Soybeans, Poverty and Inequality in the Brazilian Amazon

Diana Weinhold and Evan Killick and Eustaquio Jose Reis

London School of Economics, University of Sussex, IPEA

15. March 2011

Soybeans, Poverty and Inequality in the Brazilian Amazon

Diana Weinhold§,
London School of Economics

Evan Killick
University of Sussex

Eustáquio Reis
IPEA

March 2011
Comments welcome

Abstract: The recent growth of soybean cultivation in the Brazilian Amazon has been unprecedented, even as the debate continues over its economic and environmental consequences. Based on contemporary datasets as well as our own field studies, this paper examines the social and economic costs and benefits of increases in soybean production for local populations. After presenting some background information on the rise of soybean cultivation in Brazil we examine the relationship between increases in soybean production and local economic indicators. We find that increased soy production both reduces poverty indicators and raises median rural incomes. However, we also note that this increase is associated with increased measures of inequality, and we consider the wider political and social consequences of this connection in our qualitative fieldwork. The mixed-method approach helps shed light not only economic effects of soy cultivation but also on the more complex social and political context that is, arguably, even more policy-relevant.

Key Words: soybeans, agricultural land use, brazil, poverty, inequality
JEL codes: R11, R14, Q56, O13

§Correspondence to Diana Weinhold, Dept. of International Development, London School of Economics, Houghton Street, London WC2A 2AE.

We thank participants at seminars at IPEA, UCL, University of Manchester, and DFID for useful comments. All errors and omissions are our own.

1. Introduction

Since the 1960s, Brazil's national and regional governments have invested large sums in the development of soybean production both directly, through research and agricultural grants, and indirectly, through the large-scale infrastructural projects needed to make the enterprise profitable. Soybean products are currently one of Brazil's most valuable agricultural exports, and a key component of the country's continued economic development. With continuing investment in major infrastructure projects, particularly in the Amazon region, their importance shows little sign of diminishing.

Observers, however, remain divided about the social and environmental effects of this development. On one side many environmentalists and NGO's fear that the large scale of this plantation crop will both increase deforestation and displace small farmers, increasing inequality and poverty (Carvalho 1999, Fearnside 2001). Other researchers, however, argue that most new soybean production takes place on land converted from pasture, rather than from forest, and that the growth of supporting enterprises that accompany large soybean production creates jobs and reduces poverty (Brandao *et al.* 2005).

Neither side of this debate has been able to offer much quantitative empirical evidence. Some localized studies have been done on the environmental impacts of this industry (see Kaimowitz & Smith 2001 and Fearnside 2001), but few recent studies have presented detailed evaluations of the claims of increased local inequality and poverty rates. As Fearnside has noted, in order for countries like Brazil to take informed decisions regarding soybean expansion, "what is needed is an honest weighing of costs and benefits of expanding soybean cultivation, including all social and environmental costs" (2001:35). This paper is an attempt to evaluate some of the available economic and social data on this issue.

1b. Background

Soy was first grown in significant quantities in Brazil in the 1940s and 50s slowly becoming commercially important in the southern states of Rio Grande do Sul, Santa Catarina and Paraná (Brown *et al.* 2005:462). Gradually the Brazilian government, through The Brazilian Agricultural Research Corporation (EMBRAPA), was instrumental in developing strains of soy that could be grown in other, more northerly, regions of Brazil: first in the *cerrado* and then the equatorial forests (Andersen *et. al.* 2002:78, Mueller 2003:14, Brown 2004:159). As this progress occurred so production spread steadily north into the legal Amazon region, particularly in the northern areas of Mato Grosso (Fearnside 2001, Mueller 2003) where relatively low land prices, soil quality, mechanisation-friendly topography, and gradually improving (though often still very problematic) transportation infrastructure made production competitive in international markets (Diaz *et al.* 2006). As this process accelerated over the past ten years, the rapid growth was further spurred by the increasing price of soy in both local and international markets.

As Warnken argues, however, the Brazilian soybean industry has been pulled not only by the rapid expansion in world demand for soybean products, but also pushed by public policy (Warnken 1999:3). In the past the crop played an important role on the national stage in helping Brazil to increase export earnings for development purposes. Although Brazil has now evolved economically beyond the days of worrying much about the IMF and international debt payments, some commentators still see the crop in these terms. For example, Steward (2007) notes that the Brazilian government still 'supports soy production to generate revenue for paying down its debt and efficiently utilizing its land area' and that 'soybean farmers believe they are national heroes' (Steward 2007:111).

Soybean production, like agriculture generally, requires access to credit, so it is not surprising that a number of national and iternational banks have become involved. For example BNDES (The Brazilian Development Bank) started a programme in 2000 that significantly increased credit for agricultural machinery. Bickel & Dros (2003) have also noted how large agricultural enterprises such as the Maggi group in Mato Grosso have been financed by international banks (2003:19). Multinationals, and particularly Cargill and Bunge in Brazil, also provide soy growers with credit, usually in the form of seed, fertilizer and chemicals in return for the soy harvested (Greenpeace 2006:2).

Most of this political and economic support for the soybean industry has been based on its relatively clear profitability and growth potential. Meanwhile, soy's impact on local economies has received less attention (cf. Warnken 1999:6). The need for such work is particularly important given the numerous criticisms of the soybean industry made by many researchers, activists and local populations. The main emphasis here has been on the argument that the large scale of this plantation displaces small farmers, increasing inequality and poverty and, in turn, pushes such individuals to claim new land, often through deforestation (Carvalho 1999 and Fearnside 2001).

The basic premise of this argument is that large-scale mechanized agriculture uses less labour per hectare than small-scale farming techniques[1]. Diegues (1992) describes the effect of the move from coffee farming to soybean cultivation in the southern Brazilian states in the 1970s that was precipitated by a number of problems including 'soil depletion, plant diseases, over-production and lower producer prices':

[1] Fearnside adds that on large-scale farms in Legal Amazonia employment tends to be given to workers from outside the region (usually from the same southern states as the farm owners) rather than to local populations (Fearnside 2001:24-5).

> Between 1970 and 1980 in Parana, the number of farms smaller than 50 hectares fell by 109,000 units with a combined loss of 890,000 hectares in this category. In contrast, farms larger than 1,000 hectares increased by 450 units with a gain of more than 1,000,000 hectares… Many agricultural labourers, especially sharecroppers and other tenants, lost their only source of income. As a result, net migration from the rural areas of Parana reached 2.5 million during the 1970s compared with a net gain of 170,000 in the previous decade (Diegues 1992:12)

Kaimowitz & Smith note that during the same period Rio Grande do Sul lost some 300,000 farms (2001:202). They further argue that while "the majority of migrants moved to urban areas… a significant number went to the Amazon and cleared forest to grow crops" (2001:202)[2].

