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Doutorado em Ciências Ambientais

POR UMA AGRICULTURA MAIS SUSTENTÁVEL: PRÁTICAS DE PRODUÇÃO RESPONSÁVEL EM PROPRIEDADES RURAIS PRIVADAS

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Tese apresentada à Universidade Federal de Goiás, como parte dos requisitos do Programa de Doutorado em Ciências Ambientais para a obtenção do Título de Doutor em Ciências Ambientais

Eduardo dos Santos Pacífico

Orientador: Dr. Paulo De Marco Júnior

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ATA DA DEFESA PÚBLICA DE TESE Nº 001/2017

Aos vinte e quatro dias do mês de fevereiro do ano de dois mil e dezessete, às 08:00, reuniu-se na sala 5 (Auditório) do Núcleo Indígena na Universidade Federal de Goiás, Câmpus Samambaia, a Banca Examinadora composta pelos: Prof. Dr. Paulo De Marco Júnior – CIAMB, o Prof. Dr. Laerte Guimarães Ferreira Junior – CIAMB, o Prof. Dr. Rogério Pereira Bastos – CIAMB, o Prof. Dr. Rodrigo Damasco Daud – Laboratório de Ecologia e Funcionamento de Comunidades/UFG, e a Prof.ª Dr.ª Ane Auxiliadora Costa Alencar - IPAM para, sob a presidência do primeiro, proceder a defesa da Tese intitulada: "Por uma agricultura mais sustentável: práticas de produção responsável em propriedades rurais privadas", de autoria de Eduardo dos Santos Pacífico, discente de Doutorado do Programa de Pós-Graduação em Ciências Ambientais (CIAMB), área de concentração em Estrutura e Dinâmica Ambiental. Foi realizada a avaliação oral no sistema de apresentação e defesa de tese de autoria do discente. Terminada a avaliação oral, a Banca Examinadora reuniu-se emitindo os seguintes pareceres mediante as justificativas e sugestões abaixo:

Membro da Banca	Parecer (Aprovado/Reprovado)	Assinatura
Dr. Paulo De Marco Júnior	APROVADO	Paulo De Marco Júnior
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Dr. Rodrigo Damasco Daud	Aprovado	[signature]
Dr.ª Ane Auxiliadora Costa Alencar	APROVADO	Ane Auxiliadora Alencar

JUSTIFICATIVAS e SUGESTÕES:

____

Após a avaliação, o referido candidato foi considerado APROVADO na defesa de tese. Às 12:00 horas, o Prof. Dr. Paulo De Marco Júnior, Presidente da Banca Examinadora, deu por encerrada a sessão e, para constar, lavrou-se a presente Ata.

[signature]
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Prof. Dr. Rogério Pereira Bastos
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Prof. Dr. Paulo De Marco Júnior
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Obrigado ao meu coorientador Dr. Fausto Miziara e aos professores que participaram ativamente de minha formação. Em especial, obrigado Dr. Rogério Bastos e Dr. Rodrigo Daud.

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Namaskar!

Memorial

O objetivo dessa seção é apresentar minha formação além da tese durante o processo de doutoramento. Evidenciar outros pontos que foram trabalhados e desenvolvidos desde o 1º semestre de 2013.

Quando entrei no doutorado estava trabalhando como Analista Ambiental na OSCIP Aliança da Terra no Departamento de Projetos. Tinha como principal função reunir, resumir e analisar as informações geradas pela OSCIP e reportar para nossos financiadores. Dentre minhas funções também estava o auxílio aos trabalhos de campo em contato direto com produtores rurais. Aparentemente teria alguns anos crescendo nessa função.

Foto em viagem de campo em propriedades rurais no Mato Grosso em 2013.

Reunião com produtores rurais e empresa do setor do agronegócio em Rondonópolis (MT).

Porém tudo mudou poucos meses depois de entrar no doutorado quando meu chefe saiu. No rearranjo organizacional foi criado o Departamento de Ciência e Educação e fui nomeado como gerente do departamento. Foi uma conquista e um desafio pessoal inesperado.

Fiquei como Gerente de Ciência e Educação até minha saída da Aliança da Terra em dezembro de 2015. Nesse período coordenei parcerias com diversas instituições científicas, incluindo uma parceria com o laboratório do professor Dr. Daud da Universidade Federal de Goiás, e gerenciei um projeto de conservação de quelônios no Rio das Mortes. Realizamos com sucesso uma campanha de financiamento coletivo para comprar o motor de nossa embarcação.

Trabalho de campo avaliando efeito dos remanescentes de vegetação nativa no controle de pragas em plantações de soja em parceria com UFG.

Equipe de Ciência e Educação da Aliança da Terra.

Soltura de filhotes de quelônios com participação de crianças.

Foi espetacular o aprendizado como gerente na Aliança da Terra, entidade que sou muito grato. Tinha constantemente contato com pesquisadores do mundo inteiro, organizei eventos, contratei uma equipe, a qual tinha a função de gerenciar (3 colaboradores + 1 estagiário + 1 prestador de serviço), elaborei, executei e prestei contas de projetos, recebi cobranças externas e de superiores, passei por turbulências por falta de recursos, e aprendi a liderar.

Porém o grande projeto que mudou a direção de minha carreira foi um projeto de educação em quatro pequenos municípios no interior do Mato Grosso (Novo Santo Antônio, Alto Boa Vista, Bom Jesus do Araguaia e Serra Nova Dourada) chamado O Futuro de Nossas Florestas. Trabalhamos com ensino de serviços ambientais em todas as escolas com os alunos do 1º ao 9º Ano do Ensino Fundamental, totalizando aproximadamente 2.5 mil crianças e jovens beneficiados em dois anos (2014 e 2015). Escrevemos dois livros de divulgação científica e um livro para auxiliar os professores a implementarem o projeto. Também apresentamos as ideias de serviços ambientais para os pequenos produtores rurais. O projeto ficou em 2º Lugar no Prêmio Von Martius de Sustentabilidade da Câmara Brasil-Alemanha em 2015. Esse projeto redirecionou minha carreira profissional, inclinando-me para a educação.

Reunião com Secretário de Educação de Serra Nova Dourada para aprovação do projeto a ser executado nas escolas municipais.

Professores participantes do curso de formação.

Alunos do Ensino Fundamental com livros do projeto.

Aula do projeto O Futuro de Nossas Florestas.

Encerramento das atividades do projeto.

Com Elisa Barreto Pereira recebendo o Prêmio Von Martius de Sustentabilidade da Câmara Brasil-Alemanha da sede da Fiesp.

Aluno com prêmio recebido da Câmara Brasil-Alemanha.

Apresentando o projeto para pequenos produtores rurais em escola rural em Novo Santo Antônio (esquerda) e na câmara dos vereadores em Serra Nova Dourada (direita).

Celebrando com aluno vencedor de desafio do projeto.

(Super parênteses – a Educação)

Sempre tive proximidade com a educação, seja no auxílio de trabalhos voluntários com minha mãe, seja como monitor de acampamento infantil. Essa ligação se aprofundou em 2012 quando me tornei Evangelizador Infantil de um Centro Espírita, e se fortaleceu no projeto O Futuro de Nossas Florestas.

No segundo semestre de 2014, já totalmente envolvido com a área de educação, percebi que poderia usar minhas potencialidades para tentar mudar um pouco essa área. Sempre me entendi como alguém que deveria servir. Gosto de ser útil e fiz escolhas baseado em como poderia dar uma maior contribuição para toda a sociedade. Sou um idealista otimista pragmático.

Em outubro de 2014, junto com meu irmão João Paulo e minha amiga Flávia Pereira Lima, fundamos uma ONG de educação chamada Gaia+. Temos como missão “possibilitar que as pessoas atinjam o máximo de suas potencialidades por meio da educação e da integração entre corpo e mente para construírem um mundo melhor”. Desde o início fui nomeado como Coordenador Pedagógico.

Em fevereiro de 2015 começamos nosso primeiro projeto, denominado Gaia+ Educação, no qual recebemos 64 crianças entre 7 e 11 anos no contra turno escolar. Dentre as minhas funções estavam a elaboração de material de matemática e português e a supervisão dos trabalhos realizados.

Em 2016 assumi a Diretoria da Gaia+ e alcançamos um novo patamar. Dentre as realizações estão: mais de 2 mil crianças e jovens beneficiados e engajados; mais de 350 jovens transformando o bairro onde moram; 130 professores capacitados; criação do Selo Gaia+ Livros para arrecadação de fundos e publicação de 8 livros pelo Selo; trabalho em 4 estados (GO, MT, SC e SP); ampla divulgação, com 2.5 mil seguidores no Facebook e divulgação na mídia com mais de 10 matérias escritas; implementação do Viagem do Bem, método de arrecadação de fundos, no Costão do Santinho (Florianópolis/SC); e reconhecimento pela Secretaria de Justiça e Defesa da Cidadania do Estado de São Paulo como entidade promotora dos Direitos Humanos.

Curso de formação de professores em Ribeirão Cascalheira (MT) em 2016.

Alunos participantes de projeto da Gaia+ Ribeirão Cascalheira (MT) em 2016.

Aula de “1 minuto de silêncio” sobre concentração em Ribeirão Cascalheira (MT) em 2016.

Aula do Gaia+ Cidadania em Florianópolis (SC) em 2016.

Alunos após discussão dos problemas ambientais da cidade de Florianópolis.

Alunos de Goiânia que participaram do projeto Gaia+ Cidadania em 2016.

Trabalho desenvolvido pelos alunos de Goiânia no projeto Gaia+ Cidadania.

Em 2017 executarei o projeto Gaia+ Valores, cujo objetivo é aumentar a felicidade e o bem-estar nas crianças e jovens estimulando e desenvolvendo valores. Trabalharemos com: concentração, trabalho em grupo, perseverança, gratidão, otimismo, empatia e domínio sobre a própria mente. O projeto será realizado em Goiânia, Campos do Jordão (SP) e Florianópolis (SC), com participação de aproximadamente 1.5 mil jovens em vulnerabilidade social.

Sumário

Resumo

A agricultura é o uso dominante na superfície terrestre e os produtores rurais são os principais administradores do solo, entretanto enfrentamos o desafio de promover uma agricultura sustentável. Existem diversas barreiras e nenhum consenso sobre os fatores responsáveis pela adoção de melhores práticas agrícolas. Nós avaliamos centenas de médias e grandes propriedades rurais privadas industriais – fazendas produtoras de commodities que visam a comercialização e utilizam mão de obra assalariada. Todos as propriedades avaliadas são apoiadas pela ONG Aliança da Terra e fazem parte da plataforma Produzindo Certo, um programa voluntário e não punitivo que promove melhores práticas agropecuárias. Utilizando dados primários, nós avaliamos como (1) as características das práticas de produção responsável, (2) as características dos produtores rurais e (3) as características da propriedade rural afetam a adoção de melhores práticas agropecuárias. Encontramos que os produtores rurais se comprometem com práticas obrigatórias por lei, mas executam as práticas mais baratas e com visão de curto prazo. Eles reagem a pressão de sindicatos e associações com melhores práticas ambientais. Produtores mais velhos executam melhores práticas sociais e de produção responsável, enquanto que produtores com maior escolaridade executam melhores práticas sociais. Propriedades maiores e produtores agrícolas têm melhores práticas do que produtores médios e pecuaristas. Concluimos que não devemos utilizar apenas a estratégia de comando e controle, mas também criar incentivos positivos para eliminar as restrições financeiras, apoiar a inovação, reduzir a incerteza (política e financeira) e eliminar a lacuna de informação para se difundir com sucesso uma agricultura mais sustentável.

Abstract

Agriculture is the dominant use on Earth's surface and rural producers are the principal managers of useable lands, but promoting a sustainable agriculture still a challenge. Despite better agriculture practices is an urgent need, there are many barriers and no consensus in the responsible factors to its adoption among farmers. We evaluated hundreds of Brazilian medium to large private industrial rural properties - farms that produces commodities aiming primarily to sell and supported by paid labor. All farms evaluated are supported by NGO Aliança da Terra in the Producing Right platform, a voluntary and non-punitive program to promote better agriculture practices. We evaluated how (1) the characteristics of the Responsible Production practices, (2) the characteristics of the farmer, and (3) the characteristics of the private property affect agriculture responsible production practices adoption. We used primary data. Farmers committed to mandatory Responsible Production practices, even if these practices have high innovation degree and low relationship with productivity, but they executed practices based on finances and shorter planning horizon. Higher market pressure resulted in better environmental practices. Older farmers performed better in social and responsible production practices. Producers with higher schooling executed better social practices. Farmers with larger rural properties and crop producers performed better for sustainable agricultural practices than smaller and livestock producers. Instead of only command and control strategy, we need to create positive incentives to eliminate financial constraints for sustainability, support farmers to be innovators, reduce their uncertainty (political and financial), and eliminate information gap to spread successfully Responsible Production practices.

Introdução Geral

(por Eduardo dos Santos Pacífico, Aline Maldonado Locks e Paulo De Marco Júnior)

Uma viagem de avião entre Cuiabá e São Paulo realizada em 1960 e em 2017 seriam consideravelmente diferentes. Os aviões se tornam maiores, mais rápidos, confortáveis e seguros. Porém outro fator mudou radicalmente: a paisagem observada pelo passageiro. Se em 1960 a paisagem ainda era de exploração inicial no "interior" brasileiro em um país com menos de 71 milhões de habitantes, sendo 2.6 milhões no Centro-Oeste, em 2017 temos imensas áreas consolidadas com uso agropecuário e uma população de aproximadamente 210 milhões, com mais de 15 milhões de pessoas no Centro Oeste (IBGE, 2017). Aproximadamente um terço do território brasileiro foi convertido para a agricultura (Sparovek et al. 2010), criando um conflito direto com outros tipos de usos possíveis, como a conservação de áreas naturais para a preservação da biodiversidade (Quinn, 2013; Tanentzap et al., 2015).

A produção agropecuária tem importância social (empregando mais de 9 milhões de pessoas), ambiental (53% da vegetação nativa está dentro de propriedades privadas) e econômica (IBGE, 2016; Soares-Filho et al., 2014). O Brasil tem condições ideais para o desenvolvimento agrícola, com uma grande área disponível, recursos naturais abundantes e uma população com grande interesse em trabalhar e desenvolver esse ramo, mas devemos saber utilizar esse potencial da melhor forma possível. No momento, existe um esforço mundial no sentido de um aumento da produção de alimentos e o Brasil tem uma posição de importante protagonista nesse cenário. Nessas condições, as pressões sobre a produção agrícola e todas as atividades que se desenvolvem dentro das propriedades agrícolas estão no foco de legisladores, analistas, conservacionistas e mídia.

Para além das questões jurídicas, cabe um questionamento: o que acontece dentro de uma propriedade privada é de responsabilidade explicitamente privada, mesmo que tenham consequências para toda a coletividade? É fato notório que os efeitos das ações dentro de uma propriedade rural extrapolam muito a sua cerca. Tanto as ações positivas quanto as negativas. O alimento produzido na propriedade rural abastece toda a cidade. O emprego garante sustento para a família rural. A proteção à nascente garante água de boa qualidade para a comunidade vizinha. As áreas de vegetação nativa garantem uma boa condição micro climática localmente e podem ter efeitos benéficos regionalmente (Nepstad et al., 2008). Mas os ganhos coletivos que implicam em custos para o produtor não estão incluídos no custo de produção. Por outro lado, o agroquímico empregado na plantação pode ser carregado pelo vento para os vizinhos, pode percolar, atingir o lençol freático e poluir a água, ou pode ser usado de maneira inadequada e contaminar o trabalhador (Foley et al., 2009). Ou também o desmatamento ilegal dentro de propriedades, a perda de conectividade entre áreas de conservação, o uso de áreas frágeis aumentando a erosão e perda de solo geram custos coletivos altos. Assim, de maneira similar, pode se dizer que os custos coletivos relacionados a lucros individuais do produtor também não estão claros nem são calculados. Essa é uma dicotomia difícil de resolver, mas informações sobre a forma como atividades responsáveis ambientalmente são empregadas ajudam a avaliar para que lado pende a balança. Portanto, entender o que está acontecendo dentro das propriedades rurais privadas é de grande importância para toda a coletividade. Não é apenas uma questão local, de importância para a comunidade circunvizinha. Toda a sociedade pode ser afetada pelas ações dos produtores rurais.

