest formations, in juxtaposition with cerrado, in ecotones. Deforestation rates were around 19,100 km^2 in 2005 and declined to around 12,000 km^2 in both 2007 and 2008 (< 0.4%), followed by a substantial decline to an estimated 7,008 km^2 (0.2%) in 2009 (INPE 2008, 2009). More recent deforestation rates have maintained this downward trend, but declined less rapidly than before, suggesting a threshold may have been reached on further reductions in annual clearing rates. A significant upward spurt in 2011 was traced to the passage by the Congress of revisions in the National Forest Code, the strictures of which limit deforestation on private lands in the Amazon to 20%.

Different organizations have paved the way for public policies and guidelines to indicate how deforestation can be halted on private lands thereby allowing them to recover their economic and ecological performance. The most successful cases come are reported by projects with longer cycles and wider scope, such as the NW Mato Grosso GEF funded project (10 years, 7 municipalities). The project Biodiversity Conservation and Sustainable Use on the Forest Frontiers of Mato Grosso was implemented by the UNDP-Brazil team in partnership with the State of Mato Grosso's Environment Secretary. This program seeks political and economic interaction at the municipal, regional, state, and national level. However this plan engendered wider results, i.e., increasing income per hectare two- or three-fold in a sustainable manner after a 2-4 year maturation period. They also sought complementary projects that carried the central ideas to higher levels. One of them, *Projeto Poço de Carbono Juruena* (Carbon Sink Juruena Project), funded by Petrobras (Brazilian oil company), produced one of the most remarkable success cases in the Brazilian Amazon.

This venture explored the potential for NTFP as a basis for local development aiming to halt the pace of forest degradation in "*national champion deforestation*" municipalities in NW Mato Grosso. With multilateral support through the GEF, in accord with state and local governments, the project helped to organize a Cooperative (*Coopavam*) of farmers who occupy the Vale do Amanhecer land reform settlement, that was being the stage for illegal gold and diamond mining, with all the related disgraces (Juruena championed violent death rankings in Brazil in 2005). Local partnerships and resources were allocated for training and for building a Brazil nut (*Bertholetia excelsa*) processing plant. The program helps to protect at least 2,500 Brazil-nut trees and their habitat, inside a 11,500 ha community forest reserve. To meet demand, the co-op also purchases Brazil nut production from other family farmers, indigenous peoples and forest product extractivists throughout the Northwest region of Mato Grosso. Processed nuts and cookies are used today in school meals from six municipalities in the region and sold to companies in the southern Brazil, providing income for about 80 families and generating 300 jobs, with an average monthly income from of up to US$ 350. A micro-oil extraction plant adds even more value (from US$ 1.60/kg of nuts to around U$ 15/kg oil). Oil is sold to Natura™ Co. for the manufacture of soaps and creams that sell briskly in both Brazilian and foreign markets. Brazil

nut flour, a residue from oil processing, can then be added to cookies to increase their nutritional value. This last product is sold to a National School lunch program thereby further increasing the revenues of the cooperative participants. The settlement was the first in the region to receive an environmental licensing permit, and it is recovering its Legal Reserve with AFS, with Brazil nut and other native tress.

An evaluation study conducted by the authors aimed to identify economic and ecological parameters of innovative land use systems in the context of the mentioned initiative (UNDP/GEF supported project) found remarkable numbers. The analysis of environmental services showed that, in areas managed under AFS for more than 10 years, the values of biomass reached up to 201.6 $m^3.ha^{-1}$. Tree diversity in AFS reached 54 vascular species, against 87 in forest fragments. Low use of technological inputs and predominant use of manual labor resulted in a positive energy balance (ratio output/input), which reached up to 25.3 units (Mcal). Sightings of wildlife were reduced (≤ 20 sp) for cases where AFS and forest were 1km or more apart. Even larger areas of forest inside the farm did not affect these values, reinforcing the general assumption that lack of connectivity is critical for wildlife. In general, AFS being promoted in northwest Mato Grosso was demonstrated to play a decisive role in promoting both economic benefits and environmental services, including biodiversity, reduction of deforestation and retention of carbon stocks.