However others have argued that this kind of reasoning misses the dynamic argument that, in the long run, large scale mechanized agriculture increases overall productivity and avoids vicious cycles of rural poverty associated with low productivity smallholdings and deforestation. Nationally, increased foreign exchange earnings increases consumption and investment both directly and indirectly through terms of trade effects. Locally, wealth generated by large-scale farms adds not only to both regional economies and government revenues but also to the growth of supporting enterprises that, in turn, creates jobs and reduces poverty all over the country (Brandao *et al.* 2005, Mueller 2003 and Mueller & Bustamante 2002). It can also be argued that the associated increased investment in infrastructure also contributes to general, local welfare. Bonelli (2001) further suggests that the expansion of agriculture, the use of modern technology and the resulting gains of productivity, result in the diversification of local economies (cf. Mueller 2003:7). Another possible side-effect of increased farm size is that it makes governance and the implementation of laws aimed at social and environmental protection easier to enforce[3]. Finally, by providing an economically attractive environment that, due to strict ecological requirements is precluded from expanding too far into the rain forest areas, the presence of soy could be, in the long run, good news for the environment.

The important point for the current paper is that although there is a widespread belief among the public and NGO's about the negative effects of soy, empirical

---

[2] López *et al.* have similar findings in Argentina where they argue that the introduction of soy has contributed to the acceleration of land consolidation. "During the 1990s, the number of farms in the Pampas area decreased from 170,000 to 116,000, while the average size of farms doubled" (López *et al.* 2007:24).
[3] One response to such arguments is to contend that the building up and concentration of power among a small number of large landholders grants them undue political influence (Fearnside 2001:24).

analysis is lacking on both sides of the debate. Here we make use of a large panel data set on agricultural and economic variables to address the question of whether there is quantitative evidence to support either claim. We further complement and augment our econometric analysis with ethnographic fieldwork in a region which has recently undergone a large increase in soy production, interviewing local residents, policy makers and other relevant actors about their views on the impact of soy cultivation and using these qualitative findings to inform and explain our conclusions.

We believe that this dual quantitative-qualitative approach has many advantages over one-sided methodological alternatives. In the first instance, the econometric approach taken here is that of looking for a general, reduced form relationship between soy expansion and changes in inequality and poverty; the underlying theoretical mechanism is left, for the most part, as a 'black box.' The qualitative fieldwork, on the other hand, produces a more multifaceted and nuanced investigation within a single region, but qualitative narratives of residents may be distorted for various reasons and the external validity of the conclusions from a single site may be limited. Brought together, the two approaches can partially redress some of the others' weaknesses.

Finally, in order to have the maximum policy relevance, ideally we would like to help shed light on the whole phenomenon of soy production and economic outcomes, which includes explaining the any local or NGO beliefs about negative impacts. In other words, we want to find an *encompassing* explanation; one that explains not only how the relationship in question operates, but also why local and international observers come to the conclusions that soy is either beneficial are harmful. Statistical analysis alone is unlikely to be able to address this latter question, yet for policy makers this may be crucial.

This paper thus proceeds as follows: in section 2 we describe the data set and outline the quantitative estimation strategy. Section 3 discusses the empirical results and considers a number of possible limitations to the analysis. Section 4 introduces the qualitative case study and summarizes the findings, and section 5 discusses the interactive conclusions from the complementary approaches and concludes with suggestions for future research.

2. Quantitative Estimation Strategy

2a. The Dataset

The data available for the current study was extracted from a large database on economic, demographic, ecological and agricultural variables maintained by Eustáquio Reis at the Institute for Applied Economic Research (IPEA) in Rio de Janeiro. The primary source is the Brazilian Institute of Geography and Statistics (*Instituto Brasileiro de Geografia e Estatística*, IBGE) Agricultural Census that includes hundreds of variables covering agricultural land use, output and other economic indicators collected in 1970,1975, 1980, 1985, 1995, and 2005/6. This data is supplemented with the IBGE Demographic Census that includes data on socioeconomic variables such as income, poverty and inequality for 1980, 1991 and 2000. Poverty is measured as the proportion of the population below the poverty line, incomes are measured both as GDP per capita and as median household income, and inequality is measured using the Theil index, a weighted average of inequality within subgroups, plus inequality among those subgroups. Finally we make use of the IBGE Municipal Agricultural Survey (*Pesquisa Agrícola Municipal*, PAM) which surveys land owners annually to generate estimates of total crop production and acreage.

IBGE data is published at the municipality (*municipio*) level, but the number of total municipios, and their boundries, changes periodically. Thus in order to be able to compare the data over time, municipios are consolidated into *Minimum Comparable Areas* (MCAs). Thus the MCA is our spatial unit of analysis; in many cases this is equivalent to a current municipio, but in other cases there is no direct mapping to the current political boundaries[4].

2b. Estimating Strategy

As discussed above, we seek to analyze whether there is support in the data for a systematic relationship between soy production and the local socio-economic outcomes of interest, income, poverty and inequality. While a number of hypotheses about the underlying mechanism driving this relationship have been discussed above, most of these are rather non-specific with respect to the economics (if not the politics) (i.e. 'large scale production drives out small landholders'). Here we remain agnostic as to the underlying mechanism and treat the question in a reduced form fashion; *is* there a correlation and if so, what is it's sign?

We remain quite cautious about using the term *causality*; the spread of soy production across Brazil is endogenous, following an ecological and economic pattern that may be correlated with socio-economic outcomes of interest for reasons other than any direct causation from soy to incomes. In the absence of a man-made or natural experiment that introduces some truly exogenous variation in soy cultivation, we tackle this question the old fashioned way, with a careful choice of functional form and control variables. Nevertheless we argue that there is good reason to be cautously optimistic; in as much as soy cultivation is a large-scale mechanized industry that does not depend on low labour costs, it is unlikely that the choice to plant soy depends much on the level of wages itself. In addition, as discussed below, we attempt to control for possible unobservable omitted variables

---

[4] As the municipio, and hence MCA, are politically defined spatial entities. In regions where population is dense there tend to many MCAs and they tend to be smaller. Where population is sparse, however, such as in some parts of the Amazon, the MCAs are very large.

(such as strength of property rights or climate) that might both attract soy and be related to poverty.

Our dependent variables, GDP, poverty rates and Theil indices of inequality, both urban and rural, are measured only in 1980, 1991 and 2000. However the ten year gap between measurements is not as unfortunate as it may at first seem; poverty and inequality tend to be slow moving variables whose year-on-year changes likely contain considerable noise (if they were measured). Furthermore, the spread of soy into the Amazon is a relatively recent (post 1991) phenomenon. The advantage to us of using the 2006 Agricultural Census data is that, prior to its release, agricultural census data was available only until 1995. The addition of the new data ensures that, assuming constant annual growth rates, we can interpolate values for 2000 from the 1995 and 2006 data. In turn, we interpolate 1991 agricultural variables from the 1995 and 1985 census. Note that this necessary interpolation could potentially generate econometric problems if the 1995 data is incorrectly measured in a way that is correlated with underlying variables of interest. Due to changes in the time of year the data were collected it is highly likely that the 1985, 1995, and 2006 data suffer a number of differences (see Helfand and Brunstein, 2001 for an excellent discussion of this), but it remains unknown whether these are correlated in a way that would do more than introduce additional noise into the analysis.