O modo de atuação de comando e controle sobre as condutas a serem aplicadas nas propriedades rurais, exclusivamente top-down, com a delimitação de regras, muitas vezes criadas de forma arbitrária, a exigência de seu cumprimento e a penalização caso não obedecidas, embora tenha aspectos salutares, não pode ser a única alternativa (Stickler et al., 2013b; Tanentzap et al., 2015). Esse modo de operação já está desgastado e carece em muitos meios de uma aceitação popular, tornando algumas leis e diretrizes apenas “letra morta”, sem legitimidade social. Assim, embora em alguns aspectos as leis sejam audaciosas e imputam grande responsabilidade aos produtores, nem sempre as leis são compreendidas e/ou seguidas.

Essa grande responsabilidade dos produtores rurais costuma vir como uma cobrança social acompanhada de uma rotulação exagerada. Os produtores rurais ora são os heróis nacionais por produzirem alimentos e riqueza, ora são os vilões por degradarem o meio ambiente. Mas, afinal, quem decidiu que o agronegócio é o grande herói ou o grande vilão? A criação de antagonismos é um recurso amplamente utilizado. Bom e mau. Yin e Yang. Céu e inferno. Mas levar esse antagonismo para a conservação ambiental não é uma saída inteligente, principalmente se você coloca no outro time alguém muito importante para conseguir os seus objetivos. Porém é exatamente isso que fazem os conservacionistas e ao se posicionarem consistentemente condenando os produtores rurais. Pois, para conservar, são necessários os produtores rurais e suas áreas de vegetação nativa privadas, que geram importantes serviços ambientais. Mas também é isso que fazem os produtores rurais, ao rotular e condenar os ambientalistas, perdendo a chance de aprenderem, trocarem experiências e melhorarem suas atividades com o conhecimento ambiental.

Em uma visão simplificada é generalizada a ideia de que haverá um conflito de interesses para o produtor rural. Para ter mais lucro, objetivo das empresas no capitalismo, o produtor rural deve explorar ao máximo seus recursos naturais e a mão de obra, gerando prejuízos ambientais e desconsiderando a conservação ambiental. Contudo, essa visão não é apenas tacanha, mas também ingênua. Obviamente alguns produtores rurais, principalmente aqueles que visam “explorar” a terra, não têm nenhuma preocupação com o aspecto de sustentabilidade temporal de sua atividade pois acreditam falsamente que podem partir para a exploração de outras áreas. Entretanto, essa mentalidade tem cada vez menos adeptos e para grande parte das propriedades rurais industriais atualmente, que detêm considerável área do território nacional privado e, consequentemente, muita área de vegetação nativa, o termo “exploração” está inadequado.

Os produtores rurais estão aprendendo que o segredo para o sucesso é pensar em “manejar”. Saber ter ganhos e ser rentável no presente, mas sem perder a chance de continuar sendo rentável no futuro. Pode ser considerado uma motivação egoísta, mas criar a noção temporal traz enormes benefícios para toda a comunidade.

Obviamente todos os produtores rurais não são iguais. Da mesma forma que todos os ambientalistas não compartilham exatamente as mesmas convicções.

Porém o antagonismo está criado. A guerra entre ambientalistas e produtores rurais está explícita e é amplamente repercutida na mídia. A tendência moderna é acentuar ainda mais a radicalização. Formam-se dois grupos opostos extremos e todos devem escolher um lado. Assim, o produtor rural que teria uma tendência de agir de forma sustentável, em consonância com diversas convicções dos ambientalistas, se vê desamparado em suas ações e forçado a se juntar ao grupo de produtores extremos.

Cabe a nós desfazer esse antagonismo, criando um ambiente favorável a posições não extremas. O objetivo não é ganhar discussões ou ações pontuais (aprovação de uma lei ou uma emenda constitucional). O grande objetivo é proporcionar ao Brasil um crescimento sustentável, solidário e ético. Uma agricultura produtiva, rentável e com respeito ao trabalhador e ao meio ambiente. Para isso, o primeiro passo é disseminar de maneira ampla e irrestrita as práticas sustentáveis nas propriedades rurais brasileiras.

Essa tese tem como objetivo entender quais são os fatores que estão influenciando a adoção das práticas sustentáveis de produção rural nas médias e grandes propriedades rurais. Esse conhecimento, ainda inexplorado no Brasil, servirá de guia para a tomada de medidas efetivas. Queremos entender o produtor rural como parte da solução, e não parte do problema.

No 1º capítulo abordamos quais são as práticas de produção responsável que os produtores rurais tendem a assumir como compromisso e quais são as práticas incorporadas prioritariamente na fazenda. Esse capítulo nos fornece evidências do desgaste da política de comando e controle (ações obrigatórias são prometidas, mas não executadas) e que algumas ações simples de agricultura sustentável podem facilmente e com baixo custo serem implementadas em escala nacional (produtores executam ações de baixo custo, baixa inovação e com retorno direto e na produtividade, mesmo não obrigados pela lei). Outras ações de agricultura sustentável, principalmente as medidas de maior custo e com menor retorno percebido pelo produtor rural, deverão ser alvo de outras formas de incentivo.

No 2º capítulo compreendemos as características dos produtores rurais que influenciam a sua tomada de decisão. A pressão recebida pelos produtores que participam de associações e sindicatos tem efeito positivo nas ações ambientais. Escolaridade do produtor rural está positivamente relacionada com práticas sociais. Produtores mais idosos têm melhores práticas sociais e de produção sustentável.

No 3º capítulo avaliamos como as características das propriedades estão relacionadas com as práticas de agricultura sustentável. Propriedades rurais maiores e agricultores apresentaram melhores resultados de produção responsável do que propriedades rurais menores e pecuaristas, respectivamente, incluindo menor número de passivos ambientais, maior comprometimento em melhorar, maiores taxas de execução de práticas sustentáveis e melhores notas ambientais, sociais, produtivas e totais.

Boa leitura!

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Capítulo 1: Farmers prioritize finances instead of following the Law for sustainable agriculture practices

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Abstract

Rural producers are the principal managers of useable lands, but promoting a sustainable agriculture still a challenge. Considering that there is no consensus in the responsible factors to adoption of sustainable agriculture practices among farmers, we focused on the characteristics of the Responsible Production practices. We collected data from 432 medium to large private rural properties in Brazil. Our dependent variables were commitment to adopt and execution of Responsible Production practices. Farmers committed to mandatory Responsible Production practices, even if these practices have high innovation degree and low relationship with productivity, but they executed practices based on finances and shorter planning horizon, prioritizing practices of lower-cost, lower innovation degree and practices that will bring direct and short term productivity improve, ignoring Law. To spread successfully Responsible Production practices is essential include positive incentives and cooperative approaches to command and control policy and focus in an effective communication.

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Keywords

Command and Control Policy, Positive Incentive, Responsible Production practice, Rural property, Sustainable agriculture.

Introduction

Farmers are the principal managers of useable lands and his/her agricultural practices are responsible to shape Earth`s surface, including effects on biodiversity conservation and ecosystem functions availability (Balmford et al., 2012; Ferreira et al., 2012; D Tilman et al., 2001; Tilman et al., 2002). In the next 50 years we will experience the final human expansion period and, because we will need to produce more food, the societal and environmental consequences of farmers practices will increase in magnitude (Tilman et al., 2001). Rural practices that aim to persevere it`s systems and respect intergenerational equity compose sustainable agriculture practices (Robertson, 2015).

Despite sustainable agriculture is a hot topic present in governments, NGOs, academics and media agenda, it`s difficult to measure and monitor sustainable agriculture in the field (Hayati et al., 2010). Many practices can contribute to achieve a more sustainable production such as Best Management Practices, Wildlife Friendly Farming, Conservation Agriculture, and Integrated Pest Management (Leite et al., 2014). However neither are widely accepted as the best practice nor represent all aspects of sustainable agriculture because in practical aspects sustainable agriculture is controversial, locally specific, dynamic and dependent on temporally and spatially perspective analysis (Hayati et al., 2010). We use the concept of Responsible Production, which is grounded on the tripod environmental conservation, social responsibility and productivity increase and has been successfully applied to hundreds of rural properties in Brazil since 2004. In Responsible Production are analyzed topics related to Native Vegetation (e.g. areas of native vegetation as riparian zones), Soil conservation (e.g. reducing erosion), Pollution control (e.g. proper disposal of waste), Fire (e.g. maintenance of firebreaks), Legal regularization (e.g. obtain all Legal licenses), and Social and labor safety (e.g. deliver and supervise the use of Personal Protective Equipment).

Rural producers agree about the importance of responsible production and place a high value on the importance of all ecosystem services (Smith & Sullivan, 2014). Farmers have a strong relationship with their land and they desire to execute a good administration over their land (Ryan et al., 2003). However, this desire is not necessarily converted into actions of responsible production (Ahnström et al., 2009). Many rural producers are aware of environmental problems, but they do not understand how the practices in his/her rural property (local scale) can contribute to intensify these problems (local, regional and global scales) or they claim financial constraints, and, therefore, are resistant to change their attitudes (Ahnström et al., 2009).

Practices executed by rural producers have tremendous effects in environment, social and productive issues. More than 70% of Brazilian land is private and 53% of all Brazilian native vegetation is inside private properties (Brasil, 2010; Ipea, 2011; Soares-Filho et al., 2014). In addition, rural private properties have lots of employees (in 2006 were 16.5 million people employed in agriculture in Brazil according to official Brazilian data). The rural properties also have a fundamental role in the maintenance of society: the provision of food, fiber and other raw materials. The society charges an impact reduction of the agricultural production system on the environment, with a more efficient and fair production (Godfray et al., 2010). The society aspiration is that rural private properties contribute to biodiversity conservation and ecosystem services maintenance, enable good quality of life with guaranteed rights and opportunities for growth for rural residents, and be highly productive (Millennium Ecosystem Assessment, 2005).

In Brazil, the pressure to farmers adopt Responsible Production practices generates controversy. Rural producers claim that the onus for this change is private, while the benefits are public. The farmers decision-making is carried out under great external pressure of the market, national laws, international agreements, regulations and subsidy programs, society and media (Ahnström et al., 2009). Among the obstacles to practice Responsible Production are included opportunity costs (deforested area could be worth ten times more than areas with natural vegetation), lack of infrastructure and logistics and the dependence of the poor road network (Alexandratos & Bruinsma, 2012). On the other hand, the benefits from private properties such as ecosystem services, are enjoyed by all (Stickler et al., 2013a).

Behind the resistance position of farmers to adopt Responsible Production practices there is a lack of information, because rural producers are simultaneously concerned about the sustainability and are major polluters (Sullivan et al., 1996). Despite the large amount of available content, the communication with rural producers is inefficient. This communication process with relevant information for planning activities should not be a conviction or indoctrination, characterized by one-way flow. Best results are obtained if the communication is interactive and the message is contextualized and specific, balancing complexity and simplicity and following the data, not intuition (Fiske & Dupree, 2014; Ratner & Riis, 2014; Wong-parodi & Strauss, 2014). Awareness is an important first step in communicating about Responsible Production. Nonetheless, awareness is not enough to farmers adopt Responsible Production practices. Rural producers need to be engaged to change behaviors.

The engagement of farmers to adopt Responsible Production practices is complex and cannot be seen as something static, with a particular situation determined by one or more factors, but is a process that occurs with interactions (Siebert et al., 2006). While some factors are more commonly associated with the adoption of Responsible Production practices, there is no single clear standard, with some studies pointing in one direction and subsequent studies pointing in opposite directions (Baumgart-Getz et al., 2012; Knowler & Bradshaw, 2007). The most common and positively factors associated with the adoption of Responsible Production practices are education level, income, property size, access to information, positive environmental attitudes, environmental concern and social connections to groups such as trade unions - but even these factors are not always positive related to Responsible Production practices adoption (Prokopy et al., 2008b).

Will rural producers adopt all types of Responsible Production practices? What characteristics of Responsible Production practices are crucial to the rural producers choose what to do? We discuss the adoption of sustainable agriculture focusing on the characteristics of Responsible Production practices executed by rural producers. We use this innovative focus because establishing general standards based on features of rural producers or rural property could not produce clear patterns. Under this new approach, we are able to understand how the characteristics of Responsible Production practices influence its adoption.

Characteristics of Responsible Production practices

In general, the characteristics that can affect the adoption of Responsible Production practices are: (i) financial, (ii) innovation degree, such as the need to change behavior, (iii) legal risk of being monitored or punished if the practice is mandatory and (iv) relationship with agricultural productivity in the short term and directly (Figure 1).

(i) Financial: The financial cost required to adopt Responsible Production practices is an argument usually used by farmers in their business decisions (Farmar-Bowers & Lane, 2009). We expected rural producers adopt primarily low cost Responsible Production practices. Several farmers allege financial restrictions to not adopt responsible production practices (Ahnström et al., 2009).

(ii) Innovation degree: Change behavior, attitudes and adopt practices with high degree of innovation have high cost to rural producers. This cost is not always financial. In some cases this cost is behavioral, meaning changes in routine, adopting a new technology and/or changing old habits of farmers and his/her employees. Therefore, as technology is one of the justifications used by rural producers for their decision-making (Farmar-Bowers & Lane, 2009) and behavior change face great resistance to being modified (Carr & Tait, 1991), we expected rural producers adopt primarily low innovation degree Responsible

Production practices. Properly allocate all waste and change the routine of rural workers require a change in behavior that is considered high compared to other Responsible Production practices such as maintaining firebreaks or recover areas with erosion.

(iii) Legal risk: The requirement by law is an important factor in farmers' decision-making. Public authorities extensively used this tactic, such as in command and control policy (Nepstad et al., 2014). Government legislates and forces some actions by law. The government monitors and punishes who not act as the law obligates. We expected rural producers adopt primarily mandatory Responsible Production practices. Responsible Production practices related to native vegetation, pollution control, legal regularization and social and labor safety are required by law in Brazil and subject to monitoring, enforcement and punishment.

(iv) Relationship with productivity: An important factor considered by rural producers is its agricultural productivity and profits. All Responsible Production practices can improve productivity in the long run, either directly or indirectly. However, while some Responsible Production practices can improve productivity/profit directly in the short term, other Responsible Production practices does not have this feature. This variable does not have any relation to laws or any factor of outside the farm. We expected farmers adopt primarily Responsible Production practices that enhance directly and in short term the productivity. For example, soil conservation practices directly affect productivity, while environmental regulation (e.g. have all required environmental licenses) has a low relation to productivity in the short term.

Therefore, our hypothesis is that farmers will act rationally, being reactive and shortsighted, and they will adopt Responsible Production practices of lower cost, lower degree of innovation, higher legal risk (required by law) and that increase their productivity directly in short term.

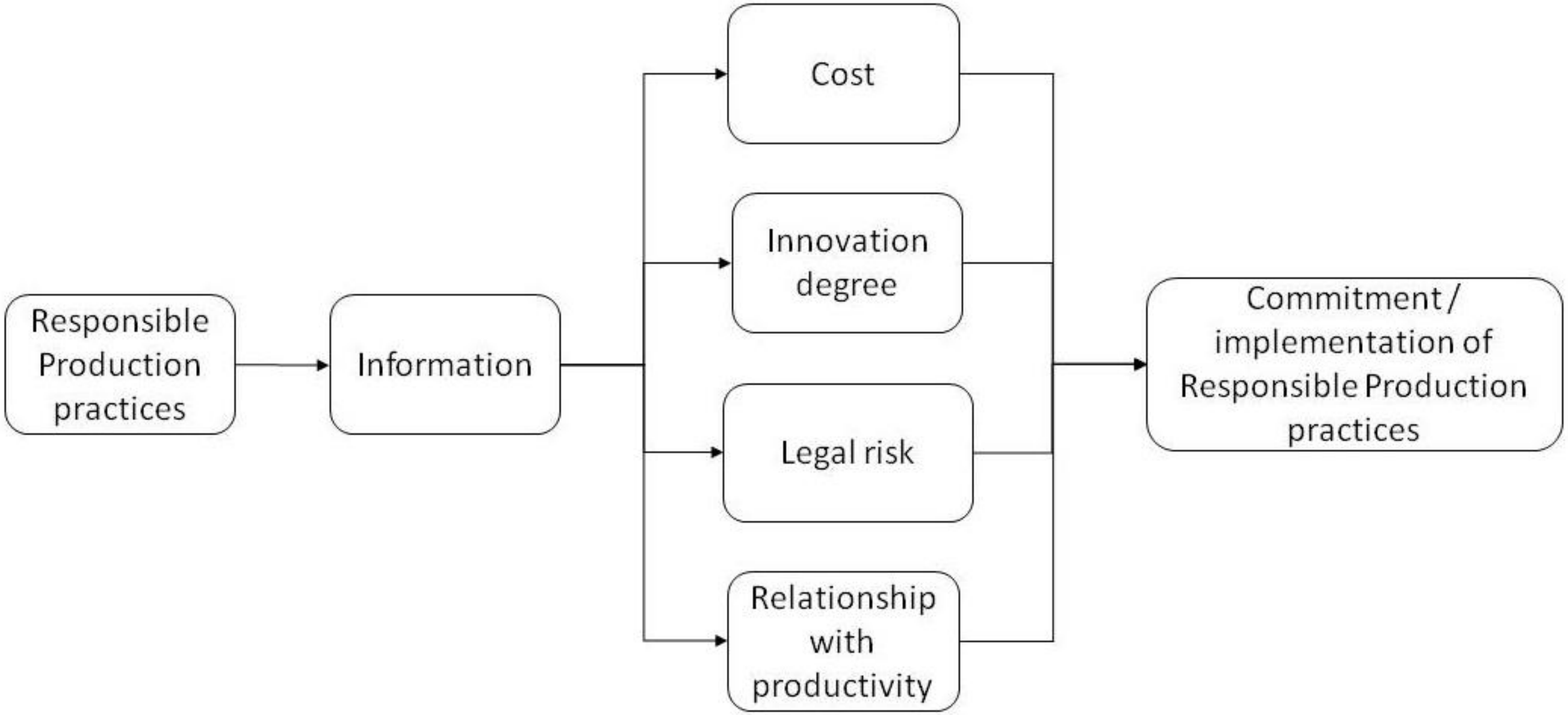

Figure 1: Conceptual scheme of how a Responsible Production practice can become a commitment or be executed by farmers. The first step required is access to information. Then, the rural producer must evaluate four features: cost to adoption, degree of innovation necessary for its implementation, legal risk, and relationship with the agricultural productivity in the short term. After analyzing these factors the farmer will decide to commit / implement each Responsible Production practice.