III.4. LAND USE SYSTEMS AND ENVIRONMENTAL SERVICES IN ATLANTIC FOREST

With the ultimate goal of evaluating the potential of alternative land-use systems in the promotion of environmental services – carbon sequestration, biodiversity conservation and energy balance – 31 production units located in the Atlantic Forest were selected. Most of these properties received support from several development projects sponsored by the Demonstrative Project (PDA) from the Brazilian Ministry of Environment (MMA), seeking to promote agroforestry systems as a strategy to conserve the Atlantic Forest biome. For comparative purposes and in order to increase the analytical universe, five properties located in the Caatinga biome were also studied. In total, an area corresponding 64.4 hectares were sampled, encompassing 92 sample units of 700 m^2 each, and 5,756 individual trees properly measured, in the states of Rio Grande do Sul, São Paulo, Rio de Janeiro, Pernambuco and Ceará. For the analysis of potential biomass production and biodiversity conservation, phytosociological surveys were conducted, where all trees in the plots were identified, and those with a diameter at breast height (DBH) greater than or equal to 15 cm were measured and the height was estimated. The data collected in the field, used for phytosociological analyses were processed through the program Native Forest ® version 2.10, obtaining the floristic (number of individuals, their families and species), diversity (Shannon-Weaner Diversity Index – H`, and Simpson's Dominance Index - C')[5], and

5 A diversity index is a quantitative measure that reflects how many different types (such as species) there are in a dataset, and simultaneously takes into account how evenly the basic entities (such as individuals) are distributed among those types. The value of a diversity index increases both when the number

horizontal structure (Value of Importance - VI). To estimate the biomass, several allometric equations were used according to the available models for each region. The energy balance was based on an analysis of the relationship between all inputs used for production and products effectively collected in the system under analysis (input / output). The method consists in converting all inputs used in the production process to its equivalent in terms of energy, and compares it with the total energy content of the harvested products. The results show that the complex and multi-diverse AFS areas, when consolidated, can accumulate more than 300 tons of CO_2 equivalent per hectare. Some of the analyzed systems harbor endangered species indicating that these systems indeed have a role to play in terms of biodiversity conservation, and can even help to restore and extend the functionality of forest fragments. In general, it can be inferred that the AFS process can also produce more food per unit of energy invested, compared with conventional systems. We can conclude, therefore, that these systems, if properly implemented, can have a prominent role to play in regard to the current challenges facing production and conservation.

Table 01. Synthesis of all case studies highlighting environmental services associated with the agroforestry systems

Project case location	Business as usual	Production strategy (AFS practices)	Environmental services associated
Mata Atlântica Biome			
Northeast littoral of Rio Grande do Sul	Banana Monocropping; pasture	Banana intercropped with heart of palm and endemic vascular species	Carbon sequestration (up to 150 tons of CO_2 equivalent), biodiversity conservation (endangered species), H` = 2,56 (medium)
Shaded coffee in Ceará	Pasture	Shaded coffee intercropped with endemic vascular species	Carbon sequestration (up to 250 tons of CO_2 equivalent), biodiversity conservation, H` = 2,47 (medium) and landscape maintenance
Southeast littoral of Rio de Janeiro (Paraty)	Pasture and banana monocropping	Fruits intercropped with endemic vascular species	Carbon sequestration (up to 100 tons of CO_2 equivalent), biodiversity conservation (endangered species), H` = 2,96 (high)
Zona da Mata (Forest zone) Pernambuco	Extensive plantations of sugarcane	Fruits intercropped with endemic vascular species	Carbon sequestration (up to 300 tons of CO_2 equivalent), biodiversity conservation (endangered species), H` = 3,00 (high)
Caatinga Biome			
Backlands of Pernambuco	Pasture and extraction of timber for fuel purposes	Endemic local species, fruits, and fodder for animals	Carbon sequestration (up to 40 tons of CO_2 equivalent), biodiversity conservation (endangered species), H` = 2,53 (medium) and water production
Araripe Plateau	Pasture and extraction of timber for fuel purposes	Endemic local species, fruits, and fodder for animals	Carbon sequestration (up to 80 tons of CO_2 equivalent), biodiversity conservation (endangered species), H` = 2,36 (medium) and water production

of types increases and when evenness increases. Values of the Shannon´s diversity index for real communities typically fall between 1.5 and 3.5.