In general we model the change (or growth) in incomes, poverty and inequality, conditioning on initial (1991) level of the dependent variable and the growth and initial levels of both soy and other crops, and other control variables. The initial level of the dependent variable, say poverty, captures all variables (even unobservables) that mattered for determining poverty in 1991. Thus if that region just has more poverty for some unobservable reason, as long as it caused higher poverty in 1991 as well, this variable should control for it (somewhat like a 'fixed effect').

The initial level of soy captures the *level* effect of soy on the subsequent change in poverty; in other words, do MCAs that have more soy initially tend to experience increases or decreases in poverty over the next 9 years? If so, the observed relationship could be either due to a time series (causal) relationship between soy and poverty (i.e. as those areas with more soy, the soy activity actively changed poverty levels over the subsequent period), or a (spurious) cross sectional relationship (i.e. soy initially established itself in areas with greater poverty, which subsequently had higher reductions in poverty for other reasons).

In order to partially address the problem of potential spurious cross sectional relationships we introduce a second soy-related control variable, a dummy for whether the MCA had *any* soy in 1991. If there are some unobservable variables that are correlated with both the evolution of poverty and the likelihood of having soy acreage in 1991 (for example, proximity to certain infrastructure or particularly well functioning property rights), that would otherwise have created a spurious correlation between the level soy variable and our dependent variable, these will be controlled for by the Soy Dummy. The inclusion of the soy Dummy as a control alters the interpretation of the coefficient on the level soy variable; now it is that *among the MCAs that already had soy in 1991*, those areas that had greater initial proportion of soy experience greater (or lesser) change in poverty over the subsequent period.

The third soy variable we include is the growth of soy area. The correlation between this third growth variable and the growth of the dependent variable should better capture a time-series effect (although this is a cross section regression); specifically the measured correlation captures whether, ceteris paribus, when soy acreage increases faster in an MCA, does poverty also change faster in that MCA? It is possible that this could be driven by a spurious cross sectional correlation, but since the levels of the variables are already controlled for, it is a much harder case to make. Thus we have more confidence that correlation between two growth rates is more likely to be representative of a within-MCA time series relationship between soy acreage and poverty.

Our basic estimating equation thus takes the form:

$$gY_{it} = \alpha + \beta Y_{it-1} + \delta_1 S_{it-1} + \delta_2 D_S + \delta_3 gS_{it} + \sum_k \lambda_k X_{kit-1} + \varepsilon_{it}$$

Where *gY* is the growth of the outcome variable (povery, inequality, GDP, either rural or urban), *X* is a vector of *k* control variables, *S* is our measure of soy acreage (in logs), D_S is the dummy variable for soy in 1991, and *gS* is the growth of our soy variable[5]. The set of control variables (in log-levels and or changes or growth rates where noted) include total area of the MCA, latitude (a measure of climate), total area in agricultural establishments, area in pasture, total area in other annual crops (besides soy), total area in permanent crops, urban and rural population, and state dummy variables.

For robustness we then explore a number of alternative specifications and control variables as discussed below. As much of the recent explosive growth in soy acreage has taken place in the Amazon we also investigate whether the socio-economic impacts there could take a different form from the rest of Brazil.

3. Econometric Results

3a. All Brazil

Table 2 presents our baseline results for the effect of soy acreage on the rural changes in poverty, inequality, median household income and GDP from 1991 to 2000 through all of Brazil. In regression (1) the level soy variable is negative for poverty, suggesting that, ceteris paribus, those municipalities (MCAs actually, but

[5] Note that the regression maps out a nonlinear relationship between soy and the outcome variable.

we refer to them now as municipalities as it is easier to read) with greater soy acreage in 1991 saw greater reductions in poverty over the subsequent 9 years. There were also strong gains in median household income (regression 3) and GDP (regression 4). However the effect on inequality in regression 2 is positive; those same municipalities saw inequality increase.

Taking into account the growth of soy variable complicates the picture. The growth of soy is *positively* correlated with change in rural poverty; ceteris paribus greater growth of soy is associated with greater (increase) in poverty, also greater inequality and no statistically significant impact on median incomes or GDP. While it seems there is an unambiguous positive correlation between soy expansion and increased inequality, independently it is harder to interpret these coefficients in the poverty regression; those municipalities that started with larger acreage of soy may very well have experienced less growth due to saturation effects. Taken all together the net effect of soy on poverty will vary from municipality to municipality, depending on how large the subsequent growth (increasing poverty) was compared to the initial level (decreasing poverty). Doing the sums, we find that across Brazil as a whole the distribution of the total net effect (total of all three soya related variables) on the change in rural poverty for MCAs that grew some soya at some point in the sample period has a median of -0.0217 and a mean of -0.0205. Overall, the average total effect on poverty is negative in 954 out of 976 MCAs.

The results presented in table 2 only consider the socio-economic effects of soy cultivation within a particular municipality. However, Fearnside (2001) and others have claimed that one of the mechanisms through which the introduction of soy increases poverty is through the displacement of small landowners. If true, these (now poorer) internal migrants might move to a different municipality and not register as an increase in their home-municipality's poverty rate. As we do not have data on individual landowners and their movements we cannot check this directly. Nevertheless we can check to see whether increases in soy acreage in neighboring areas has an impact on municipalities that themselves have no soy. Specifically, we calculate a weighted average of soy acreage in an municipality's five closest neighbors. We then examine the impact that neighborhood soy acreage has on socio-economic outcomes in our sample of municipalities that themselves have no soy. The results of this exercise are presented in Table 3. In regressions (5), (6) and (7) we see that those soy-less municipalities whose neighbors have greater acreage of soy have lower rural poverty rates, higher rural inequality and higher rural median household income; in other words, the same direction of association that within-municipality soy had with these indicators[6]. In sum, while we cannot rule out longer-range out-migration of the displaced, we find no evidence that

---

[6] The spatial impact on urban poverty, median household income and urban inequality was not statistically significant. The effect on rural GDP was not statistically significant but the effect of greater spatial soy on urban GDP was positive and significant, results available upon request.

increased soy in neighboring municipalities increases poverty or incomes in the home region (although there is some impact on inequality, as at home).

There are several alternative interpretations of the spatial results. If we take them at face value, these results suggest that our coefficients of the effects of soy on local socio-economic outcomes may be under-estimated; the 'control' set with no soy benefits from spillover effects and thus provides a poor counterfactual. On the other hand, there could also be some related omitted variables associated with the soy that have strong and far-ranging spatial socio-economic effects themselves, such as enhanced infrastructure, that could be driving the outcomes. In other words, perhaps it is not soy itself *per se*, but rather a whole package of infrastructural, institutional and economic changes that are more causally related to our outcomes of interest. Indeed, we should keep in mind that this is in fact what many of soy's critics are claiming; not that there is something necessarily bad about the crop itself, but rather with the way it is cultivated and all the associated changes that accompany the arrival of 'big soy' to an area.