Method

The data was collected in medium and large private rural properties in Brazil by NGO Aliança da Terra (Figure 2). We followed a protocol to collect the field data (Figure 3):

1. Rural producer contact: Our team makes contact directly with rural producer and schedule a visit to rural private property.

2. Technical visit: We collected the data in the field, taking photos with geographic coordinates and taking notes. We visited the entire farm, delimiting with GPS the productive areas, areas of native vegetation and built-up areas, and get all information of the rural private property.

3. Social and Environmental Diagnostic Development: We analyze all data in the office and elaborate a specific diagnosis for each property. This Social and Environmental Diagnostic has the good points and the points to be improved on the property, called liabilities. We also describe in the Diagnosis how to resolve the liabilities. This diagnosis is a management tool because, when presenting a detailed description of the property, assists decision making of farmers.

4. Social and Environmental Diagnostic Delivery: The Social and Environmental Diagnostic is delivered to farmer. With this Diagnostic farmer comprehends the positives points and the liabilities of his/her rural property and how to resolve these liabilities (through Responsible Production practices). Rural producer can voluntarily commit to adopt certain Responsible Production practices to correct its liabilities. When the producer chooses which Responsible Production practices he/she will adopt, the liability became a commitment, and the rural producer sets the deadline to adopt the practice. We

not require any rural producer to correct all liabilities. In this step, farmers received accurate information, specific to his/her demand and with high technical quality. Therefore, information is no longer an impediment to the adoption of Responsible Production practices.

5. Monitoring: Every year we carried out visits to rural properties or called farmers to provide support in the resolution of liabilities and to know what commitments were executed. At this stage we evaluated if commitments were executed.

This work system is characterized by being completely voluntary and non-punitive to rural producers. There are no obligations on farmers during any step. Farmers may, at any time, leave the process without any punishments. Rural producers and NGO signed a document that the data obtained on private properties can be used to scientific purposes. After farmer consent, the data are free available on Producing Right Platform (http://www.aliancadaterra.org/).

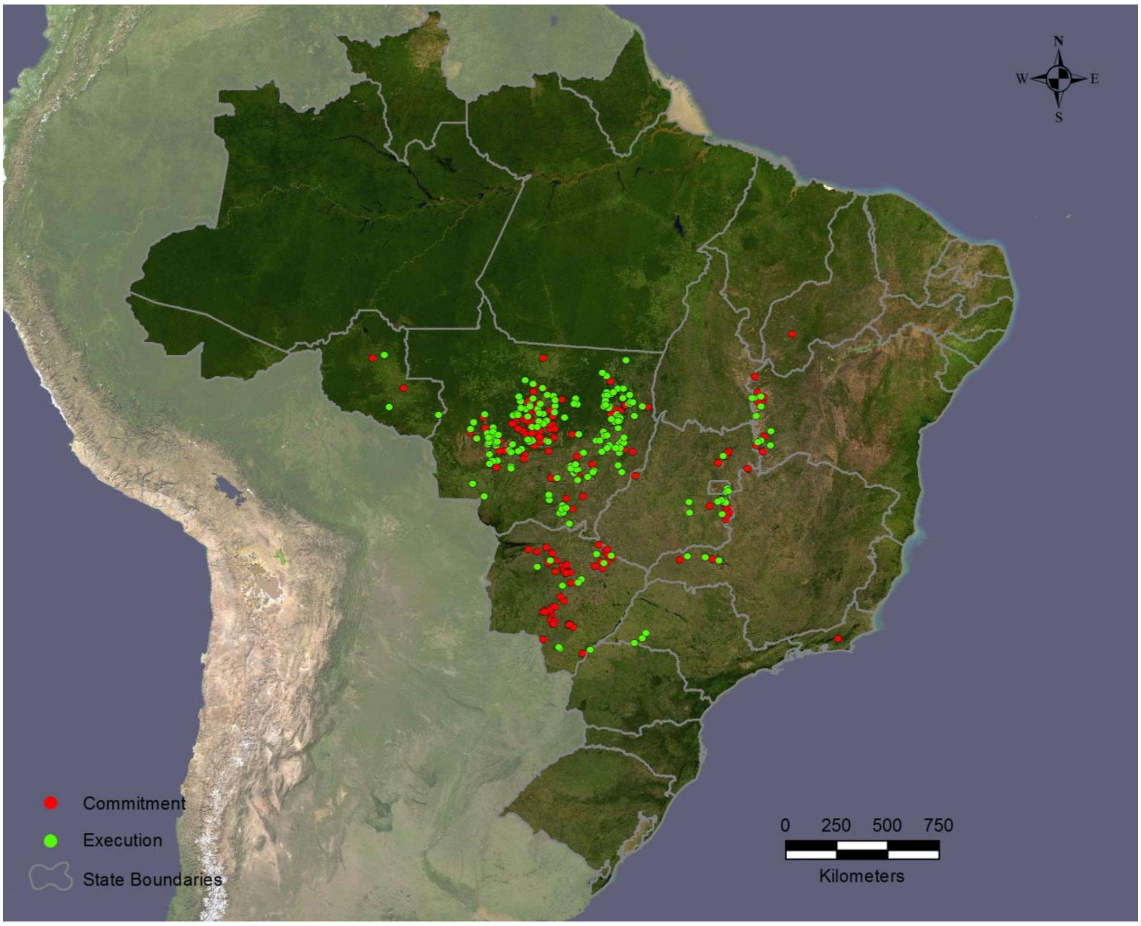

Figure 2: Private rural properties evaluated. The red dots represent the farms that have been evaluated only for commitment of Responsible Production practices because they did not have commitments to run until the date of follow-up. The green dots represent rural properties that were used to assess commitment and execution of Responsible Production practices.

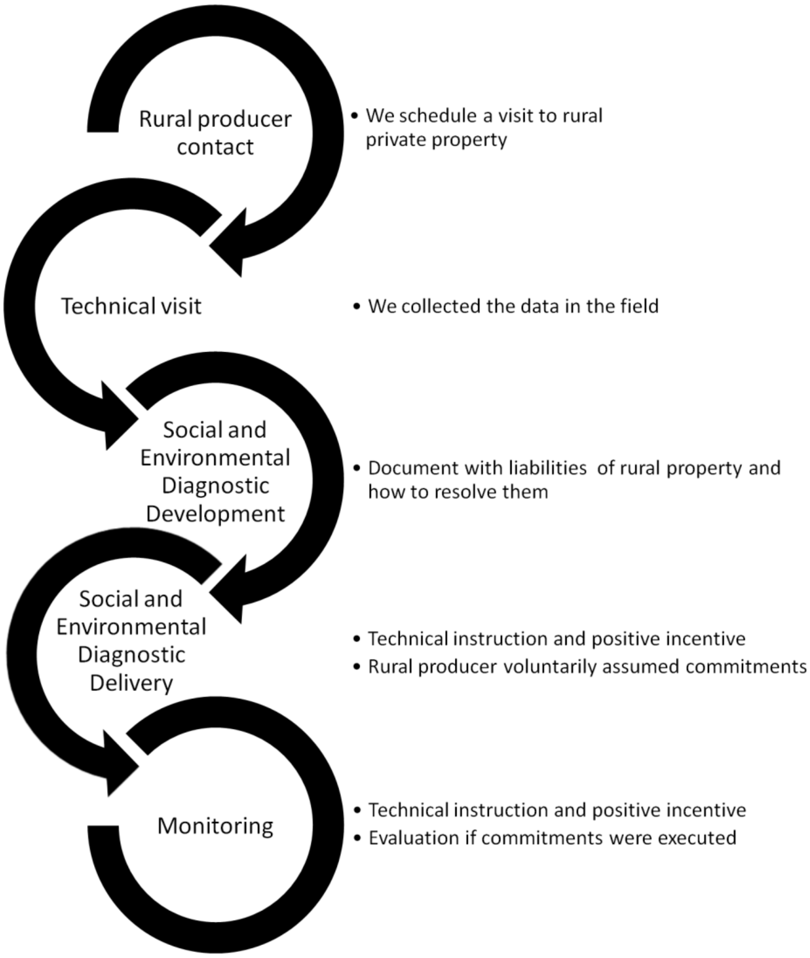

Figure 3: Work protocol with data collection, information processing, technical instruction and positive encouragement to rural producers.

Sample – rural properties

Only medium and large properties (over 4 fiscal modules, following standardization of the Brazilian government) were sampled. Properties of this size are only 6.3% of all Brazilian rural properties, but they represent 71.8% of total area in rural properties. Considering this imbalance and the importance of medium and large properties to economics, ecological and social aspects, we focused in properties over 4 fiscal modules. We sampled a total of 432 private rural properties, representing 1,973,450.82 hectares.

In the 432 rural properties sampled we have representatives from 10 Brazilian states (Bahia, Goiás, Minas Gerais, Mato Grosso, Mato Grosso do Sul, Piauí, Paraná, Rio de Janeiro, Rondônia, São Paulo) and the Federal District, totaling properties in 109 Brazilian municipalities. Of the total area of properties, 1,973,451 hectares, 840,594 hectares are covered by native vegetation (42.6%). The properties have in their lands 2,958 springs and employ over 7.5 thousand people. The main productive activity of 247 properties is agriculture, for 120 is agriculture and livestock and for 65 only livestock.

Dependent variable – Commitment and execution

We performed analyses for two dependent variables: commitment and execution (Figure 4). Commitments are the Responsible Production practices presented in the Social and Environmental Diagnostic that farmer voluntarily promise to achieve and determine a deadline for compliance. Execution is verified during Monitoring and evaluates if the rural producer adopted the Responsible Production practice committed.

All liabilities and commitments can be divided into six categories: (1) Native vegetation (e.g. protection of riparian areas), (2) Soil conservation (e.g. elimination of erosion points), (3) Pollution control (e.g. adequacy of infrastructure such as agrochemicals deposit), (4) Fire (e.g. maintenance of firebreaks), (5) Legal regularization (e.g. obtaining Legal licenses), and (6) Social and labor safety (e.g. deliver and monitor the use of Personal Protective Equipment).

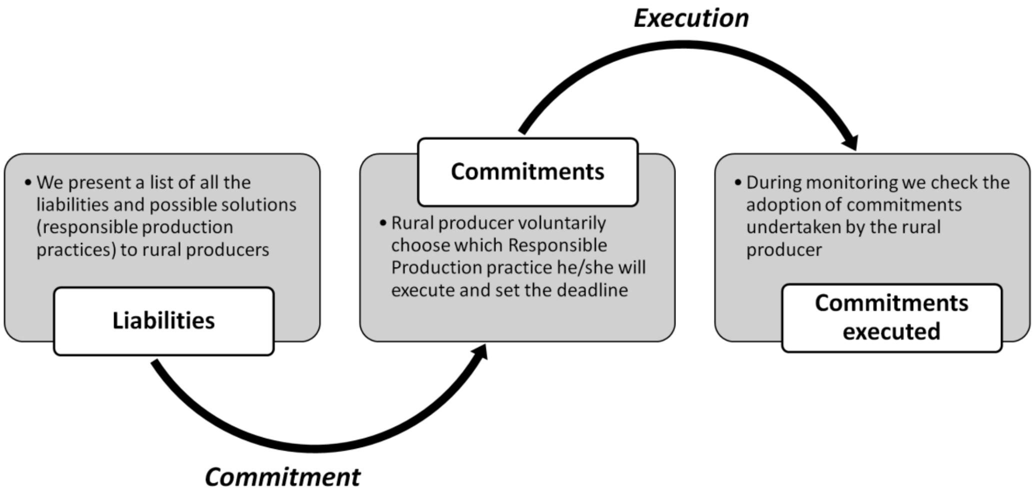

Figure 4: Scheme of how we understood the commitment and execution, our response variables. We presented to farmers points in their properties to be improved, denominated liabilities. The rural producer can make a commitment that is, voluntarily choose which Responsible Production practices he /she will adopt to resolve the liabilities of the farm and sets its own deadlines. These practices selected by the farmer are denominated commitments. During monitoring we check which commitments were executed.

The samples for commitment analyzes were Responsible Production practices presented to rural producers in the Social and Environmental Diagnostic to resolve the liabilities in their rural properties. In total, 10,112 practices were presented and for each practice was assigned value 0 or 1. Responsible Production practices that rural producer have not committed to perform received value 0. Responsible Production practices that have become commitments received value 1.

The samples for execution analyzes were Responsible Production practices committed by farmer that should have been executed until 2013. This deadline was selected because the monitoring conducted in 2014 only checks 2013 commitments, since 2014 commitments can run up hogmanay. We analyzed 3,155 commitments, which received value 0 or 1. Commitments which have not been executed received value 0, and commitments executed received value 1.

Property size effect

Even focused only on medium and large properties, rural properties sampled ranged from 84 to 89,207 hectares (4,568 hectares average, standard deviation of 7,808 hectares). Considering that some studies showed that larger farms tend to perform more responsible practices (Baumgart-Getz et al., 2012; Wilson, 1997), we evaluated the effect of property size in commitment and execution of Responsible Production practices. If there was effect of property size in our response variable, we would include this parameter in the following analysis.

We analyzed the effect of property size in commitment and execution of Responsible Production practices using logistic regression. The property size was calculated by the number of fiscal modules of each property. Fiscal module is a land measurement unit expressed in hectares corresponding to minimum area required for a rural property be economically viable. The fiscal module was determined for each municipality by law (Law No. 6,746, of December 10, 1979) and considers the following factors: predominant type of rural properties in the county, income from the predominant type of exploration, and other significant types of land exploration in the county.

Predictor variables

Cost

We analyzed the effect of cost of Responsible Production practices in commitment and execution using logistic regression. As practices costs differ widely, we use the logarithm of the costs values in the logistic regression analyzes. We evaluated costs according to the description of the activity that should be adopted. We obtained the values of the activities with rural producers and agribusiness professionals (Annex A).

Innovation degree

We determined the innovation degree based on necessity of behavior change or technological innovation associated with each Responsible Production practice. We associated a value of innovation degree for all practices: low or high.

We considered low innovation degree Responsible Production practices related to Native Vegetation, Soil conservation, Fire and Legal regularization. Responsible Production practices related to these themes require less technology and less behavioral change compared with practices related to Pollution control and Social and labor safety. Adapt infrastructure and change the workers habits require a higher innovation degree and behavior change (Table 1).

Legal risk

We determined Legal risk for Responsible Production practices based on Brazilian Law. Practices that are mandatory were considered as high Legal risk. Practices that are not mandatory were considered as low Legal risk.

We considered high Legal risk Responsible Production practices related to Native Vegetation, Pollution control, Legal regularization and Social and labor safety because they are required by Brazilian law and, if not executed, are subject to penalties. On contrary, we considered low Legal risk Responsible Production practices related to Soil conservation and Fire because they are volunteers and there is no specific legislation requiring the adoption of those Responsible Production practices (Table 1).

Relationship with productivity

Most Responsible Production practices will improve productivity in the long run, either directly or indirectly. However, we considered in this variable the relationship with productivity directly and in short-term. We associated a value of Relationship with productivity for all Responsible Production practices: low or high.