IV. CONCLUSIONS

Despite the stark contrasts between the different contexts studied in Brazil, some recurrent issues – as well as specificities from each case – provide valuable lessons for reinforcing successes and overcoming barriers. First, it is clear that AFS should not be promoted as a panacea for overcoming the overwhelming barrage of market and policy forces that lead to unsustainable land use practices. Rather, they must be part of a more systemic approach to curtailing deforestation and enhancing rural livelihoods. Such a strategy must take into account political forces and players as well as social, economic, and ecological factors. We know how we got here and where it all went wrong, and there is enough blame – from naked greed, to willful insensitivity, to pure apathy – to go around. From this point forward our focus should be, in a word, on the "now and how" of the problem.

Those AFS cases considered successful must be understood primarily at the local or landscape level in light of key factors that have made them successful. Factors such as: property size, varied access to markets, functional inputs (especially fertilizers or labor), and types of products with proven public appeal – those that are fresh, minimally processed, and storable – as well as the capacity for investing in new technologies. These have all had a hand in recent successes.

In Mato Grosso, successful farmers identified according to these parameters exist despite generally "unfavorable" or "neutral" local political scenarios. Additionally, AFS farmers who produce a wider array of products are less vulnerable to market fluctuations and plant diseases, and are also more flexible in their ability to allocate labor. But it is also clear that where the local government and/or the NGOs did play a more supportive role through technical assistance, by providing inputs, or helping to increase access to markets, a greater number of farmers

adopted AFS as their main farming strategy. In general, access to institutional markets such as PAA and PNAE played a pivotal role and greatly encouraged the cultivation of a wider diversity of crops.

There is yet another key AFS lesson that must now be mainstreamed into the policy-creating arena, and that is the idea that ultimate success hinges largely on the availability of qualified and responsive extension and technical assistance services. While the provider of these extension services has varied from case to case studied by the authors, in all situations, technical support tailored to the specific needs of smallholders, was considered absolutely instrumental in ensuring the adoption of more sustainable farming systems. Moreover, the availability of technical assistance, coupled with greater social organization (and their associated benefits such as: access to better planting materials, better site-level planning, and more knowledgeable and conscientious management) have emerged as crucial factors for AFS development. For research and extension services to be effective, however, they must actively involve farmers through iterative and mutual learning processes that feed into wider technical discussions and policy debates. Such a process enables positive feedback loops and peer-to-peer and horizontal learning strategies that have been proven to be essential tools for creating success among farmers.

In the policy arena, the most important federal government initiatives were undoubtedly the two programs aimed at improving market access for smallholders – the Food Procurement Program and the National School Feeding Program. Though not directly aimed at developing agroforestry per se, these two programs arguably have done more for encouraging and developing AFS than all the other targeted programs put together. In order to understand why these policies are playing such an important role, one must first grasp their underlying rationale.

As seen in many cases, the extent to which farmers adopt AFS hinges not only on ecological variables, such as the degree of degradation and soil fertility, but on a series of interwoven economic factors such as access to markets, the availability of turnover capital during initial stages, and the amount of income generated. These factors should also be combined with social and human factors such as the farmers' openness to innovation, their involvement in social networks, and access to knowledge transfer systems. Generally speaking, AFS initiatives providing long-term support, such as the GEF/UNDP project, tend to have wider impact, especially when they strengthen the capacity of government institutions to provide services to smallholders beyond local NGOs.

Despite significant progress of Brazilian laws over the last decade, the local case studies in all regions as well as our wider policy analyses point to the need for a legal framework more tailored to the specificities of AFS and other smallholders. Likewise, regulations pertaining to processing need to be simplified and adjusted to the context of smallholders' planting using an agroforestry system. Decentralizing environmental licensing procedures at the municipal level may contribute to a reduction of some of those barriers inhibiting smallholders from investing in and harvesting of certain timber species in the system, as well as hindering them from using AFS to recover degraded lands in areas considered environmentally sensitive.

The lack of social cohesion among smallholders, their limited capacity to manage their businesses, their inability to access markets for new AFS products, also remain to be substantial hurdles. The answer to these issues, according to ASF, are those farmers who managed, on their own, to organize themselves and who gained direct access to consumers through farmer's markets and programs to such programs as PNAE and PAA.

Several case studies highlighted the importance of AFS for solutions to extreme climate events: in the Caatinga region AFS strategies were considered important for combating desertification and increasing the rural communities' capacity to cope with the effects of droughts. Indeed, the case study from the Caatinga shows that agroecological systems, when properly managed, can be highly productive by encouraging the retention of biologically diverse systems that increase food security and income generation, even in the harsh semi-arid conditions.