3b. Legal Amazonia

As discussed above, much of the recent concern about soy is due to its explosive growth in the Brazilian Amazon where the potential environmental effects, such as direct or indirect deforestation, could be significant. Furthermore, there are number of reasons to suspect that the recent socio-economic impact of soy in the Amazon could be different than in the south of Brazil. In the first case the initial conditions - the climate and soil quality, the protection (or lack thereof) of property rights, the accessibility of newly converted and forest land, the degree of existing poverty and extent of small land holders - are all very different. Saturation effects should be much more limited. Second, the introduction and growth of soy in the Amazon has been very rapid, and the exponential expansion has been fueled by export and trade rather than by domestic demand.

In order to focus on the impact of soy in Legal Amazonia in Tables 4, 5 and 6 we re-do our analysis using only the sample of 253 MCAs (municipalities) of that region. Table 4 presents the poverty results and we note several important differences from the All-Brazil regressions. First, our soy dummy is positive and significant for change in rural poverty. In other words, in the cross section, those municipalities that had at least some soy production in 1991 experienced *increases* in poverty over the subsequent 9 years compared to those who had no soy in 1991. We not know *why* this is; but it suggests that either soybean production does in fact increase poverty, or that there may be significant unobservable (omitted) factors that are correlated both with poverty and with the presence of soy, and thus whose omission (in the absence of the soy dummy) could create an omitted variable bias in the correlation between soy and poverty.

However the coefficient on the log-level soy variable is *negative*; although those municipalities with soy in 1991 had, on average, increases in poverty compared to those that didn't (the soy dummy), among those with soy those that had larger proportions of crop area planted in soy saw poverty *fall* further. This is not consistent with a story in which soy itself is causing the increase in poverty captured by the soy dummy, reinforcing the interpretation of the soy dummy coefficient as capturing omitted cross sectional unobservables. Indeed, in all but three Amazonian municipalities the net effect of soy on change in poverty is negative. Further more, in regression (10) we look at the impact of soy on *urban* poverty rates and find no statistically significant effect. This gives us additional confidence that in regressions (8) and (9) we are indeed capturing a rural effect of soy, not just a spurious, general trend in regional poverty.

The coefficient estimates on the growth of soy on rural poverty are positive but not statistically significant. The combination of a positive (in magnitude) coefficient and high standard error suggests that there may be some areas in which growth of soy and increases in poverty are occurring simultaneously, whereas in others the opposite relationship prevails. Any observer of either type of location could come away with a strong impression of a soy-poverty link, even if that relationship does not hold as generally as they might think.

Regressions (11)-(13) in Table 5 look at inequality and soy in the Amazon. Consistent with the results for all Brazil, we find that both the log-level and growth of soy are correlated with increased rural inequality, although the former are not statistically significant and the latter only marginally so (at the 10% level).

Finally, in table 6 we look at the association between soy production and incomes. We find that both levels and changes of soy are positively and significantly correlated with increases in median rural household income, but not with median urban household income. Both soy variables are also strongly positive and statistically significant for both rural and urban total GDP (*per capita*, as we are controlling for rural and urban population).

Agricultural and other economic activity is not independent across space; municipalities near to each other may share a common climate and geography and markets are linked. As we are modelling growth and changes the potential spatial correlation is less than in levels, but we cannot ignore the possiblity. In regressions (9)-(17) then we report Moran-I statistics for spatial correlation of the residuals (using a spatial weighting matrix which weights the five closest neighbors according to distance). The Moran-I statistic ranges from -1 to 1 where 0 is no spatial correlation and 1 is perfect positive spatial correlation. A low p-value (reject the null of MI=0) thus implies the presence of spatial correlation. We find no evidence of spatial correlation in the models of rural and urban poverty change (9 and 10), urban inequality change(13), or median rural income growth (14), but weak evidence for rural inequality change (11), median urban income growth (15) and urban GDP growth (17). Finally , we find strong evidence of spatial correlation in the model of rural GDP growth. In tables 7 and 8 we repeat the main regressions, including a spatially lagged dependent variable. The results for the spatial lag and key soy-related explanatory variables are found in regressions (18)-(25); we find that the basic results on the soy variables are not changed. Looking at the Moran-I statistics for the residuals, we find that including the spatial lag eliminates the spatial correlation (of the variety tested for!) for the change in rural inequality (regression 20). However the other weak effects (regressions 23 and 25) remain, and there is still strong evidence of spatial correlation in the model of growth of rural GDP (model 24). In this latter model, the evidence suggests that spatial correlation is true residual correlation; the spatial lag of the dependent variable carries almost no explanatory power or statistical significance. With spatial correlation in the residuals, the standard errors in model (16) may be biased (and the coefficients could be biased as well in model 24 as we have included a lagged spatial dependent variable in the presence of spatial correlation of the residuals), so some caution exercised in interpreting these results. Nevertheless, especially for the other models, we find it reassuring that the main results on the soy variables are robust to the inclusion of the spatial terms.

Table 9 provides a concise summary of the primary quantitative results. In sum, we find that the relationship between soy and socio-economic outcomes is heterogeneous; the patterns that prevail across the whole Brazilian sample are not replicated in Legal Amazonia. Controlling for spurious cross sectional correlation between soy location and incomes, we find no robust evidence that increased soy cultivation increases poverty within an MCA; to the contrary our evidence suggests that if anything poverty declines. We do find increased soy cultivation is associated with increased rural income inequality in both the full sample as well as the Amazon-only sample, but the relationship is only marginally statistically significant in the latter sample. Finally, in both samples, even controlling for total agricultural area and crop composition, increases in soy cultivation are associated with strong increases in rural median household income and rural GDP per capita. This overall income effects are especially strong in the Amazon sample, where we find both level and growth effects for rural median household income and GDP, and for urban GDP as well.

4. Qualitative Fieldwork

Initial fieldwork has been conducted in the Santarém region of Pará state (see Figure 1). The region has been chosen for fieldwork because it offers a microcosm of some of the central issues surrounding increased soybean cultivation including economic, political and environmental factors. It is of particular interest because of its recent history in relation to the soy industry. Specifically a port for the international export of soy was opened by Cargill in 2003. While large-scale agriculture has been used in the area since the influx of migrants linked to the construction of the Trans-Amazonian highway in the 1970s, the period since the port's opening has seen a large increase in the production of both soy and rice. This increase has been associated with various social and political changes in the area.