We considered high Relationship with productivity Responsible Production practices related to Soil conservation, Fire and Social and labor safety. Maintain soil integrity and reduce losses from erosion, run practices that prevent the spread of fire (which can destroy entire production) and having employees with better working conditions have a direct influence in the short term in property productivity. On the other hand, we considered low Relationship with productivity Responsible Production practices related to

Native Vegetation, Pollution control and Legal regularization. For example, protect riparian areas for conservation can even lead to loss part of the productive area (Table 1).

We analyzed the effect of Innovation degree, Legal risk and Relationship with productivity using Log-Linear Analysis (Agresti, 1992).This analysis allowed us to check for interaction between variables. Two analyzes were done separately, firstly for commitment and then to execution. In all analyzes the four categorical variables were included (the three predictor variables - Innovation degree, Legal risk and Relationship with productivity - and a response variable).

We calculated odds ratio and its 95% confidence interval to evaluate the effect size. This metric is a measure of association between exposure and its outcome. The odds ratio is a chance of a result occur given a particular exposure, compared to the chance of the same outcome occur without the exposure (Szumilas, 2010). In our analyzes, outcome is the commitment or execution, and exposure are the characteristics of the predictor variables.

Table 1: Categories of liabilities and Responsible Production practices evaluated in rural properties, with examples, and its relations with the predictor variables. Innovation degree is related to behavior change and/or technological innovation associated with practice. Legal risk is related to the compulsory or voluntary nature of Responsible Production practices according to Brazilian law. Relationship with production is the direct and short-term relationship among practice and the increase properties productivity. Legal reference was presented to compulsory Responsible Production practices.

Category	Example	Innovation degree	Legal risk	Relationship with productivity	Legal reference
Native vegetation	Permanent Preservation Areas degraded	Low	High	Low	Federal Law 12,651 of May 25, 2012
Soil conservation	Areas with erosion	Low	Low	High	Voluntary
Pollution control	Inadequate infra structures and improper waste disposal	High	High	Low	Federal Law 12,305 of August 2, 2010 and Regulatory Norm 31 of the Ministry of Labor and Employment
Fire	Firebreaks without maintenance	Low	Low	High	Voluntary
Legal regularization	Property with Legal license	Low	High	Low	Decree 7,830 of October 17, 2012

Social and labor safety	Houses / living areas unsuitable and lack of delivery / monitoring of PPE	High	High	High	Federal Law 5,452 of May 1, 1943 and Regulatory Norm 31 of the Ministry of Labor and Employment

Results

We found 10,112 liabilities in 432 rural properties (average of 23 liabilities per rural property). Of these liabilities, 6,639 have become commitments, that is, rural producers voluntarily assumed the commitment to adopt 65.65% of Responsible Production practices presented (average of 15 commitments per rural property). To analyze execution, we evaluated 3,155 commitments. These commitments were from 211 rural properties (average of 15 commitments per rural property). Of these commitments, 2,499 were executed (79.21% of execution - average of 12 Responsible Production practices executed per rural property).

Property size effect

Rural producers with smaller properties had higher intention to implement Responsible Production practices (logistic regression, $\chi^2 = 7.437$, df = 1, p = 0.006), but the effect size is minimum. A rural producer with a smaller property is 0.03% more likely to make a commitment than a rural producer with a larger property (Odds Ratio, CI 95% 1.00008 - 1.00050). On the other hand, producers with larger properties are more likely to execute commitments (logistic regression, $\chi^2 = 259.951$, df = 1, p <0.001), but again the effect size is minimum. Rural producers with larger properties are 0.5% more likely to execute a commitment than rural producers with smaller properties (Odds Ratio, CI 95% 1.005 - 1.006). Therefore, considering that the property size has a tiny effect on the commitment and execution of Responsible Production practices, this factor was discarded in the following analysis.

Cost

The cost of Responsible Production practices had no effect on rural producers commitment (logistic regression, $\chi^2 = 1.304$, df = 1, p = 0.253). However, rural producers executed primarily lower-cost Responsible Production practices (logistic regression, $\chi^2 = 22.128$, df = 1, p <0.001). Lower cost commitments are 12.2% more likely to be executed than higher cost commitments (Odds Ratio, CI 95% 1.069 - 1.178).

Innovation degree, Legal risk and Relationship with productivity

Any interaction between variables Innovation degree, Legal risk and Relationship with productivity had effect on commitment or execution of Responsible Production practices. We tested all possibilities of interactions among all predictor variables and response variable (commitment or execution) and we did not found interaction effect (log-linear, always p> 0.005). For interaction between one predictor variable and the response variable, all predictor variables had an effect (Tables 2 and 3).

Table 2: Results of log-linear analysis with chi-square values, degrees of freedom and p values. Values in bold represent that predictor variable had an effect on the response variable.

	Commitment			Execution		
	χ^2	df	p	χ^2	df	p
Interaction between all variables	0.015	1	1	1.008	1	0.315
Innovation degree and Legal Risk	0.152	2	0.927	1.376	2	0.503
Innovation degree and Relationship with productivity	0.248	3	0.969	1.623	3	0.654
Legal Risk and Relationship with productivity	0.947	4	0.918	1.635	4	0.802
Innovation degree	**81.349**	**5**	**< 0.001**	**34.136**	**5**	**< 0.001**
Legal Risk	**14.735**	**5**	**0.012**	**22.336**	**5**	**< 0.001**
Relationship with productivity	**36.693**	**5**	**< 0.001**	**25.823**	**5**	**< 0.001**

Table 3: Effect size of response variables Innovation degree, Legal risk and Relationship with productivity for commitment (n = 10,485) and execution (n = 3,212). The percentages represent the values of commitments and executions comparing different levels of the predictor variables. In parentheses in the Odds Ratio column we present 95% confidence interval. In bold are highlighted the highest values.

	Commitment			Execution		
Innovation degree						
	High	Low	Odds Ratio	High	**Low**	Odds Ratio
	71,8%	63,2%	1,480 (1,347 - 1,626)	72,9%	**80,7%**	1,555 (1,269 - 1,906)
Legal risk						
	High	Low	Odds Ratio	High	**Low**	Odds Ratio
	66,9%	60,7%	1,307 (1,174 - 1,408)	78,9%	**80,3%**	1,089 (0,874 - 1,358)
Relationship with productivity						
	High	**Low**	Odds Ratio	**High**	Low	Odds Ratio
	61,5%	**67,2%**	1,286 (1,174 - 1,408)	**81,8%**	78,4%	1,243 (1,008 - 1,533)

Rural producer tends to commit to Responsible Production practices that require high degree of innovation, are mandated by law and has low relationship with productivity, regardless of the cost of these practices. The chance of compromising Responsible Production practice was 48% higher for high Innovation degree, 30.7% greater for high Legal risk and 28.6% higher for low Relationship with productivity practices compared, respectively, with low Innovation degree, low Legal risk and high Relationship with productivity practices.

For the execution of Responsible Production practices the result is the opposite. Rural producers executed lower-cost practices, practices with lower levels of innovation, not required by law and practices highly related to the productivity in short-term. The chance of executing Responsible Production practices was 12.2% higher to lower-cost practices, 55.5% higher for low Innovation degree, 8.9% higher for low Legal risk and 24.3% higher for high Relationship with productivity practices compared, respectively, with higher cost, high Innovation degree, high Legal risk and low Relationship with productivity practices.

Discussion

Rural producers commit to mandatory Responsible Production practices, even if these practices have high innovation degree and low relationship with productivity, but they execute practices based on finances and shorter planning horizon, prioritizing practices of lower-cost, lower innovation degree and practices that will bring direct and short term productivity improve, ignoring Law (Figure 5).

Although Brazilian government confidence in command and control policy, this simplistic and broad scale tactic is not being effective in Responsible Production practices execution. Command and control is the most widely used policy and it is considered more directly in the conduct of population attitudes. The fear of fines and embargoes are incentives for rural producers to take the necessary measures. It is believed that the obligation by laws associated with intervention in soy and beef chains and access to credit restrictions helped to reduce deforestation in the Amazon (Nepstad et al., 2014). However, in this study, although rural producers have committed to adopt practices required by law, during execution farmers gave priority to non-mandatory practices. Only command and control policy is not enough to successfully spread Responsible Production practices, particularly in the current context in which policies and programs to prevent deforestation weakened politically in recent years in Brazil, strengthening the sense of impunity (Loyola, 2014). The lack of execution of mandatory practices can partly be explained by economic benefits of non-compliance of Brazilian Forest Code that are perceived by rural producers (Stickler et al., 2013a), Brazilian Legal uncertainty and inefficient/ insufficient monitoring and enforcement systems (Gibbs et al., 2015).

Rural producers high rates of commitment (65.65%) and execution (79.21%) of Responsible Production practices evidence that an informative, educational and not punitive approach, even without any financial incentive, get positive results. Economic interests, although important, are not the only determining factor in the decision making of farmers (Siebert et al., 2006). Rural producers like to engage in activities that show them as good rural managers (Ryan et al., 2003), but lack of quality information is a prominent impediment of

Responsible Production practices adoption (Rolfe & Gregg, 2015). The approach used in this work, totally divorced from direct economic gains and with all costs for practices implementation belonging to farmer, was enough to generate a large positive impact on rural areas. Among the Responsible Production practices implemented by producers are recovering approximately 2,000 hectares of native vegetation, recovery over 230 points of erosion and construction / maintenance of 300 km of firebreaks.

The adoption of Responsible Production practices have greater success if supported by a wide range of motivations, including cooperative approaches, and not limited on economic issues (Ryan et al., 2003; Siebert et al., 2006). Ryan et al. (2003) found for US producers that government payment for conservation was the worst motivation for the adoption of conservation practices. Farmers need not only financial support but also information, motivation, awareness, aspiration and engagement to execute Responsible Production practices (Ahnström et al., 2009; Farmar-Bowers & Lane, 2009; Prokopy et al., 2008b). We must show to rural producers the consequences of his actions beyond the border of their properties, revealing their social contribution to the local community, and exploring the fact that farmers like to be perceived as good managers (Ryan et al., 2003).

We worked in a specific geographic region (Brazil, mainly in Mid-West region) with agribusiness medium to larger properties (solely rural properties with more than four fiscal modules). Even though they do not represent a typical Brazilian rural producer (6.3% of Brazilian rural properties has 4 or more fiscal modules), they represent rural producers that occupy 71.8% of Brazilian territory (IBGE, 2007). Other caveat is that social network is an important feature that improves chance of producer to adopt a Responsible Production practice (Baumgart-Getz et al., 2012). Our sample is composed only by rural producers that have contact with a NGO of rural producers, and, therefore, our sample can be positive biased to accept adoption. Conversely, our sample is composite by rural producers with productivity identity, and, consequently, our sample can be negative biased to accept adoption (Reimer et al., 2012; Sulemana & James Jr., 2014). We do not have evidence to believe that one caveat is stronger than other, so we considered that their effects can nullify each other.

Information gap is a barrier to rural producer adopts Responsible Production practices of low innovation degree, strong relationship with productivity and low cost (Rolfe & Gregg, 2015). With technical rural assistance agencies work, it is expected that such practices will be widely adopted regardless if its practices are mandatory or not. Farmers understand that the financial, operational, technological and behavioral costs are low and the return is fast for some Responsible Production practices, with wide positive balance in the short term. Among such practices there are soil conservation activities, such as construction of barriers to prevent erosion, and actions to prevent fire, such as maintenance of firebreaks and prepare equipment for firefighting.

The adoption of new Responsible Production practices that have high innovation degree and may require behavior change face great resistance by farmers (Carr & Tait, 1991). For our data, the greater effect size for Responsible Production practices execution was associated with low innovation degree, that is, Responsible Production practices with less adoption difficulty tends to be more executed. Behavioral changes and adoption of high technology appear as the main barriers to the widespread dissemination of Responsible Production practices. Technical rural assistance agencies play a key role to disseminate information and can support rural producers to adopt high innovation degree Responsible Production practices. Therefore, it is important to strengthen technical rural assistance agencies to popularize Responsible Production practices (ABC, 2015b).

The big challenge is disseminating Responsible Production practices of high cost and high innovation degree. For that we need to incorporate into command and control policy some strategies in which punitive measures are complemented by positive incentives (Nepstad et al., 2014), with easy access to technologies and high quality information, and reduction in cost for Responsible Production practices implementation. Special credit lines for environmental services payments, differentiated risk classification and tax benefits can be used and conditioned specifically for Responsible Production practices of higher cost, high innovation degree and with direct relationship in the short term with productivity (ABC, 2015b). However, we need attention to policies that offer a financial reward for some practices adoption to not reduce intrinsic rural producers interest to engage in Responsible Production programs (Farmar-Bowers & Lane, 2009).

The Brazilian government has been adopted public policies to reduce the cost of execution of Responsible Production practices. One of this policy was launched in 2012, namely Low Carbon Agriculture Plan (ABC, for Brazilian acronym), in which rural producers or cooperatives can apply for financial credit with low interest rates and long deadlines to implement Responsible Production practices such as restoration of degraded pastures and recovery of degraded areas. However, ABC program is facing difficulties as great time and effort required to obtain the credit, lack of training of rural producers and technicians to access the credit, and insufficient government monitoring and control (ABC, 2015b). In addition, resources are unevenly distributed in the country, with most loans being used by rural producers at richer states (ABC, 2015a). Another mechanism used by Brazilian government to encourage the adoption of Responsible Production practices is the Brazilian Forest code (Law n. 12,651 of May 25, 2012). Despite recently change in the law have caused damage to conservation and environmental restoration (Garcia et al., 2013), a tool, the Rural Environmental Registry (CAR, for Brazilian acronym) was established, which will assist in the control, monitoring, environmental and economic planning and combating deforestation. After implemented nationally, this public policy will assist in the conduct of practices related to the conservation of native vegetation, but should have no direct effect on other Responsible Production practices. Despite the increasing number of initiatives that work with positive incentives for farmers, these incentives are not yet operating on a scale that take effect in reducing Brazilian deforestation and disseminate Responsible Production practices (Nepstad et al., 2014).

Concluding remarks

It is essential include positive incentives and cooperative approaches to command and control policy to spread successfully Responsible Production practices. A suite of policy mechanisms that combines education, support, supervision and punishment can get better results for Responsible Production practices execution on private property, promoting agriculture with environmental conservation, social responsibility and productivity increase (Nepstad et al., 2014; Rolfe & Gregg, 2015; Siebert et al., 2006). To achieve success among farmers we need to focus in an effective communication and increase environmental awareness, explaining to rural producers potential benefits of Responsible Production practices and potential risks if its practices were not adopted (Arbuckle & Roesch-McNally, 2015; Prokopy et al., 2008b). It is critical and urgent that agricultural production does not conflict with environmental conservation (Ferreira et al., 2012). Independently of rural producer decision-system – family, farm trading business or land ownership (Farmar-Bowers & Lane, 2009), a suite of policy mechanisms will fit him/her. Thus, financial, rural and environmental sectors should strengthen their relations to promote convergence goals to achieve sustainable agriculture.

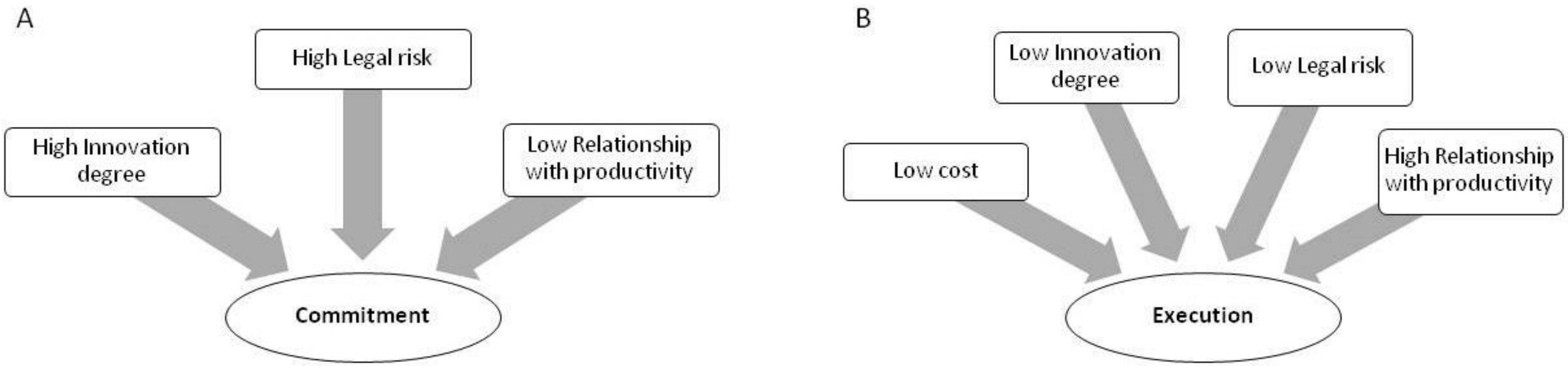

Figure 5: Characteristics of Responsible Production practices that are associated with (A) commitment and (B) execution by farmers. A - Responsible Production practices with a high innovation degree, high legal risk (required by law) and low relationship with productivity have greater commitment. B – Responsible Production practice with low cost, low innovation degree, low legal risk (not required by law) and high relationship with productivity are most executed.