As stressed in so many ways above, the majority of these AFS initiatives were proven to be successful despite their having to swim against the current of wider agribusiness-oriented rural development initiatives. The ultimate challenge for Brazil, then, lies in mainstreaming smallholder policies into wider development practices while also rendering agribusiness-oriented policies more amenable to those practices that have made AFS so successful, like adopting low carbon emission/high carbon stock agroecological methods. Enabling such a shift on the ground entails not only preserving ecological functions in tree-based agroforestry systems for smallholders but also including trees into the wider agricultural landscape. In Brazil, it means adopting more systemic and integrated methods to landscape planning and rural development policies.

But more than anything, all of this is just "pie in the sky" unless we all learn the most important lesson of all: rather than continuing to speak from positions of inflexible intransigence, there has to be a shift in thinking. All of us who are interested in higher yields, increased profits, better farming systems, and sustainable practices have to understand that working together rather than warring against provides us with the capacity to move forward. Surely both sides can learn from each other, but someone must lead the way. Perhaps the AFS movement, with its proven track record, can now be seen as a movement with sufficient substance and potential to take its rightful place in the dialogue among all others who have a right to be included in the conversation.

Additional policy changes needed to promote Agroforestry

To overcome or at least diminish the affect of the obstacles revealed by virtue of the Brazilian case study review, while also reinforcing the drivers behind agroforestry development, a series of policy changes are needed. Some are structural in nature and pertain to existing policies and programs, whereas others might involve creating new policy instruments. Our recommendations propose policy changes that meet some of the structural challenges identified in this paper without needing to create overly ambitious new institutions or policy structures. We also propose specific mechanisms and initiatives that might have wide-reaching impact without entailing gargantuan investments. So, while we do make some broad recommendations that cut across all sectors, our focus remains on en-

hancing, adjusting, or intermingling existing institutional structures, while adapting and fine-tuning the regulatory framework.

Generally speaking, rural development policies, especially research, credit, and extension services, need to be tailored to more diversified and complex farming systems. This could be accomplished by adopting more flexible and simpler technical guidelines, norms, and procedures. The concept of an "agroecological transition" included in 2003 by the Ministry of Agrarian Development in its extension policies, is a step in this direction by finally targeting agroforestry systems, refining financing mechanisms, and enhancing the training of extension agents for formulating agroforestry rural credit projects.

As of August 2011, the initial set of AFS farmers became eligible for rural credit. Thirty-two combinations of two perennial species are now listed including *açaí*, cocoa, coffee, citrus, and Brazil-nut, associated with other fruit or timber trees, representing possibilities for both the Amazon and Atlantic Rainforest biomes. While still insufficient to acknowledge the specific needs of each user community, this initiative may be positively viewed as the first step in supporting AFS through federally funded financial mechanisms. Indeed, rural credit policies must be specifically tailored to AFS, involving all key players in the chain of service provision, including banks, technical assistance agencies, NGOs, farmers' unions, and smallholder organizations, so as to expedite and simplify procedures for issuing loans. One clear example of this is the need to further adjust bank spreadsheets and procedures for assessing the economic feasibility of AFS by taking into account their technical and economic specificities. For instance, planting guilds and intercropping may entail higher initial costs and lower yields per crop, as well as longer payback periods. But such practices might also mean higher overall yields per hectare and more stable income on a long-term basis.

Likewise, assessing the social, economic and environmental sustainability of AFS in decision-making processes must go beyond the economic analyses and take into account the importance of these systems in providing environmental services, such as ecological functions, water retention, and carbon sequestration. These assessments must also recognize the role that AFS plays in bolstering food security, livelihoods, and in increasing smallholders' capacity to adapt to climate change. One way of softening the financial burden that farmers are called upon to bear would be to include provisions in credit programs allowing smallholders to pay off a portion of their loans through the provision of such environmental services. For this to work, technical parameters for measuring and monitoring carbon stocks, for instance, need adjustments to be more easily adopted by local technicians and government agencies.

At the same time, zoning and land use policies should put into place specific guidelines based upon the AFS model for attenuating the negative impact of large-scale monocultures on landscapes and livelihoods. ´This might be done through a mosaic approach to land-planning while also encouraging farmers to recover degraded lands and protected areas by using those AFS guidelines. Indeed, environmental laws also need to be more tailored to the needs of smallholders so that more of them might increasingly adopt AFS as their preferred method of farming.