Figure 1: Fieldwork site

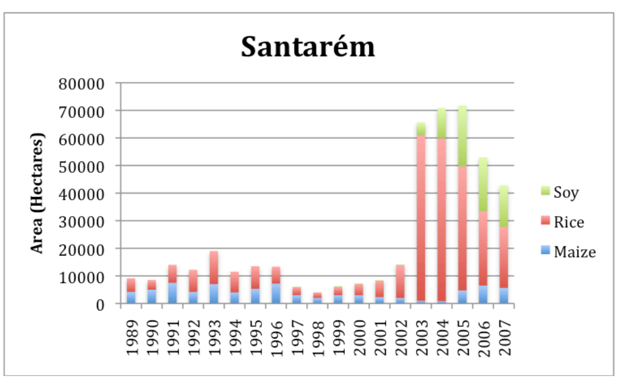

Figure 2: selected crop output in Santerem

The key to ethnographic research is a long term engagement with individuals and groups and a flexible use of different methods in order to uncover the underlying pattern and logic of people's decisions and behaviour. Fieldwork was conducted for four months in 2009 in a rural community, Belterra, in the Santarém region using participant observation with local people supplemented by formal and semi-formal interviews with individuals related to the soy industry. The population under study included recent newcomers to the region who were mainly focused on large-scale agriculture, and older populations that had a variety of livelihoods, including both small and large-scale agriculture and private and state employment, as well as the unemployed and retired.

An effort was made to seek out different members of society according to age, ancestry and socio-economic status, with interviews focused explicitly on attitudes to the environment, local development, agriculture and government policies. Qualitative information from the interviews about the local land issues and development was supplemented through the use of GPS data on landholdings and, where possible, the discussion of such data with interviewees.

4b. Preliminary Ethnographic Findings

The primary aim of Cargill's port was to provide an alternative export option for large-scale soy farmers in the state of Mato Grosso. The port's development was linked to a government-backed project to pave the BR-163 that runs from Cuiabá to Santarém. As this project has stalled for various economic and political reasons Cargill has been keen to promote the production of soy and rice in the immediate Santarém region in order to make use of the new facilities.

The incentives offered by Cargill, as well as loans from the regional development bank, Banco da Amazônia, local political encouragement[7] and the availability of relatively cheap land encouraged farmers from southern Brazilian states to move to the area. Fisher (2007) notes that the federal government deliberately targeted immigrants from southern Brazil in the belief that "their previous technical and administrative experience would allow them to transform financial resources into 'physical capital' of the kind desired by planners" (Fisher 2007:352). Indeed, soy is a relatively expensive crop to grow, needing a high level of investment in fertilizers, pesticides and machinery - it is generally held that it is not economically viable to grow soybeans on plots of less than 500 hectares. This means that while many local existing residents and landowners have been interested in, or attempted to, grow soy they have seldom found it to be profitable. On the other hand, newly arrived migrants from the South, with significantly greater financial resources, have been very successful farming soy.

However families from the southern Brazilian states tend to be of North European heritage and their physical appearance and cultural practices tend to differ from the older local populations whose ancestry includes elements from indigenous Amazonian, Southern European and African (via Brazil's Northeast region) populations. These differences are noted and often commented on by members of both groups in the region. More than physical distinctions, individuals tend to emphasise the cultural differences that exist in the working and social practices of the two groups. One focus is on the distinctions between homes and living styles.

---

[7] A previous Mayor of Santarém, Lira Maia (an agronomist), started to encourage the growing of soy in the region from as early as 1997.

While local populations tend to have smaller houses and spend more time sitting outside them in their surrounding grounds, immigrants from the south bring a particular style of large house, with surrounding verandas that provide privacy from the outside. Local old-timers self-portray themselves as very sociable in comparison to the southern new-comers. However people from the South tend to portray such sociability as a form of laziness that they contrast with their own work ethic. Such tensions obviously link to older histories of colonialism, as well as the relative separation of the Amazonian region from the rest of Brazil. They are also linked to the relative wealth of individuals and families coming from the South.

These differences play out in both physical and cultural features of the two populations, and in the current context the fieldwork found that these tensions tended to find a particular expression around the issue of increased soybean cultivation. Even as local residents found employment on these larger farms or benefited from their custom, the underlying racial and political tensions continued to feed animosity. These feelings have also been encouraged by the local media, religious groups, and local and international NGOs. For example, an article in a local paper in Santarém describes confrontations between incoming soy farmers and 'local' Santarém populations during a demonstration organised by Greenpeace against soybean farming. It reports one of the farmers as saying 'we who are coming here are bringing development for you, you are indians, stupid and lazy'[8] (*Gazeta de Santarém* - 24 May 2006).

5. Concluding remarks

Even as our data shows the rise of median incomes and local GDP associated with soybean production and, most importantly, a lowering of poverty levels, it also supports the view that increased soy production increases inequality. This appears to be linked to our qualitative observation, noted above, that soybean production in Legal Amazonia is mostly controlled by wealthy land-owners on large farms and hence it is them that get the largest benefits from increased production. Thus, even as all levels of local populations benefit economically from the growth of soybean production, large landowners accrue relatively more gains.

From our field observations it appears that it is local perceptions of this growing inequality that fuel much of the opposition to the increase in large-scale soy farming in the Amazon region. We believe that the emphasis on inequality is linked to other social and political factors, and in particular the fact that most large-scale farmers are immigrants to the region from the south of the country. In the context of our quantitative findings, these tensions help to explain some of the continued animosity felt towards soybean cultivation even as its appears to have the effect of lowering poverty levels.

---

[8] 'nós que estamos vindo aqui trazer desenvolvimento pra vocês, vocês são índios, burros e preguiçosos'

These issues are of particular importance in light of current discussions about the role that various deforestation reduction schemes, including carbon trading schemes and international payments for environmental services, might play in the future protection of the forests. In calculating future payments for forest protection, not only must the services of the standing forest be considered but also the lost opportunity costs of using its land for other purposes. In such situations clear understandings of the economic and social benefits and costs of land use in the Amazon will be of vital importance.

Indeed, our ethnographic research turned up qualitative evidence on the extent to which current government moves against large-scale agriculture is having an impact on the fortunes of small landholders. Specifically, one farmer, Alfredo Wagner, who came to the area in 2003 and was cited in Cargill literature at the time as calling soy ‘gold’ and talking of the benefits of agriculture for his family. However when he was contacted in the summer of 2009 in the context of our fieldwork, his fields were empty. The soy embargo had worked not only on soy but other crops; he had been unable to plant because of the lack of loans. He was now ill with cancer and two of his children had abandoned the family land, taking up jobs in the local municipal government in order to pay for his medical bills and keep the family together.