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Annex A

Table 1: Cost estimate of Responsible Production practices committed and implemented by farmers. Costs were obtained from farmers and experts in agribusiness.

Category	Practice	Cost
Native vegetation	Recover native vegetation	R$ 2.100,00/ha
	Buy natural vegetation area	R$ 6.000,00
	Build nursery	R$ 3.000,00
	Recover exploration area	R$ 1.000,00
Soil conservation	Build contour	R$ 350,00/ha
	Build erosion control systems	R$ 100,00
	Recover erosion – rill erosion	R$ 2.000,00
	Recover erosion – gully erosion	R$ 1.000,00
	Recover erosion – channel erosion	R$ 3.000,00
Pollution control	Adequacy of garage	R$ 1.000,00
	Adequacy of agrochemicals deposit	R$ 5.000,00
	Adequacy of deposit of agrochemicals empty containers	R$ 2.000,00
	Adequacy of machine wash area	R$ 1.000,00
	Adequacy of fuel tank	R$ 1.500,00
	Adequacy of oil gallons disposal	R$ 100,00
	Bury waste fortnightly	R$ 50,00
	Build and install water dispenser to cow	R$ 4.500,00
	Put Danger signs	R$ 500,00
	Treatment of feedlot residue	R$ 10.000,00
	Treatment of swine residue	R$ 10.000,00
Fire	Environmental Education course	R$ 1.000,00

	Buy fire-fighting equipment	R$ 450,00
	Maintenance of firebreaks	R$ 0,20/m
Legal regularization	Farm georeferencing	R$ 15.000,00
	Obtain Environmental License	R$ 1.200,00
	Obtain Rural Environmental Register	R$ 3.000,00
Social and labor safety	Adequacy of housing and living area	R$ 2.000,00
	Build garden	R$ 3.000,00
	Offer Best Management Practices course for employees	R$ 1.000,00
	Offer Risk Management course for employees	R$ 1.000,00
	Provide individual cups	R$ 250,00
	Provide PPE (Personal Protective Equipment)	R$ 200,00/employee
	Implement suggestion box	R$ 100,00
	Implement Risk Plans	R$ 21.600,00
	Provide 1st aid kit	R$ 250,00
	Monitor PPE use	R$ 600,00
	Reform employees houses	R$ 10.000,00
	Implement point registration for employees	R$ -

Capítulo 2: Market pressure, age of producers and schooling positively affect agriculture responsible production

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Abstract

Brazil has exhaustively used command and control policies, and faces now the challenge of incorporate positive incentives as a rural policy instrument. To achieve better results, it is important to known how responsible production practices adoption is affected by: (i) market pressure, (ii) personal involvement of rural producers on farms, (iii) property size, (iv) age of producers, (v) yield, and (vi) schooling. We studied 25 soybean producers in Brazil. Higher market pressure results in better environmental

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practices. Older farmers perform better in social and responsible production practices. Producers with higher schooling execute better social practices.

Keywords

Agriculture, Private Property, Environmental attitudes, Social Profile, Sustainable Agriculture

Introduction

World population increased from 2.5 billion in 1950 to 6.9 billion in 2010, with projections to reach 9.15 billion in 2050. Therefore, agriculture has expanded to face the challenge of feeding this continuously increasing world (Alexandratos & Bruinsma, 2012; Godfray et al., 2010; United Nations: Department of Social and Economic Affairs, 2013). According to current projections, the world crops area will increase 70 million ha until 2050 (Alexandratos & Bruinsma, 2012). Soybean, a protein source mostly used as feedstock but also for human food and biofuel, had its production increased from 28.6 million tons in 1961-65 to 217.6 million tons in 2005-07 (Masuda & Goldsmith, 2009). The harvested area increased significantly from 24.7 million ha in 1961-65 to 94.1 million ha in 2005-07 (Masuda & Goldsmith, 2009). Nowadays, Brazil is the second largest producer of soybean in the world, representing 24.8% of the world soybean production, with 49% of the Brazilian grain production area dedicated to this commodity. Projections of Brazilian government indicate increases in grain production between 20.7 to 34.3% from 2013/14 to 2022/23, expanding between 8.2 to 20.9% in area (Ministério Da Agricultura Pecuária E Abastecimento, 2013).

Rural properties are a key aspect in the biodiversity crisis debate since agriculture is responsible for threat more species to extinction than any other human activity (Green et al., 2005). In Brazil, due to both decreases in demarcation of new protected areas and the low amount of area devoted to conservation in specific biomes (e.g. Cerrado) (Klink & Machado, 2005; Nóbrega & De Marco, 2011), the importance of rural properties for biodiversity conservation becomes even more prominent. Brazilian farms also have a significant role in generating employment and income. More than 29 million Brazilians inhabits rural areas, representing 15.6% of the total population, with more than 17 million rural workers (IBGE, 2007). Nowadays, agribusiness plays a central role in the Brazilian economy, accounting for over 23% of the national Gross Domestic Product (GDP) (Cepea, 2014). Soybean export, in particular, grew 29.7% from 2012 to 2013 in Brazil, reaching a new record of 22.812 million U.S. dollars (Ministério Da Agricultura Pecuária E Abastecimento, 2013).

Brazil has excelled in rural productivity over the past few years (Fuglie et al., 2012). In the last four decades Brazil increased soybean yield from 862 kg/ha to 2.583 kg/ha (Sidra, 2017). Nevertheless, rural producers need a high level of technology and investment to make profitable soybean crops. Consequently, medium and large producers are responsible for the majority of soybean production. Technology development was the key factor enabling increases in soybean production in the Cerrado biome (Mueller, 2003), the dominant vegetation in Brazilian Midwest region. Mainly due to efforts of the Brazilian Corporation of Agricultural Research (Embrapa), production of Brazilian Midwest region went from less than 2% of national soybean production in 1970 to 49% nowadays (Sidra, 2017).

In the past, it was very common solely seek to improve yield without considering environmental sustainability or labor conditions. As a result, many areas were deforested, reducing ecosystem services and degrading labor conditions (Millennium Ecosystem Assessment, 2005). To reduce conflicts between agricultural expansion and conservation priorities, increases in productivity must be in consonance with management of natural resources and respect for workers. As consequence of this approach to agriculture, the environmental, social and productive tripod became the basis for responsible production, usually been used by farmers to add value to its commodities. Assuming the great value of agricultural production and landowners as the managers of useable areas of the world (David Tilman et al., 2002), we should encourage landowners to produce with responsibility. We consider as responsible production the appropriate sustainable management of natural resources, preventing their exhaustion. A responsible production needs to be productive and includes the respect for workers, promoting their professional qualification and enabling them to have a good life quality with proper labor conditions and housing (AT, 2014).

Under a rigorous environmental law system, Brazil has exhaustively used command and control practices to govern and regulate environment, labor and land. For Brazilian society rural properties have social, environmental and productivity functions and landowners are charged to fulfill such functions. Under Brazilian law, unproductive lands are liable to be expropriated for agrarian reform (Article 186 of the Brazilian Constitution). The Brazilian law also determines austere labor standards and environmental preservation in rural private area. In addition, demand of Brazilian society for responsible production - here conceived as environmental conservation, social respect and high productivity - is growing, as exemplified by the growth of source seals of responsible production (e.g. Round Table on Responsible Soy) or the existence of Brazil's Soy Moratorium (Gibbs et al., 2015). The command and control policies, widely used by Brazilian government, had some good results but are saturated nowadays. An example of this saturation is Amazon deforestation. Brazilian government achieved good results in the beginning of this century reducing Amazon deforestation. However, to maintain such reductions in deforestation, we must associate positive incentives to command and control policies (Nepstad et al., 2014). Now we are exhausting the command and control phase and facing the challenge of incorporate positive incentives in our system (Nepstad et al., 2014; Stickler et al., 2013a).

In this new political phase an important question needs to be answered: Which producers are adopting a responsible production attitude? Answering this question will enable an efficient spread of the responsible production actions among landowners. Social actions, however, are determined by a complex set of purposes (Reimer et al., 2012). Factors that influence farmer decisions regarding agri-environmental issues are complex and not yet fully understood (Wilson, 1997). Generally, producers with larger farms, higher incomes and higher schooling are more committed to soil conservation (Hoag & Holloway, 1991). Despite the importance of economic factor, there are non-financial reasons (mainly ethical) which motivates many landowners to adopt conservation attitudes (Boonstra et al., 2011; Greiner & Gregg, 2011). Producers with exclusively commercial view of their properties adopt less responsible practices than producers with stewardship, who are concerned about the effects generated outside the farm and that fells responsible for land (Reimer et al., 2012).

Studies show that even exhaustively tested variables such as education and farm size, although usually having a positive and significant influence, may negatively affect the conservation practices in some cases (Ahnström et al., 2009; Knowler & Bradshaw, 2007). In this sense, even producers who are aware about the impacts of agriculture on the environment do not adopt conservation practices. Thus, rural producers are key persons for planning due to their great power in changing landscapes (Primdahl, 1999). Despite this, we did not find any study in this field conducted in Brazil. Therefore, considering the importance of rural properties to environment, economy and life quality of rural dwellers, this study aimed to evaluate how soybean responsible production is affected by: (i) market pressure, (ii) personal involvement of rural producers on farms, (iii) property size, (iv) age of producers, (v) soybean yield, and (vi) schooling. We hypothesized that higher market pressure, higher personal involvement, larger property sizes, younger producers and higher education levels will be positively related to all aspects of responsible production, namely Environmental, Social and Productivity Profiles.

Methods

Field Observations

We conducted our survey with 25 soybean producers of Midwest Brazil. The Midwest region is the main soybean producer in Brazil, reaching 49% of national production in 46% of the planted area in the country (Sidra, 2017). Producers were interviewed in the three states of the region (Goiás, Mato Grosso and Mato Grosso do Sul). All farms are located in Cerrado biome, where species richness coincides with indicators of agriculture and cattle ranching (Rangel et al., 2007). All properties are considered from medium to large size (600 to 15.000 ha, mean of 3.318 ha) and are members of the Registry of Social-Environmental Responsibility program of the Non-Governmental Organization Aliança da Terra (aliancadaterra.org.br). This program aims to help landowners to produce with responsibility. However, become member of conservation programs and be aware of conservation are not the same (Morris & Potter, 1995). Thus, we sought a sample with different levels of responsible production, aiming to ensure variability in the degree of responsibility presented by rural properties.

We interviewed soybean producers in their farms to collect the independent variables “market pressure”, “personal involvement”, “property size”, “age of producers”, “soybean yield”, “schooling of the producer”, “agricultural area”, and “soybean crop area”. We filled a semi-structured questionnaire in individual and face-to-face interviews.

We evaluated “market pressure” using eight questions, enabling farmers to distinguish among the sources of pressure to produce responsibly. Sources of pressure included buyers, suppliers, society and institutions (e.g. trade unions and associations). We also asked about the responsible production as a differential in marketing, if the producer has obtained better sale conditions and how was his/her responsible production performance compared to his/her neighbors. Producers evaluated each question assigning a score from 1 (worst) to 5 (best). To summarize all items of “market pressure” we performed a Principal Component Analysis (PCA). Using the Broken-Stick method we selected only the first axis of PCA. This axis was negatively related to all variables, explaining 61% of data variance.

We evaluated “personal involvement” also using eight questions. We asked about the number of hours worked exclusively on farm, the number of working days per week spent in the rural property, the percentage of working time devoted to the rural property, if the producer has another professional occupation, about the personal involvement with employees and satisfaction with the property and the activity performed in the farm. Producers evaluated each question with a score from 1 to 5. Also in this case, we performed a PCA to summarize all “personal involvement” items and used Broken-Stick method to select PCA axes. The two first axes accounted, together, for 82% of the data variance.

We obtained the dependent variables without any direct contact with producers, through the inspection in loco of soybean farms by a specialized technician. We used four dependent variables: “Environmental Profile”, “Social Profile”, “Production Profile” and “Responsible Production Profile”. The Environmental, Social and Productive Profiles are composed by the average of six items each. Items of the Environmental Profile comprise: conservation of native vegetation, fire prevention, soil conservation, solid waste management, use of agrochemicals and fertilizers, and environmental legal compliance. The Social Profile items are: working conditions, health and safety, capacitation and training, housing quality, child welfare, and personal freedom. Items of the Productive Profile are: legal compliance, infrastructure, productivity index, use of antibiotics and hormones, level of professionalization, and use of technology. We assigned a score from 1 to 4 for each item, being 1 the worst and 4 the best. We calculated the average of Environmental, Social and Productive Profiles to obtain the values of the Responsible Production Profile.

Analytical Approach

Collinearity may compromise the interpretation of multiple regression results (Graham, 2003). Thus, we first performed a correlation analysis, followed by a multiple regression including all quantitative independent variables – the first axis of “market pressure” PCA, the two first axes of “personal involvement” PCA, “property size”, “agricultural area”, “soybean crop area”, “soybean yield”, and “age of producer”. Due to their significant correlation with “agricultural area” we excluded from multiple regression analysis the variables second axis of “personal involvement” PCA, “property size” and “soybean crop area”. Therefore, variables used in multiple regression were: the first axis of “market pressure” PCA, the first axis of “personal involvement” PCA, “agricultural area”, “soybean yield”, and “age of producers”. A redundancy analysis of this model showed tolerances equal or higher than 0.843, representing acceptable models in respect to the collinearity problem. We also evaluated the independence and normal distribution of residuals. Additionally, the first axis of “market pressure” PCA was positively related to “Environmental Profile”. Therefore, we performed simple regressions with all eight variables of “market pressure” to improve the understanding of this relationship.

We avoided including “schooling of the producer” (a categorical variable separated between producers that began studies at the university and producers who have not started) into the multiple regression analysis due to the complexities of model comparison under a covariance analysis framework generated by the inclusion of higher order interactions. Thus, we used an independent t-test to evaluate the effect of schooling comparing low to high schooling.

Results

Market Pressure

The higher the market pressure perceived by landowners, best environmental practices are performed by them (multiple regression, first axis of “market pressure” PCA, which is positively related to all “market pressure” variables, b = 0.075, t = 2.168, df =19, p = 0.043 - Table 1). To explore this result, we evaluated all “market pressure” items independently. Such exploration revealed that the perception of pressure that the producer receives from trade unions and associations is the only item that differed from random variation. Therefore, higher pressure of trade unions and associations on landowners induced the implementation of best environmental practices on farms (linear regression, b = 0.153, R^2 = 0.166, df =19, p = 0.043). All other market pressure variables, however, had no effect on independent variables (Table 2).

Table 1. Relationship among “market pressure”, “personal involvement”, “agricultural area”, “soybean yield” and “age of producers” and Environmental, Social, Productive and Responsible Production Profiles. Table numbers are the non-standardized regression coefficients (B) of multiple regression analysis. Numbers in bold have p>0.05.

	Environmental	**Social**	**Productive**	**Responsible Production**
Intercept	2.294	0.377	0.743	1.138
Market pressure	**0.075**	0.025	0.010	0.036
Personal involvement	-0.024	0.213	0.015	0.068
Agricultural area	<0.001	<0.001	<0.001	<0.001
Soybean yield	<0.001	0.017	0.016	0.011
Age of producers	0.005	**0.018**	0.014	**0.012**
R^2	0.298	0.329	0.259	0.434
$F_{(5,19)}$	1.612	1.863	1.326	2.910
P	0.205	0.149	0.295	0.041

Personal involvement, Agricultural area and Soybean yield

The personal involvement, agricultural area and soybean yield did not have effect on Environmental, Social, Productive nor Responsible Production Profiles (p > 0.05 -

Table 1). Agriculture area and Soybean yield had no correlation ($R^2 = -0.15$, df = 23, $p < 0.05$). For medium and large properties, soybean yield in Midwest Brazil is independent from agriculture area.

Table 2. Relationship among Market Pressure items and Environmental Profile resulting from a linear regression analysis. Numbers in bold have $p < 0.05$.