Under current legislation, the low availability of fertile soils in many regions means that smallholders feel they must encroach upon protected areas within their own lands to continue farming. Within these contexts, Agroforestry Systems emerge as a promising alternative that enables small-scale farmers to maintain the ecological balance of sensitive areas while reconciling those impulses with food production and poverty reduction. The challenge here lies in establishing guidelines that are flexible and simple enough to be widely adopted while at the same time ensuring that the approach adheres to the conservation-oriented principles laid out in the environmental laws.

Furthermore, educational institutions, especially rural schools and agricultural training institutions should draw together educators, extension workers, and smallholders for dialogues and iterative learning processes. Dissemination of Agroforestry System precepts could be greatly increased through peer-to-peer learning among farmers and technicians and training-of-trainers geared toward farmers who already adopt successful experiences and can serve as guideposts for others. Higher education institutions, particularly Agronomy, Forestry, and Environmental Science programs, should also mainstream AFS and agroecological farming principles into their curricula.

It is further possible for AFS to be instrumental in bringing about a shift in extension and technical assistance services that require adopting more simple, field-based tools for site-level assessments and do not require sophisticated equipment or laboratories. Such changes would enable extension workers to assist smallholders in adapting AFS principles to their own very specific needs. This shift also involves forging more horizontal relationships between researchers, extension workers, and farmers, through participatory research. Already proven in practice, these innovative methods enable developing cropping strategies that take into account and make allowances for farmers' underlying vulnerabilities (their lack of resources, the low availability of family-based labor, poor soil fertility, and low access to public assets). And finally, extension services might institute basic technical guidance to better assist the small farmer in making the transition from monocrops to more diverse planting techniques. Strategies such as the use of green manure, intensive and science-based pruning, direct sowing of tree seeds in the field, systematic mulching, and other management techniques that improve soils, increase yields more rapidly and reduce the dependence on costly external inputs. These are all potentially beneficial practices that can be taught, promoted, and supported by AFS managers and mentors.

With regard to markets, programs are needed to bridge the gap between smallholders and prospective markets. There needs to be specific steps taken to set up what is called, "institutional markets," such as PNAE and PAA which was discussed extensively above. Oftentimes, it is simply enough to provide the space and logistical support that functions as a springboard for these markets to come into existence. On the demand side, conducting campaigns to raise consumer awareness about the social and environmental features and benefits of agroforestry products that set them apart from other conventional products would also go a long way to increasing their value thereby allowing farmers to gain inroads into these yet untapped markets. Additionally, policies transforming byproducts of crops typically grown in agroforestry systems into commodities consumed on

a wider scale would also greatly increase the demand for them and provide incentive for widening the appeal of AFS practices. Such a byproduct might be the converting of cassava flour into wheat flour, as we've indicated above.

Another strategic marketing scheme to gain access to new groups of consumers might be the creation of participatory certification program to identify products grown in Agroforestry production systems thereby building on, yet reaching beyond, existing organic certification. In this way, the products would become "value added" commodities that would command more economic value in the marketplace. These strategies, of course, must be based on clear guidelines – procedures and methods of measurement that set AFS apart from mere organic farming systems. Without such guidelines and regulations, however, that might add more complexity or expense to the lives of our participating farmers. In other words, they must be simple enough to be implemented and monitored at the local and regional level, preferably by involving smallholders' organizationa working hand-in-hand with extension services, research institutions, or sub-national governments. The payoff for such certifying/licensing of AFS timber produced would greatly encourage farmers to plant and manage native timber species on their plots to generate income while enhancing environmental conditions.

Finally, upscaling programs, such as the Brazilian Sociobiodiversity Plan – one that provides tax and regulatory incentives for products associated with sociobiodiversity – would spur farmers to plant underutilized edible species deemed suitable for AFS programs but are often left out by farmers because of low market access and/or high production prices. Such underutilized products include a variety of fruits, nuts, and essential oils. Indeed, the regulatory framework pertaining to the management of native and planted forests needs to be both simplified and standardized so as to be more easily interpreted and readily applied. Specific guidelines need to be in place for AFS including explicit provisions and management practices designed to encourage smallholders to invest in the planting of timber species in conjunction with their cropping systems. Such regulations (in deference to the strict native tree prohibitions) would provide farmers with the certainty that they will be able to selectively harvest these species in the future.

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