Tables

Table 1: Increase in Area of Soybean Cultivation and Percentage change in domestic price of soy

Year	Soybean Area, total (Hectares)	% change in soy area	% change in domestic soy price (time of marketing)
1980	8,774,023		-
1990	11,487,303	0.31	-
1999	13,061,410	0.14	9.9.
2000	13,656,771	0.05	7.6
2001	13,985,099	0.02	-7.4
2002	16,359,441	0.17	15.4
2003	18,524,769	0.13	42.8
2004	21,534,868	0.16	26.3
2005	22,948,874	0.07	-
2006	22,047,349	-0.04	-
2007	20,565,279	-0.07	

source: author's own calculation from Instituto Brasileiro de Geografia e Estatística, Pesquisa Agrícola Municipal (IBGE/PAM)

Table 2: Soy and Rural social indicators, All Brazil

Dep Var:	(1) Change in rural poverty rate, 1991- 2000	(2) Change in Theil index of inequality rural 1991- 2000	(3) Growth of median hh income, rural 1991-2000	(4) Growth of real GDP, rural 1991-2000
Rural poverty rate 1991	-0.411*** (-21.4)			
Theil index, rural 1991		-0.867*** (-39.8)		
Log median hh income, 1991			-0.532*** (-26.8)	
Log GDP, rural 1991				-0.926*** (-68.6)
Log(area)	0.012*** (2.6)	0.018** (2.25)	-0.038*** (-2.65)	-0.223*** (-6.18)
Latitude	0.012*** (10.4)	-0.005** (-2.04)	-0.045*** (-10.8)	-0.042*** (-5.87)
Log(population), rural 1991	0.015*** (3.39)	0.002 (0.251)	-0.051*** (-4.62)	0.204*** (8.88)
Log(population), urban 1991	-0.001 (-0.75)	-0.003 (-0.77)	0.028*** (4.98)	0.143*** (12.4)
Dummy for soya in 1991	**-0.007 (-0.65)**	**-0.041* (-1.9)**	**0.006 (0.183)**	**0.089* (1.79)**
Log(area in soya), 1991	**-0.003* (-1.75)**	**0.014*** (3.88)**	**0.015*** (2.92)**	**0.049*** (6.2)**
Log(area in other temp crops) 1991	-0.007*** (-3.58)	0.002 (0.579)	0.008 (1.48)	0.163*** (11.4)
Log(area in perm crops) 1991	-0.009*** (-10.3)	-0.003* (-1.91)	0.022*** (8.02)	0.081*** (13.7)
Log(area in pasture) 1991	-0.023*** (-6.46)	0.001 (0.129)	0.031*** (3.26)	-0.147*** (-7.13)
Log(total establishment area) 1991	0.025*** (3.86)	-0.003 (-0.25)	-0.021 (-1.04)	0.64*** (13.1)
Change in soya area, % 1991-2000	**0.119** (2.5)**	**0.167* (1.8)**	**-0.002 (-0.015)**	**0.244 (1.07)**
Change in other temp. crop area, % 1991-2000	-0.057*** (-3.27)	0.031 (1.03)	0.196*** (3.4)	0.812*** (5.98)
Change in perm. crop area, % , 1991-2000	-0.058 (-1.43)	0.079 (1.08)	0.343*** (2.81)	1.85*** (5.53)
Change in pasture area, %, 1991-2000	-0.007 (-0.401)	-0.019 (-0.704)	-0.073 (-1.48)	-0.226*** (-2.61)
Change in establishment area, %, 1991-2000	-0.004 (-0.488)	-0.0075 (-0.599)	0.025 (0.986)	0.159*** (3.53)
Growth of population, urban				0.186*** (3.13)
Growth of population, rural				0.27*** (5.17)
Nobs	3585	3585	3585	3585
R-squared	0.4744	0.4851	0.4119	0.8677

Please note: all regressions include state dummies (not shown). Robust t-statistics in parentheses

Table 3: Spatial spillovers of soy, all Brazil

Dep Var:	(5) Change in rural poverty rate, 1991- 2000	(6) Change in Theil index of inequality, rural 1991- 2000	(7) Growth of median hh income, rural 1991-2000
Rural poverty rate 1991	-.409*** (-14.2)		
Theil index, rural 1991		-.882*** (-35.4)	
Log median hh income, 1991			-.53*** (-21.7)
Extent of Spatial (Neighborhood) Soy, 1991	**-0.144**** **(-2.05)**	**.164**** **(2.53)**	**.537***** **(3.1)**
Log(area)	.010** (2.1)	.0171** (2.02)	-.0402** (-2.55)
Latitude	.015*** (10.1)	-.00399* (-1.66)	-.0493*** (-10.3)
Log(population), rural 1991	.012** (2.08)	.005 (.718)	-.0383*** (2.91)
Log(population), urban 1991	.000 (.0245)	-.000803 (.21)	.028*** (4.33)
Log(area in other temp crops) 1991	-.007*** (-3.2)	-.000306 (-.09)	.0054 (.873)
Log(area in perm crops) 1991	-.008*** (-7.48)	-.00122 (-.713)	.0213*** (6.88)
Log(area in pasture) 1991	-.023*** (-5.15)	.00646 (1.11)	.0374*** (3.37)
Log(total establishment area) 1991	.025*** (3.21)	-.0101 (.852)	-.0262 (-1.18)
Change in other temp. crop area, % 1991-2000	-.047** (-2.33)	-.00038 (.012)	.13** (2.09)
Change in perm. crop area, % , 1991-2000	-.059 (-1.27)	.0406 (.561)	.282** (2.07)
Change in pasture area, %, 1991-2000	-.007 (-.424)	-.0348 (1.22)	-.102* (-1.92)*
Change in establishment area, %, 1991-2000	.001 (.113)	.00495 (.362)	.0327 (1.19)
N. Obs	2612	2612	2612
R-sq.	.480	.517	.431

Please note: all regressions include state dummies (not shown).
Robust t-statistics in parentheses

Table 4: Soy and Poverty, Legal Amazonia

	(8) Change in Rural Poverty 1991- 2000	**(9) Change in Rural Poverty 1991-2000**	**(10) Change in Urban Poverty 1991-2000**
Rural poverty rate 1991	-0.456*** (-4.3)	-0.403*** (-3.31)	
Urban poverty rate, 1991			-0.429*** (-7.38)
Log(area)	0.003 (0.508)	0.007 (1.08)	-0.008 (-1.44)
Latitude	0.006*** (2.01)	0.005 (1.55)	0.004 (1.27)
Log(population), rural 1991	-0.001 (-0.0668)	0.003 (0.23)	0.013 (1.44)
Log(population), urban 1991	0.001 (0.132)	0.007 (1.03)	-0.023*** (-3.81)
Dummy for soya in 1991	**0.075*** (2.01)**	**0.077** (2.13)**	**0.009 (0.248)**
Log(area in soya), 1991	**-0.018*** (-2.85)**	**-0.017*** (-2.7)**	**-0.003 (-0.476)**
Log(area in other temp crops) 1991		-0.005 (-0.87)	-0.006 (-1.62)
Log(area in perm crops) 1991		-0.009** (-2.06)	0.000 (0.121)
Log(area in pasture) 1991		-0.004 (-0.923)	-0.006 (-1.22)
Log(total establishment area) 1991		0.006 (0.621)	0.020** (2.21)
Change in soya area, % 1991-2000	**0.345 (0.753)**	**0.054 (0.117)**	**-0.366 (-0.679)**
Change in other temp area, % 1991-2000		-0.104 (-1.24)	-0.027 (-0.313)
Change in perm area, % 1991-2000		-0.042 (-0.0475)	0.053 (0.0611)
Change in pasture area, % 1991-2000		-0.106 (-1.37)	0.016 (0.265)
Change in establishment area, % 1991-2000		0.027 (0.92)	0.009 (0.273)
Nobs	254	253	253
R-squared	0.5120	0.5448	0.4421
Moran-I of residuals		-0.042 p-value=.155	-0.031 p-value =.236