	Environmental Profile		
	R^2	p	B
Buyers	0.093	0.138	0.079
Suppliers	0.045	0.308	0.066
Society	0.076	0.184	0.083
Trade unions and associations	**0.166**	**0.043**	**0.153**
Differential in marketing	0.095	0.135	0.107
Better sale conditions	0.123	0.085	0.119
Neighbors adopting responsible production	0.127	0.081	0.105
Comparison with neighbors	0.001	0.876	-0.017

Age of producers

Older landowners had better Social Profile and Responsible Production scores than younger landowners (Social Profile: b = 0.018, t = 2.252, df = 19, p = 0.036;

Responsible Production Profile: b = 0.012, t = 2.614, df = 19, $p = 0.017$ - Table 1). Age of producers interviewed ranged from 29 to 66 years old (mean = 52 ± 11). There was no significant correlation ($R^2 = 0.01$) between the age of producers and schooling (measured as years in school). When using schooling only as a categorical variable (i.e. separating producers who did not go to university from producers who at least started their undergraduate studies), the mean ages were not different (average age for low schooling was 54.6 years old whereas for high schooling was 53.3 years old, t(23) = 0.203, $p = 0.841$). Therefore, age and schooling of farmers were not related.

Schooling

Producers with higher schooling (i.e. which at least began their university studies) produce with greater social responsibility than producers with lower schooling levels (t = 2.529, df = 23, $p = 0.020$ - Table 3). Schooling, however, had no effect on Environmental, Productive or Responsible Production Profiles.

Table 3. Relationships between schooling and different Profiles (Environmental, Social, Productive and Responsible Production) estimated with a t-test. Numbers in bold have $p < 0.05$. All tests have 23 degree of freedom.

	Environmental	**Social**	**Productive**	**Responsible Production**
Mean high schooling	2.620	**2.510**	2.497	2.542
Mean low schooling	2.704	**2.069**	2.722	2.498
t	-0.519	**2.529**	-0.912	0.312
p	0.612	**0.020**	0.376	0.758

Discussion

In sum, for middle to large soybean producers in Brazil, responsible production practices adoption is affected by market pressure – positive related to environmental practices, age of producer – older farmers performed better in social and responsible production practices, and schooling – positive related to social practices.

Higher pressure of trade unions and associations on landowners induced the implementation of best environmental practices on farms. The environmental issue is the most debated topic of responsible production of rural areas in the media, been widely required by the society and government. Examples include meetings like the Conference of the Parties (COP), discussions on mechanisms such as the Reducing

Emissions from Deforestation and Forest Degradation (REDD+) and other payments for ecosystem services (Balderas Torres et al., 2013). Such global movement has implications for regional environmental practices. In recent years, the Brazilian government has launched several programs inducing farmers to environmental compliance. For example, in Pará State, the most deforested state in Brazil since 2006 (INPE, 2015), the state government launched the Green Municipality Program, in 2011, in partnership with municipalities, civil society, private companies, Brazilian Institute of Environment and Renewable Natural Resources (IBAMA), and Federal and State Public Prosecution Services. Such program aims to fight deforestation and strength sustainable production (Programs, 2013). The list of priority Amazon municipalities, created by the Federal Government through Decree nº6.321/2007, is another action that presses municipalities to improve the environmental issue of their farms. Farms of the listed municipalities are subjected to several restrictions (e.g. restrictions on financial credit), causing great commotion of society and inducing changes in producers' actions. Since 2007, 11 municipalities have already left the list. Nevertheless, the list still includes 41 municipalities.

Pressure of trade unions and associations, an item of "market pressure", positively affected the Environmental Profile of landowners. This may have occurred because trade unions and associations receive pressures from society and government, efficiently redirecting such pressures to producers. Due to the proximity between trade unions and associations and producers, this relationship trespass commercial aspects and may generate real results. Usually, producers have friends and relatives in trade unions and associations, and social support of pairs is more effective than the charging of less intimate players such as society, buyers or suppliers (Shumaker & Brownell, 1984). Society is usually understood as a more distant and abstract entity. Buyers and suppliers, in turn, have a more commercial and impersonal relationship with producers. Thus, the strengthening of trade unions and associations may effectively improve environmental practices on farms. Such improvement may be achieved because trade unions and associations pass the pressures received from society and government, often supporting landowners to achieve good results.

Unlike the environmental practices, productive and social practices receive less attention from media and society. Experts recognize that better productive practices increase productivity and resource use efficiency, and can reduce pressure on the environment, requiring lower areas to land use change (Koohafkan et al., 2012; Tilman et al., 2002). Despite this, society and government pay little attention on production efficiency on rural properties. Better productive practices are also linked to better social issues. Farms with more skilled, trained and motivated employees could use better production techniques, impacting less the environmental and worker health (Vanclay, 2011). However, these relationships and the importance of productive and social questions are not clearly disclosed and charged. As a consequence, the market pressure may not exist or have no effect. In our study, the Responsible Production Profile, calculated as the mean of Environmental, Social and Productive Profiles, was not affected by “market pressure”.

Personal involvement had no effect on any responsible production variable analyzed. Management of farms has changed over time. In the past, properties were smaller and personal involvement of landowner was complete, with the active participation of producer in all stages of production. Nowadays, many properties are similar to companies, with complex information systems and lower personal involvement of producer, which acts as a manager (e.g. Future Farm, project funded by the European Union). The Brazilian proverb "the eye of the owner is what fattens the cattle" means that rural properties under the close care of landowners achieve better results. Our results showed that even properties under less personal involvement of producers did not have their responsible production standard affected. Disconnection between personal involvement of rural producer and responsible production can occur because even producers that do not participate in daily activities of their farms may have an efficient management of their farms. Therefore, under the responsible production perspective, we should not worry about the conversion of properties into companies or stay alarmed with the existence of old fashion producers, who experience the daily life of property. New forms of personal involvement in the relationship between employers and employees seem to have neither negative nor positive impact on responsible production.

Despite experts recognize the importance of increased productivity for sustainable agriculture (Tilman et al., 2002) highly productive properties obtained Responsible Production scores similar to those of properties with lower productivity. Similarly, medium and large properties obtained comparable Responsible Production scores.

We were unable to identify which factor explains the observed relationship between older producers and best social and responsible production practices. However, we identified that such factor is not the same present in the variable schooling. Additionally, we identified that experience and culture (i.e. non-formal culture) are possible explanatory factors that should be better evaluated in future work. Experience is related to the largest working time on farms and the recognition of the benefits in maintaining a good working environment. Therefore, experience may be related to higher scores in Social Profile and to the practical learning on how to achieve a sustainable production, also increasing the higher scores of Responsible Production. Assuming these relationships, we are able to predict that producers tend to naturally improve practices in their farms over time. On the other hand, the cultural factor may indicate the values, mores and moral learned by older producers as well as the importance of interpersonal relations. Furthermore, cultural factor may directly affect farmer responsibility in practicing a sustainable agriculture.

Most farmers who took classes on university studied issues related to agriculture. Consequently, we expected that these producers had higher scores on Productive Profile by assuming that they had classes on efficient productive techniques. Better scores on Environmental Profile were also expected to be higher for producers with high schooling, since they supposed acquired environmental knowledge regarding the interrelationship between natural systems and the importance of ecological balance for production. However, we did not find such relationships (schooling affecting neither Responsible Production nor Environmental Profiles). Additionally, we expected that Social Profile would be the factor less affected by schooling due to the unusual addressing of this topic on Agronomy courses in Brazil (MEC, 2006). Nevertheless, contrary to our expectations, Social Profile was the only factor affected by schooling.

Relationship between higher schooling and better Social Profile score suggests that environmental and productive issues are more accessible to producers, regardless of formal studies. Other means, such as trade unions and associations, technical assistance or non-governmental organizations may be providing information to producers more equally, enabling the responsible production under the Environmental Profile and Productive Profile regardless of university studies. On the other hand, social issues may be not yet widely disseminated or motivated to be adopted. Therefore, only producers with higher levels of schooling and of access to information are properly instructed and/or motivated to adopt appropriate social practices. In this case, schooling may be more related to culture instead of technical knowledge.

Conclusions

Despite recognizing the existence of a variety of farmers (Vanclay, 2004), we revealed some key factors that affect the responsible production for medium and large soy producers in Midwest Brazil (representing almost half of soy production in Brazil, the second largest producer in the world). Market pressure, more specifically trade unions and associations, affect positively Environmental Profile. Age of producers has a positive effect on both Social and Responsible Production Profiles. Schooling positively affects Social Profile. Therefore, to improve the rural responsible production, society should focus its efforts in these specific points. Additionally, considering our findings and aspects of responsible production, the ideal farmer would be a person with more than 52 years old, associated to a trade union, and who had at least initiated his/her studies at university.

To improve the Environmental Profile of farms we should strengthen trade unions and associations, encouraging them to act closely with producers and assist them in their development, charging and supporting landowners. Trade unions and associations are organizations close to the producer, who have his trust and moral authority.

To improve the Social Profile of farms, we should invest on training and education of farmers. In addition to the access to technical training and academic experience, university promotes opportunities for producers, resulting in better social performance.

The pressure of society for responsible production has increased worldwide, been perceived by farmers. Such pressure is effective when combined with other actions (e.g. pressure by trade unions and associations), but may also be transformed into public policies to assist producers in the field. Only the cries of urban residents, with no further action, have no effect on rural responsible production.

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Capítulo 3: Larger farms and crop producers perform better for sustainable agricultural practices

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Abstract

Agriculture is the dominant use on Earth's surface but it has not been done in a sustainable way. Despite sustainable agriculture practices is an urgent need, there are many barriers to its adoption. There is no conclusive answer of the factors that influence sustainable agriculture practices adoption. Our goal is to comprehend how characteristics of rural property affect sustainable agriculture practices adoption by farmers. We evaluated 729 properties (3.4 million hectares) in Brazil, focused in industrial rural properties. Farmers with larger rural properties and crop producers perform better for sustainable agricultural practices than smaller and livestock producers, including have less liabilities, higher commitment and execution rate, and better environmental, social, productive and total score. Farms with certification have less liabilities and perform better in social score than farms without certification. We did not found neighborhoods' effect in sustainable agriculture. We strong suggest that government and society need to support farmers, mainly small and livestock producers,

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to achieve a more sustainable production. Instead of only laws and punition, we need to create positive incentives to eliminate financial constraints for sustainability, support farmers to be innovators, reduce their uncertainty (political and financial), and eliminate information gap.

Keywords

Agriculture; Conservation agriculture; Farming; Innovation; Natural resource management; Neighborhood effect; Policy; Rural property; Sustainability.

Introduction

World's biggest challenge is match the rapidly increasing demand for food with environmental and social sustainability, requiring, among other things, new farming practices (Godfray et al., 2012). We need to consider that agriculture ought to produce enough food to the world, but the vast majority of increase production of food must come from existing agricultural land, avoiding conversions from natural vegetation to agriculture (Foley et al., 2011; Godfray et al., 2012; Godfray & Garnett, 2014). We already use most of Earth's land to produce food - cropland cover about 12% of Earth's land area and pastures cover about 26% of Earth's land area, totalizing 38% of Earth's ice-free land (FAO, 2016). There is a growing concern that simply improve technology will not make farming more sustainable (Ervin et al., 2010). The goal is not only intensify to increase productivity, but sustainable intensify production to optimize food production in a complex landscape with environmental and social justice outcomes, recognizing and preserving ecosystem services that affect human well-being (Díaz et al., 2006; Ervin et al., 2010; Godfray et al., 2012; Godfray & Garnett, 2014).

Sustainable agriculture is not related to *conservation* meaning maintenance of status quo, but *conservation of ecological processes*, which requires the dynamism to became sustainable (Giller et al., 2015). Thus, sustainable agriculture includes intergenerational and intragenerational equity concerns and integration of multiple dimensions (Ervin et al., 2010), but with the need to increase yield and increase resource efficiency to meet the food demand (Foley et al., 2011). Although these main directions are clear and well accepted, sustainable agriculture has tens of definitions, emphasizing different values, priorities and goals. A precise and absolute description of what is sustainable agriculture is impossible because the nature of its concept is complex and related to local context (Pretty, 1995b). Currently it is possible to identify different approaches related to sustainable agriculture, such as Conservation Agriculture, Precision Agriculture, Integrated Pest Management, Organic Agriculture and Optimal Water Use Management for irrigation (Leite et al., 2014), with different characteristics. To adhere to one of those approaches it is important to consider that sustainable agriculture practices need to be tailored to local circumstances of the farmers (Corbeels et al., 2014; Giller et al., 2015). We have been using top-down approaches to promote sustainable agriculture, but we are not getting success (A. Reimer et al., 2014). For instance, Conservation Agriculture (CA) is a very well disseminated and studied practice, and is promoted by many international and non-governmental organizations in Africa, however CA is not successful adopted over the continent (Corbeels et al., 2014; Pittelkow et al., 2014). CA has three main fundamentals: (1) minimal soil disturbance, (2) permanent soil cover and, (3) crop rotation, including crop diversification (Andersson & D’Souza, 2014; Pittelkow et al., 2014). Despite many positive outcomes, CA has come under scrutiny, with limited results in many areas, including reducing yields and higher greenhouse gas emissions (Corbeels et al., 2014; Kuhn et al., 2016; Palm et al., 2014; Pittelkow et al., 2014). This is an example that neither practice of sustainable agriculture is 100% accepted without restrictions.

Considering those limitations, for the purposes of this study we defined sustainable agriculture based on Responsible Production practices developed by NGO Aliança da Terra, which its’ success was published recognized (Galford et al., 2013; Soares-Filho et al., 2012). The Responsible Production practices are more comprehensive than other practices such as CA and are not related to only adopt new agricultural technologies. Responsible Production practices include a set of 48 topics to compose Responsible Production Score – 19 of Environmental Score, 12 of Social Score and 17 of Productive Score. In Environmental Score is included topics related to Conservation of native vegetation, Fire prevention, Soil conservation, Waste management, Responsible use of fertilizers and agrochemicals, and Legal environmental regularization. In Social Score is included topics related to Labor condition, Labor health and safety, Labor training, Labor house quality, Child welfare, and Personal freedom. In Productive Score is included topics related to Legal compliance, Infrastructure, Animal welfare, Professionalism, and Technology and Innovation adoption. Farmers receive a document with all liabilities of the farm and chose, with support from a specialized analyst, how and when he/she will resolve the liabilities. This participation to choose the better technique, empowering farms, has great influence on farmers' engagement.

Even knowing that sustainable agriculture practices can improve yields and meet society' demand, these practices found barriers to its adoption. Norms and laws are not enough to change farmers behavior (Stickler et al., 2013a). The process by which decision is reached plays fundamental role in the quality of the decision-making (Sayer et al., 2013). The social network of farmer, socio-economic and institutional contexts play important role in enhancing sustainable practices adoption, including governmental subsidies, agricultural policies, and markets (Andersson & D'Souza, 2014; Knowler & Bradshaw, 2007; Wossen et al., 2013). Farms need to be profitable and farmers are rational self-interest in maximizing their economic returns, such as other entrepreneurs. Perception of a clear financial benefit for sustainable practices is a major factor to farmers adopt sustainable agriculture practices, whereas perceived cost of sustainable practices is the greatest barrier (Morgan et al., 2015; Perry-Hill & Prokopy, 2014). Consequently, the lack of short time increase in farm income can explain in many cases the non-adoption of sustainable farming practices (Corbeels et al., 2014). Artificial incentives such as provided by international donors payments, although can support fast spread of adoption of sustainable practices, can also jeopardize its sustainability if it is the main method to influence farmers adoption (Andersson & D'Souza, 2014).

Many recent reviews about what affect adoption of sustainable agriculture produced inconclusive results (Reimer et al., 2014). Knowler and Bradshaw (2007) did not found any variable that could universally explain adoption in 130 case studies. They also conduct an analysis by region and find that farm size tends to be significant in studies in Africa, whereas farmers` education tends to be significant in studies in North America (Knowler & Bradshaw, 2007). Prokopy et al. (2008b) used vote count to analyze sustainable agriculture practices in United States. The methodology could not distinguish variable significance, and "the results are clearly inconclusive about what factors consistently determine" adoption (Prokopy et al., 2008b). Baumgart-Getz, Prokopy and Floress (2012) realized a meta-analysis of 46 studies to investigate the motivations of farmers in United States to adopt best management practices. The most important variables in adoption were "access to and quality of information, financial capacity, and being connected to agency or local networks of farmers or watershed groups" (Baumgart-Getz et al., 2012).