Please note: all regressions include state dummies (not shown).
Robust t-statistics in parentheses

Table 5: Soy and Inequality, Legal Amazonia

Dep Var:	(11) Change in Theil index of inequality, rural 1991- 2000	(12) Change in Theil index of inequality, rural 1991- 2000	(13) Change in Theil index of inequality, urban 1991-2000
Theil index, rural 1991	-0.872*** (-10.6)	-0.906*** (-11)	
Theil index, urban 1991			-0.87*** (-15.3)
Log(area)	0.026** (2.34)	0.0501*** (2.7)	0.04*** (2.95)
latitude	0.003 (0.642)	0.001 (0.113)	-0.007 (-1.38)
Log(population), rural 1991	-0.042 (-1.26)	-0.038 (-1.14)	-0.032** (-2.04)
Log(population), urban 1991	0.020 (0.785)	0.021 (0.801)	0.034*** (3.84)
Dummy for soya in 1991	**-0.093 (-0.918)**	**-0.091 (-0.892)**	**-0.066 (-1.01)**
Log(area in soya), 1991	**0.015 (1.1)**	**0.016 (1.2)**	**0.019* (1.83)**
Log(area in other temp crops) 1991		-0.005 (-0.332)	-0.006 (-0.802)
Log(area in perm crops) 1991		0.003 (0.257)	0.009 (1.58)
Log(area in pasture) 1991		0.0296** (2.34)	0.002 (0.185)
Log(total establishment area) 1991		-0.060*** (-2.76)	-0.026 (-1.36)
Change in soya area, % 1991-2000	**4.93* (1.83)**	**5.13* (1.85)**	**-0.863 (-0.9)**
Change in other temp area, % 1991-2000		-0.183 (-0.976)	0.29 (1.24)
Change in perm area, %, 1991-2000		-0.597 (-0.26)	-3.6 (-1.27)
Change in pasture area, % , 1991-2000		0.0719 (0.414)	0.204* (1.8)
Change in establishment area, %total, 1991-2000		-0.0321 (-0.513)	-0.117* (-1.69)
Nobs	254	253	253
R-squared	0.3070	0.3202	0.6013
Moran-I of residuals		-0.061 p-value=.042	0.007 p-value=.385

Please note: all regressions include state dummies (not shown).
Robust t-statistics in parentheses

Table 6: Soy and Incomes, Legal Amazonia

Dep Var:	(14) Growth of median hh Inc, rural 1991-2000	(15) Growth of median hh Inc, urban 1991-2000	(16) Growth of real GDP, rural 1991-2000	(17) Growth of real GDP, urban 1991-2000
Log(median hh income), rural 1991	-0.383*** (-3.81)			
Log(median hh income),urban 1991		-0.541*** (-8.41)		
Log(GDP), rural 1991			-1.02*** (-15)	
Log(GDP), urban 1991				-0.918*** (-7.03)
Log(area)	-0.007 (-0.216)	0.054** (2.41)	-0.072 (-1.27)	0.011 (0.248)
latitude	-0.003 (-0.252)	-0.015 (-1.54)	-0.010 (-0.419)	-0.009 (-0.444)
Log(population), rural 1991	-0.046 (-0.824)	-0.038 (-1.24)	0.496*** (5.66)	0.227*** (3.06)
Log(population), urban 1991	0.020 (0.587)	0.093*** (5.23)	0.117* (1.93)	0.812*** (6.04)
Dummy for soya in 1991	**-0.239 (-1.58)**	**-0.036 (-0.319)**	**-0.544** (-2.31)**	**-0.574*** (-2.68)**
Log(area in soya), 1991	**0.043* (1.82)**	**0.024 (1.29)**	**0.12*** (2.93)**	**0.111*** (2.99)**
Log(area in other temp crops) 1991	-0.006 (-0.264)	-0.003 (-0.178)	0.002 (0.0702)	-0.089*** (-3.08)
Log(area in perm crops) 1991	0.032* (1.69)	0.018 (1.6)	0.042* (1.72)	0.041** (1.98)
Log(area in pasture) 1991	0.035* (1.67)	0.015 (0.822)	0.128*** (3.2)	-0.039 (-0.819)
Log(total establishment area) 1991	-0.035 (-0.799)	-0.077** (-2.14)	0.3*** (3.58)	0.0291 (0.352)
Change in soya area, % total 1991-2000	**6.11** (2.01)**	**1.24 (0.885)**	**8.18** (2.38)**	**3.99** (1.99)**
Change in other temp area, % total 1991-2000	0.26 (0.646)	0.48 (1.23)	0.844 (1.17)	-0.523 (-1.01)
Change in perm area, % total, 1991-2000	2.98 (0.826)	-2.68 (-0.745)	-1.67 (-0.261)	18*** (2.91)
Change in pasture area, % total, 1991-2000	0.205 (0.693)	0.236 (1.32)	0.223 (0.402)	-0.249 (-0.896)
Change in establishment area, %total, 1991-2000	-0.049 (-0.384)	-0.138 (-1.22)	0.072 (0.284)	0.12 (0.743)
Growth of urban population, 1991-2000			0.09 (0.618)	0.842*** (5.99)
Growth of rural population, 1991-2000			0.191 (1.53)	0.132* (1.65)
Nobs	253	253	253	253
R-squared	0.4598	0.4853	0.8822	0.8479
Moran-I of residuals	-0.040 pvalue=.167	-0.058 p-val= .076	0.161 p-val: 0.00	0.038 p-val: 0.124

Please note: all regressions include state dummies (not shown). Robust t-statistics in parentheses

Tables 7 and 8: Soy and Incomes, Legal Amazonia, with spatial lag

Dep Var:	(18) Change in Rural Poverty 1991-2000	(19) Change in Urban Poverty 1991-2000	(20) Change in Theil index of inequality, rural 1991-2000	(21) Change in Theil index of inequality, urban 1991-2000
spatial lag of dep. variable	-0.272** (-2.34)	-.351*** (-3.1)	-.295* (-1.82)	.0996 (1.18)
Dummy for soya in 1991	0.070 (2.07**)	.0167 (.491)	-.0931 (-.969)	-.0666 (-1.02)
Log(area in soya), 1991	-0.017 (-2.88***)	-.0032 (-.559)	.0184 (1.45)	.0187* (1.82)
Change in soya area, % total 1991-2000	0.312 (0.71)	-.464 (-.941)	5.11** (2.04)	-.785 (-.805)
Nobs	253	2553	253	253
R-squared	.5566	.4621	.3346	.6035
Moran-I of residuals	0.014 p-val= .310	0.045 p-val=.093	-0.002 p-val=.474	-0.023 p-val=.301