In light of these inconclusive answers and the importance of the context, a better way to investigate sustainable practices adoption is research in a particular locality (Dunn et al., 2016). Brazil is the leading global producer and exporter of beef and soy and maintains one of the highest absolute rates of deforestation in the world (INPE, 2015). This agricultural growth pattern reinforced Brazil' status as one of the world's most inequitable countries in terms of income distribution (Martinelli et al., 2010). Although these dangerous situation, we found only one study of motivations to adopt sustainable agricultural practices. Leite et al. (2014) studied 53 grain farmers from São Paulo State (southeast Brazil) and described that farmers with larger areas have greater adoption rate of sustainable agricultural practices than farmers with small areas. They also pointed that "increase productivity" is the most relevant factor to adopt sustainable agriculture practices, whereas "lack of agricultural policy" is the most relevant barrier (Leite et al., 2014). They founded that higher farm size generally lead to better adoption rates, because usually small farms have more difficult to adopt sustainable practices (Chopin & Blazy, 2013; Dunn et al., 2016; Prokopy et al., 2008a). However, even this variable has exceptions (e.g. Tavernier & Tolomeo, 2004). Amsalu & de Graaff (2007) found contradictory results. Farm size has a positive effect in adoption of a sustainable agriculture practice in Ethiopian, but negative effect in continued use this practice (Amsalu & de Graaff, 2007). Although we can hypothesize that larger farmer will present higher adoption rates and a more sustainable production, the uncertainty of previous studies and lack of data from Brazil make this investigation necessary.

Here, we pursue a better understanding about adoption of sustainable practices in three predominant production activities: (i) Livestock, (ii) Crop producers, and (iii) Mixed Crop-Livestock. We were unable to find studies comparing adoption rates among different productions, but we have reasons to expect differences. In Brazil, livestock producers are predominantly more traditional farmers, and normally they are less familiarized with risk exposure. In Brazil herd is culturally considered a safety investment. Vast regions of Brazilian Amazon are slightly profitable even for extensive and non-technological cattle ranching (Bowman et al., 2012). Pressures on livestock producers are mainly focused to stop deforestation, such as cattle agreement (Gibbs et al., 2015; Nepstad et al., 2014). On the other hand, crop producers and mixed crop-livestock producers are generally farmers that need to invest many funds and time to promote innovations to enhance yields and be profitable. They need to take decision fast and they are more familiarized to risk exposure. Pressures on crop producers includes stop deforestation such as Soy Moratorium, but also contain, through supply chain interventions such as international certification, responsibilities to produce in a sustainable way (Gibbs et al., 2015; Gyau et al., 2014; RTRS, 2013; Soares-Filho et al., 2012). Mixed crop-livestock systems can enhance both activities through synergies among productions and receive pressures from both sides (Herrero et al., 2010). So, we can hypothesize that crop producers and mixed crop-livestock producers will present higher adoption rates and a more sustainable production than livestock producers. We hypothesize that among crop producers and mixed crop-livestock producers, producers with supply chain certification will present higher adoption rates and a more sustainable production than producers without certification.

An important factor that influences farmers' actions is neighborhoods' pressure (McGuire et al., 2013). The opinion of neighborhoods is important to farmers because they seek social approval in sustainable actions and they wish to show commitment to common values (Borges et al., 2014; Michel-Guillou & Moser, 2006). Farmers can even modify their identity due to saw their neighborhoods acting in sustainable way (McGuire et al., 2013). Consequently, neighborhoods can positively affect adoption of sustainable practices (van Dijl, Grogan, & Borisova, 2015). Thus, we hypothesize that will exist a strong spatial autocorrelation in sustainable agriculture practices among farmers.

Our goal is to comprehend how characteristics of rural property affect sustainable agriculture practices adoption by farmers. We evaluated sustainable agriculture scores (environmental, social, productive and total score), number of liabilities (problems in a rural property that farmer can resolve), intention to change, execution of sustainable practices and neighborhoods' effect. Our hypothesis are: (i) we will find high neighborhoods' effect in sustainable agriculture; (ii) larger properties and crop producers / mixed crop-livestock producers perform better for sustainability than farmers in smaller properties and livestock producers; (iii) among crop producers and mixed crop-livestock producers, properties with certification will have more sustainable agriculture production than properties without certification (Table 1). Considering both the extension of our questions and the nature of our dataset – that included a large sample of agriculture farms in a large geographic area -- we expect that our findings provide a support to design new polices that promote sustainable agriculture practices adoption.

Table 1: Our hypothesis for the relation between independent variables (in columns) and dependent variables (in lines).

<table>
<tr><th colspan="2"></th><th>Property size</th><th>Predominant production</th><th>Certification*</th><th>Neighbors' effect</th></tr>
<tr><td colspan="2">N° of liabilities</td><td>Without relation</td><td>Livestock > (Mixed crop-livestock = Crop producer)</td><td>No > Yes</td><td rowspan="7">Strong effect</td></tr>
<tr><td colspan="2">Commitment rate</td><td rowspan="6">Positive relation (larger properties > smaller properties)</td><td rowspan="6">(Crop producer = Mixed crop-livestock) > Livestock</td><td rowspan="6">Yes > No</td></tr>
<tr><td colspan="2">Execution rate</td></tr>
<tr><td rowspan="4">Score</td><td>Environmental</td></tr>
<tr><td>Social</td></tr>
<tr><td>Productive</td></tr>
<tr><td>Total</td></tr>
</table>

* Certification was evaluated only to crop and mixed crop-livestock producers.

Methods

Different from most of related studies, our response variable was collect in the field, and not through interview with farmers, a common caveat from many studies (Prokopy et al., 2008b). The data was collected by field team of NGO Aliança da Terra from 729 private rural properties in Brazil (http://aliancadaterra.org/), which gentle shared the data for this work. Aliança da Terra is a Brazilian NGO established in 2004 with the mission to create a popular mobilization, originating among farmers and adopted across Brazil. The 729 properties of our sample have in total 3.4 million hectares (mean = 4,670 hectares, ± 11,426 hectares), with 1.5 million hectares of native vegetation. We investigated properties in 12 Federal States (Bahia, Goiás, Minas Gerais, Mato Grosso, Mato Grosso do Sul, Pará, Paraná, Piauí, Rondônia, Roraima, São Paulo and Tocantins) and in Federal District, totaling properties in 156 Brazilian municipalities. In these properties, there are almost 14 thousand employees.

We focus this study on industrial rural properties. We understand industrial rural properties as farms that produces commodities (such as soy, corn or beef) aiming primarily to sell and supported by paid labor. Family farm production was not analyzed in this study.

Most of the properties are located in central-west region (613 properties – 84.1%), the most productive agriculture area in Brazil (Sidra, 2017). This region comprises 31.6% of agriculture area in Brazil, but is responsible in 2016 for 48% of the corn and 45% of the soy produced in Brazil (Sidra, 2017). This region is predominantly occupied by Cerrado biome, a biodiversity hotspot with high endemism rate (Klink & Machado, 2005). Cerrado biome is highly threatened by anthropogenic actions, including conversion agriculture expansion, with severe impacts for biodiversity and ecological functions (Brannstrom et al., 2008; Carvalho et al., 2009; Dobrovolski et al., 2011; Rangel et al., 2007; Silva et al., 2006). This region is where the recent agricultural expansion has taken place (Sparovek et al., 2010).

During a technical visit, it is collected all data in each farm. It was visited all parts of the property recording GPS information and taking photos of every detail. It was identified and georeferenced all land uses and recorded the agriculture techniques, erosion and barriers to control erosion, labor conditions, infra structure adequacy, and farm management. After data processing in laboratory, it is delivered to farmers a Social and Environmental Diagnostic, which contains the good points and the points to be improved on the property. The number of liabilities means number of problems in a rural property that farmer can improve through a sustainable agriculture practice. It is also described in these Diagnostic how to resolve the liabilities. Farmer voluntarily commit to adopt certain sustainable agriculture practices to correct its liabilities. Therefore, information is no longer an impediment to the adoption of sustainable agriculture practices.

It is continually offered support to farmers to improve their farms through information and technical assistance. All this process is completely voluntary and non-punitive to farmers.

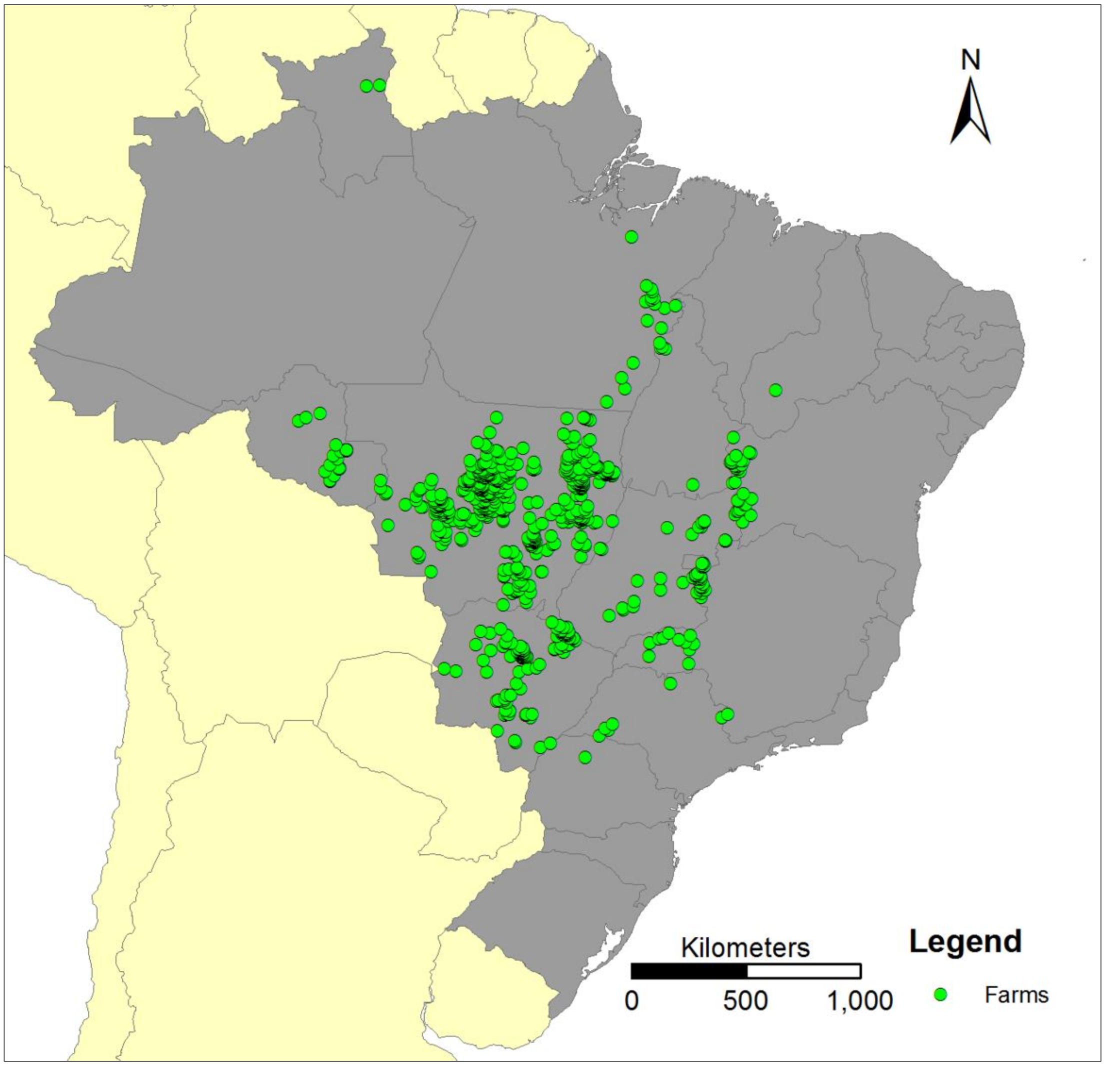

Figure 1: Farms evaluated in Brazil. Mostly of the farms are in central-west region, the most agricultural productive and ecological threatened region in Brazil.

Dependent variables

Number of liabilities

These data are obtained in the field through observing farming practices and visiting all area and buildings. Examples of liabilities are recovering riparian vegetation, maintenance of firebreaks or correctly dispose farms' waste. We used for this variable data from 614 farms because we used only farms visited and that we have confidence of the total number of liabilities of the farm.

Commitment rate

Farmer could commit to sustainable agriculture practices he/she was planning to develop. Commitment rate was calculated as the number of commitments to apply sustainable agriculture practice to resolve some liability divided by the total number of liabilities of the farm. This variable ranges from zero – farmers that do not commit to any change in the farm, to one – famers that commit to resolve all liabilities through applying all sustainable agriculture practices. We used for this variable data from 542 farms because we used only farms that farmer received support from NGO analyst about how to resolve farm's liabilities.

Execution rate

The Execution rate was calculated as the number of sustainable agriculture practices developed divided by total number of commitments done by farmer. This variable ranges from zero – farmers that did not change anything he/she committed, to one – farmers that executed all commitments done previously. We used for this variable data from 231 farms because we used only farms that have commitment to implement at least one sustainable agriculture practice until 2013 and our team could verify this implementation in 2014.

Environmental, Social, Productive and Total Scores

We collect data of each property from a check list which includes a set of 48 topics related to sustainable agriculture practices. These topics can be divided into three categories – Environmental, Social and Productive.

In Environmental Score is included topics related to:

- Conservation of native vegetation (% of riparian zones preserved, % of native vegetation preserved according to Brazilian Law, anthropogenic interferences in native vegetation);

- Fire prevention (firebreaks, equipment to combat fire and training to combat fire);

- Soil conservation (organic matter, conservation agriculture techniques, number and condition of erosions);

- Waste management (Residual Management Plan, waste disposal, selective collection);

- Responsible use of fertilizers and agrochemicals (agrochemical application control, agrochemical application techniques, agrochemical storage, empty packages transference);

- Legal environmental regularization (Rural Environmental Registry – in Portuguese CAR, environmental licenses and regularization of native vegetation reserve).

In Social Score is included topics related to:

- Labor condition (hiring process, Legal registry of employees, recreational areas);

- Labor health and safety (personal protective equipment – PPE, actions to prevent accidents, water access);

- Labor training (employees training);

- Labor house quality (adequacy and structure of houses);

- Child welfare (children education and health, prohibition of children work);

- Personal freedom (communication between employer and employee and labor association freedom).

In Productive Score is included topics related to:

- Legal compliance;

- Infrastructure (all structures, such as warehouse);

- Animal welfare;

- Professionalism (support from technical guidance);

- Technology and Innovation adoption.

Each topic received a score that ranges from 0 (not implemented) to 3 (totally implemented). We calculated the mean score of the topics of each category (Environmental, Social and Productive). The mean score of the three categories results in the Total Score. We used for this variable data from 722 farms because we used only farms that received scores.

Independent variables

Neighborhoods' effect

The variable Neighborhoods' effect is obtained from the spatial localization of each farm. We used the geographic coordinates obtained during field data collection of the principal house or principal office of the farm. The distance among farms is calculated as the minimum distance in straight line to evaluate the spatial autocorrelation in sustainable agriculture practices among farmers.

Property size

Property size is a usual variable to understand sustainable agriculture practices (e.g. Amsalu & de Graaff, 2007; Chopin & Blazy, 2013; Dunn et al., 2016; Leite et al., 2014; Prokopy et al., 2008b). To analyze this variable, we used the number of fiscal modules of each farm. Fiscal module is a Brazilian official land measurement unit that corresponds to the minimum area required for a farm to be economically viable. The fiscal module was determined for each municipality by law (Law No. 6,746, of December 10, 1979) and considers the predominant type of rural properties in the county, income from the predominant type of exploration, and other significant types of land exploration in the county. The use of this measure allows to control for the inherent discrepancies related to the enormous extent of Brazil that caused that a farmer with 50 hectares near a big city, such as São Paulo, may have totally different constrains that the same 50 hectares has in the middle of Amazon, such as Tefé county. Using the fiscal module approach, we can compare in a fair way the property size in all Brazil. In our previous example 50 hectares in São Paulo is equivalent to 1,000 hectares in Tefé, since in São Paulo one fiscal module has 5 hectares and in Tefé one fiscal module has 100 hectares.

Property size sampled ranged from 7 to 159 thousand hectares (mean of 4,170 hectares, ± 11,426 hectares). In fiscal module, property sizes samples ranged from 0.12

to 2,278 fiscal modules (mean of 66.6 fiscal modules, ± 159.5 fiscal modules). Because these huge variation, we used on the analyzes the logarithm of the fiscal modules as property size.