Please note: all regressions include state dummies + other regressors from tables 4 and 5 (not shown) . Robust t-statistics in parentheses

Dep Var:	(22) Growth of median hh Inc, rural 1991-2000	(23) Growth of median hh Inc, urban 1991-2000	(24) Growth of real GDP, rural 1991-2000	(25) Growth of real GDP, urban 1991-2000
spatial lag of dep. variable	-.307* (-1.82)	-.151 (-1.47)	.124 (1.41)	-.0736 (-.779)
Dummy for soya in 1991	-.214 (-1.56)	-.0288 (-.253)	-.548** (-2.32)	-.622** (-2.43)
Log(area in soya), 1991	.0444** (2.15)	.0231 (1.23)	.12*** (2.94)	.118*** (2.7)
Change in soya area, % total 1991-2000	5.29* (1.92)	1.25 (.892)	7.97** (2.31)	4.04* (1.95)
Nobs	253	253	253	253
R-squared	.4717	.4897	.4786	.4178
Moran-I of residuals	0.016 p-val=.293	-0.017 p-val=.361	0.135 p-val=.000	0.046 p-val=.087

Please note: all regressions include state dummies plus other regressors from table 6 (not shown). Robust t-statistics in parentheses

Tables 9: Soy and Incomes in the Amazon, Summary of main quantitative results

Regressor: Dep. Variable:	**Soy dummy**	**Level area of soy**	**Growth of soy area**	**spatial correlation?**
Change rural poverty	positive	negative	no effect	no
Change urban poverty	no effect	negative	no effect	no
Change rural inequality	no effect	no effect	positive	maybe
Change urban inequality	no effect	positive	no effect	no
Growth rural median hh inc.	no effect	positive	positive	no
Growth urban median hh inc.	no effect	no effect	no effect	maybe
Growth rural GDP	negative	positive	positive	yes
Growth urban GDP	negative	positive	positive	maybe

References

Andersen, Lykke E., Clive W. J. Granger, Eustaquio J. Reis, Diana Weinhold and Sven Wunder, 2002, *The Dynamics of Deforestation and Economic Growth in the Brazilian Amazon,* Cambridge UK: Cambridge University Press.

Bickel, Ulrike & Jan Maarten Dros, 2003, *The Impacts of Soybean Cultivation on Brazilian Ecosystems,* WWF Forest Conversion Initiative.

Brandão, A.S.P., Gervásio Castro de Rezende and Roberta Wanderley da Costa Marques, 2005, *Agricultural Growth In The Period 1999-2004, Outburst In Soybeans Area And Environmental Impacts In Brazil,* Rio De Janeiro.

Brown, J. Christopher, Matthew Koeppe, Benjamin Coles and Kevin P. Price, 2005, Soybean Production and Conversion of Tropical Forest in the Brazilian Amazon: The Case of Vilhena, Rondônia, in *Ambio*, Vol. 34, No. 6: 462-469

Brown, L. R. 2004. Outgrowing the Earth: the food security challenge in an age of falling water tables and rising temperatures. New York, NY: W. W. Norton

Diaz, M. del C. V., R. Kaufmann, D. Nepstad, and P. Schlesinger. 2006. Soybean yield in the Amazon Basin: climatic, edaphic, and economic determinants. *Agricultural Economics*

Diegues, Antonio Carlos, 1992, The Social Dynamics of Deforestation in the Brazilian Amazon: An Overview, (UNRISD) Discussion Paper No. 36, July 1992.

Fearnside, P.M., 2001, Can Pasture intensification discourage deforestation in the Amazon and Pantanal regions of Brazil?, in C.H. Wood (ed.), *Patterns and Processes of Land Use and Forest Change in the Amazon*, Gainesville, FL.: University Presses of Florida.

Fisher, William H., 2007, Surrogate Money, Technology, and the Expansion of Savanna Soybeans in Brazil. In *Rethinking Environmental History: World-System History and Global Environmental Change*, edited by Alf Hornborg, J. R. McNeill, and Joan Martinez-Alier. Lanham, MD: Altamira Press. Pp. 345–360

Greenpeace, 2006, *Eating up the Amazon*, London: Greenpeace.

Helfand, S. and L. Brunstein, 2001, "The Changing Structure of the Brazilian Agricultural Sector and the Limitations of the 1995/96 Agricultural Census," *Revista de Economia e Sociologia Rural*, Vol. 39, No. 3, July/Sept., pp. 179-203.

Kaimowitz, David & Joyotee Smith, 2001, Soybean Technology and the loss of natural vegatation in Brazil and Bolivia, in Arild Angelson and David Kaimowitz (eds.), *Agricultural Technologies and Tropical Deforestation,* Wallingford UK: CAB International. Pp.195-211.

Kaimowitz, David, Benoit Mertens, Sven Wunder & Pablo Pacheco, 2004, *Hamburger Connection Fuels Amazon Destruction: Cattle ranching and deforestation in Brazil's Amazon,* Center for International Forestry Research.

López Villar, J., B. Freese, A. Bebb, N. Bassey, C. Améndola & M. Ferreira, 2007, *Who benefits from GM crops?: an analysis of the global performance of GM crops (1996-2006),* Friends of the Earth International

Mueller, C. C. and M. Bustamante. 2002. *Análise da Expansão da Soja no Brazil*. (Analysis of the Expansion of Soybeans in Brazil). (In Portuguese).

Mueller, Charles Curt, 2003, Expansion and modernization of agriculture in the *Cerrado* – the case of soybeans in Brazil's Center-West, Universidade de Brasília, Department of Economics Working Paper 306

Nepstad, D., C. Stickler, B. Soares-Filho, P. Brando, F. Merry.2008. Ecological, economic, and climatic tipping points of an Amazon forest dieback. *Phil. Trans. Royal Society B doi:10.1098/rstb.2007.0036*

Nepstad, Daniel C., Claudia M. Stickler & Oriana T. Almeida, 2006, Globalization of the Amazon Soy and Beef Industries: Opportunities for Conservation, in *Conservation Biology*, Vol.20/6:1595-1603.

Steward, Corrina, 2007, From colonization to ''environmental soy'': A case study of environmental and socio-economic valuation in the Amazon soy frontier, in Agriculture and Human Values, 24:107–122

Warnken, Philip F., 1999, *The Development and Growth of the Soybean Industry in Brazil,* Ames, Iowa: Iowa State University Press

Xavier, M. R. 2007. The Brazilian sugarcane ethanol experience. *Issue analysis* No.3. Washington, DC: Competitive Enterprise Institute.