Predominant production

Although predominant production is not a usual variable used in sustainable agriculture practices adoption studies, we developed earlier (in introduction section) reasons to expected differences among productions. We classified each farm in one of three categories of predominant production: (i) Livestock, (ii) Crop producers, and (iii) Mixed Crop-Livestock.

Certification

We analyzed the variable Certification for two predominant production categories, Crop producers and Mixed Crop-Livestock, because we analyzed two commodity certification schemas: Round Table on Responsible Soy (RTRS), and International Sustainability & Carbon Certification (ISCC). RTRS is "the result of a multi-stakeholder development process" initiated in 2004 and officially launched in 2006 and today has more than 180 members from 20 countries (RTRS, 2013; Schouten et al., 2012). In 2014 RTRS certified 1,3 million tons of soy, and 60% of this came from Brazil (RTRS, 2016). ISCC is a "multistakeholder initiative governed by an association with currently more than 80 members" which has a "certification system covering the entire supply chain and all kinds of biobased feedstocks and renewables" started in 2010 (ISCC, 2016). Both certification schemas created a standard for sustainable agriculture and have certified farms in Brazil. Farms that have certification of at least one of these commodity certification schemas received value 1. Farms that do not have any certification received value 0.

Statistical analyzes

Neighborhoods' effect

To analyze Neighborhoods' effect we measure spatial autocorrelation using Moran's I spatial autocorrelation coefficient (Zuur et al., 2007). The numerator of Moran's I consists of a sum of cross-products of centered values comparing the values found at all pairs of points in the 14 distance classes used (Legendre & Fortin, 1989). We used equal distances to define class size. Moran's coefficient ranges from -1 to 1, with positive values corresponding to positive spatial autocorrelation and negative values corresponding to negative spatial autocorrelation. Values near to 0 mean that there is no spatial correlation (null hypothesis). Usually Moran's I coefficients > 0.10 in the first distance class represent significant positive spatial structures (Rangel et al., 2010). We did seven analyzes, one for each dependent variable (number of liabilities, commitment rate, execution rate, Environmental Score, Social Score, Productive Score and Total Score). We analyzed the data in SAM program (Rangel et al., 2010).

Property size, Predominant production and Certification

All analyzes were done in R program (R Core Team, 2015). To analyze the effect of Property size, Predominant production and Certification in number of liabilities, commitment rate and execution rate we used a Generalized Least Squares (GLS) model (Table 2). We need to use GLS because our data presented auto-correlated residuals, and through GLS we impose a variance structure to explicitly include those elements in the model and, consequently, our parameter estimators had better statistical properties and our model was more informative (Robinson & Hamann, 2011). We tested several variance structures to test which fits better the model. The variance structures tested were fixed variance, different variances per stratum, power of the variance covariate, exponential of the variance covariate, constant plus power of the variance covariate, and a combination of variance functions. We chose the variance structure based on the model with lowest AIC and made a graphical validation of the optimal model (Zuur et al., 2009). In number of liabilities analyzes we made a logarithm of liabilities to reduce variability. To analyze liabilities and execution rate we used exponential of the variance covariate of property size and predominant production. To analyze commitment rate, we used different variances per stratum in predominant production. To analyze liabilities and certification we used different variances per stratum in certification and constant plus power of the variance covariate in property size. To analyze commitment rate and certification we used constant plus power of the variance covariate of property size. To analyze execution rate and certification we used exponential of the variance covariate in property size. We get the results from the optimal model and analyze if the interaction has effect on dependent variable using Anova. If the interaction did not present effect, we analyzed the independent factors singly.

To analyze the effect of Property size, Predominant production and Certification in Environmental Score, Social Score, Productive Score and Total Score we used

Ordinal Logistic Regression (Table 2). The Ordinal Logistic Regression was suitable for our purpose because our response variables were ordered in four categories (scores 1, 2, 3 or 4). The Ordinal Logistic Regression is an extension of the logistic model and can be called proportional odds or cumulative logit model (Kleinbaum & Klein, 2010). We used Odds Ratios (OR) and Odds Ratio Confidence Interval (ORCI) to evaluate the size of the effect (Kleinbaum & Klein, 2010). If the ORCI is always above or always under 1, we considered that the variable has effect. But, if ORCI cross number one, we considered that the variable does not have effect.

Table 2: Analyzes done to evaluate the effect of predictor variable (first line) in response variables of sustainable agriculture (lines).

		Property size x Predominant production	Property size x Certification	Neighborhoods' effect
N° of liabilities		Generalized Least Squares (GLS) with variance structure (fitted to each model)		Moran I
Commitment rate				
Execution rate				
Score	**Environmental**	Ordinal Logistic Regression		
	Social			
	Productive			
	Total			

Results

Result Overview

Considering the complexity of the results of this work, we presented in table 3 an overview of all relevant results. We offer this summary as a guide to the more detailed statistical results that will be presented in the next sub-sections.

Table 3: Summary of the results of the analyzes of property size, predominant production and international supply chain certification on sustainable agriculture practices.

		Property size and Predominant Production	Property size and Certification	Neighborhood' effect
Nº of liabilities		Interaction (increasing property size increases liabilities, Livestock increases > Mixed Crop-Livestock > Crop)	No Certification > Certification and Larger properties > Smaller properties	No effect
Commitment rate		Crop > (Mixed Crop-Livestock = Livestock)	No effect	
Execution rate		Larger properties > Smaller properties	Larger properties > Smaller properties	
Score	**Environmental**	(Crop = Mixed Crop-Livestock) > Livestock and Larger properties > Smaller properties	Larger properties > Smaller properties	
	Social	Interaction (increasing property size increases social scores for Crop)	Certification > No Certification	
	Productive	Larger properties > Smaller properties	Larger properties > Smaller properties	
	Total	(Crop = Mixed Crop-Livestock) > Livestock and Larger properties > Smaller properties	Larger properties > Smaller properties	

Neighborhoods' effect

We did not find a Neighborhoods' effect in sustainable agriculture practices score, number of liabilities, commitment rate nor execution rate for Brazilian farms. In all cases Moran's I coefficients in the 1st distance class were < 0.10. This occurred to all dependent variables (Table 4).

Table 4: Results for Neighborhoods' effect for dependent variables. In all cases Moran's I coefficients in the 1st distance class were < 0.10, representing no spatial autocorrelation.

		Neighborhoods' effect **Moran's I coefficients in the 1st distance class**
N° of liabilities		0.096
Commitment rate		0.020
Execution rate		<0.001
Score	**Environmental**	0.062
	Social	0.045
	Productive	0.035
	Total	0.044

Property size and Predominant production

The interaction between property size and farm predominant production affected the number of liabilities in each rural property ($F_{608,2}$= 5.571, p = 0.004 – Table 5). In general, larger farms had more liabilities, but this phenomenon is more evident to livestock producers, followed by mixed crop-livestock producers (regression coefficients respectively, 8.086 and 6.835). Crop producers were less affect by increasing rural property size (regression coefficient = 4.404). For a farm with property size of 1 Fiscal Module, if the predominant production is Crop the predicted number of liabilities is 10, if is Mixed Crop-Livestock or Livestock is 18 liabilities. For a farm with property size of 10 Fiscal Modules, if the predominant production is Crop the predicted number of liabilities is 10, if is Mixed Crop-Livestock or Livestock is 19 liabilities. For a farm with property size of 100 Fiscal Modules, if the predominant production is Crop the predicted number of liabilities is 16, if is Mixed Crop-Livestock is 24 and if is Livestock is 25 liabilities.

Crop producers had higher commitment rates to implement sustainable agriculture practices than mixed crop-livestock producers and livestock producers ($F_{536,2}$= 7.701, p = 0.001 – Table 5). Crop producers committed to implement in their farms 71.2% of the suggestions presented to improve their sustainable agriculture (95% CI 68.5% - 74.0%). Mixed crop-livestock and livestock producers committed to 63.1% and 60.8%, respectively (95% CI 57.9% - 68.2% and 55.1% - 66.4%). The interaction among property size and property predominant production and only property size did not present effect in commitment rate (respectively $F_{536,2}$= 2.303, p = 0.101 and $F_{536,1}$= 0.354, p = 0.552).

Larger properties presented higher execution rates of sustainable agriculture practices ($F_{225,1}$= 4.525, p = 0.035 – Table 5), however the effect is small, with regression coefficient = 0.0002. According to predicted values, for property size of 5, 10, 50 and 100 hectares, crop producers presented execution rates of 83%, 85%, 88% and 90%, and mixed crop-livestock producers presented execution rates of 73%, 76%, 82% and 84%, respectively. Livestock producers presented execution rates of 79% for all property sizes. The interaction among property size and property predominant production and only property predominant production did not present effect in execution rate (respectively $F_{225,2}$= 0.839, p = 0.436 and $F_{225,2}$= 2.813, p = 0.062).

Larger properties and farms with crop had better environmental score (property size: OR = 5.229 CI = 3.288 – 8.544; mixed crop/livestock: OR = 4.260 CI = 1.369 – 13.569; crop: OR = 4.142 CI = 1.730 – 10.182 – Table 6). For each increase in 10 Fiscal Modules, the rural property had more than five times higher chance to get a better environmental score. Farms with predominant production of crop and mixed crop-livestock had more than four times higher chance to get better environmental scores than livestock farms. Mixed crop/livestock and crop producer had the same chance to get better environmental score. We did not find effect for interaction among property size and predominant production in environmental score (mixed crop/livestock-property size: OR = 0.650, CI = 0.311 – 1.350; crop-property size: OR = 0.613, CI = 0.323 – 1.157).

The interaction among property size and crop production affected the social score (OR = 2.614 CI = 1.526 – 4.509 – Table 6). Larger farms with crop as the predominant production had more than 2.6 times higher chances the increase social score. We did not find effect for interaction among property size and mixed crop/livestock production in social score (OR = 0.831 CI = 0.455 – 1.525).

Larger properties had better productive score (OR = 2.360 CI = 1.656 – 3.400 – Table 6). For each increase in 10 Fiscal Modules in the property size, the rural property had more than double of chance to get a better productive score. We did not find effect for interaction among property size and any predominant production nor for any predominant production in productive score (mixed crop/livestock-property size: OR = 0.870, CI = 0.486 – 1.548; crop-property size: OR = 1.308, CI = 0.785 – 2.174; mixed crop/livestock: OR = 2.037, CI = 0.821 – 5.140; crop: OR = 1.488, CI = 0.739 – 3.010).

Larger properties and farms with crop had better total score (property size: OR = 4.828 CI = 3.019 – 7.983; mixed crop/livestock: OR = 6.155 CI = 1.955 – 19.850; crop: OR = 5.649 CI = 2.300 – 14.401 – Table 6). For each increase in 10 Fiscal Modules in property size, the rural property had almost five times higher chance to get a better total score. Farms that include crop production in the predominant production had more than five times higher chance to get better total scores than only livestock farms. We did not find effect for interaction among property size and any predominant production in total score (mixed crop/livestock-property size: OR = 0.526, CI = 0.253 – 1.086; crop-property size: OR = 0.572, CI = 0.301 – 1.076).

Property size and Certification

For crop and mixed crop-livestock producers, larger properties presented more liabilities than smaller properties ($F_{488,1}$= 79.107, $p < 0.001$ – Table 7), however the effect is small, with regression coefficient = 0.1251. Properties with international supply chain certification had fewer liabilities than properties without certification ($F_{488,1}$= 12.487, $p < 0.001$; 17.9 ± 19.3 liabilities for farms with certification and 21.6 ± 24.3 for farms without certification). The interaction among property size and certification did not have effect on number of liabilities ($F_{488,1}$= 0.066, $p = 0.797$).

International supply chain certification and property size did not affect commitment rate, neither the interaction nor the variables alone (for interaction $F_{431,1}$=

0.125, p = 0.723, for certification $F_{431,1}$= 1.947, p = 0.164, and for property size $F_{431,1}$= 0.252, p = 0.616 – Table 7).

Larger farms had higher execution rates ($F_{174,1}$= 7.199, p = 0.008 – Table 7), however the effect is small, with regression coefficient = 0.037. Neither the interaction among certification and property size nor certification affected execution rate (for interaction $F_{174,1}$= 0.142, p = 0.706, for certification $F_{174,1}$= 1.300, p = 0.256).

Larger properties had greater chance to increase their environmental score (OR = 3.045 CI = 2.155 – 4.354 – Table 8). For each increase in 10 Fiscal Modules in the property size, the rural property had more than three times higher chance to get a better environmental score. We did not find effect for interaction among property size and certification nor for certification in environmental score (OR = 1.181, CI = 0.292 – 4.249 for interaction and OR = 2.331, CI = 0.277 – 24.583 for certification).

Farms with certification had greater chance to increase their social score (OR = 8.435 CI = 1.458 – 48.863 – Table 8). Properties with international supply chain certification had eight times higher chance to have a better social score than properties without certification. We did not find effect for interaction among property size and certification nor for property size in social score (OR = 0.484, CI = 0.171 – 1.384 for interaction and OR = 1.134, CI = 0.836 – 1.546 for property size).

Larger properties had greater chance to increase their productive score (OR = 2.409 CI = 1.785 – 3.262 – Table 8). For each increase in 10 Fiscal Modules in the property size, the rural property had more than 2.4 times higher chance to get a better productive score. We did not find effect for interaction among property size and certification nor for certification in productive score (OR = 1.925, CI = 0.660 – 5.528 for interaction and OR = 0.365, CI = 0.066 – 2.080 for certification).

Larger properties had greater chance to increase their total score (OR = 2.482 CI = 1.787 – 3.484 – Table 8). For each increase in 10 Fiscal Modules in the property size, the rural property had almost 2.5 times higher chance to get a better total score. We did not find effect for interaction among property size and certification nor for certification in total score (OR = 1.171, CI = 0.301 – 4.177 for interaction and OR = 1.970, CI = 0.250 – 18.690 for certification).

Table 5: Analyzes of Property size and Predominant production and number of liabilities, commitment rate and execution rate, with effect size (if statistical significant), F value, degree freedom, and p value. For number of liabilities and execution rates, the effect size is a regression coefficient. For Commitment rate, the effect size is the percentage and it 95% Confidence Interval of each predominant production. The significant values are in bold.

	N° of liabilities	Commitment rate	Execution rate
Property size	$F_{608,1}$= 246.486 ; p= <0.001	$F_{536,1}$= 0.354 ; p= 0.552	**Regr. Coef.: 0.035** **$F_{225,1}$= 4.525 ; p= 0.035**
Production	$F_{608,2}$= 24.678 ; p< 0.001	**Crop=71.2% (68.5%-74.0%), Mixed crop/livestock=63.1% (57.9%-68.2%), Livestock=60.8% (55.1%-66.4%)** **$F_{536,2}$= 7.701 ; p= 0.001**	$F_{225,2}$= 2.813 ; p= 0.062
Interaction	**Regr. Coef.: Livestock=8.086, Mixed crop/livestock= 6.835, Crop=4.404** **$F_{608,2}$= 5.571 ; p= 0.004**	$F_{536,2}$= 2.303 ; p= 0.101	$F_{225,2}$= 0.839 ; p= 0.434

Table 6: Analyzes of Property size and Predominant production and Responsible Production scores. The significant values are in bold. We present the Odds Ratio (OR) and in parentheses the Confidence Interval of the Odds Ratio.

	Score			
	Environmental	**Social**	**Productive**	**Total**
Property size	**OR= 5.229 (3.288 – 8.544)**	OR= 0.681 (0.457 – 1.009)	**OR= 2.360 (1.656 – 3.400)**	**OR= 4.828 (3.019 – 7.983)**
Mixed crop/livestock	**OR= 4.260 (1.369 – 13.569)**	OR= 2.957 (1.107 – 7.870)	OR= 2.037 (0.821 – 5.140)	**OR= 6.155 (1.955 – 19.850)**
Crop	**OR= 4.142 (1.730 – 10.182)**	OR= 0.609 (0.276 – 1.335)	OR= 1.488 (0.739 – 3.010)	**OR= 4.828 (3.019 – 7.983)**
Interaction - Mixed crop/livestock : property size	OR= 0.650 (0.311 – 1.350)	OR= 0.831 (0.455 – 1.525)	OR= 0.870 (0.486 – 1.548)	OR= 0.526 (0.253 – 1.086)
Interaction – Crop : property size	OR= 0.613 (0.323 – 1.157)	**OR= 1.614 (1.526 – 4.509)**	OR= 1.308 (0.785 – 2.174)	OR= 0.572 (0.301 – 1.076)

Table 7: Analyzes of Property size and Supply Chain Certification for crop and mixed crop-livestock producers and number of liabilities, commitment rate and execution rate, with effect size (if statistical significant), F value, degree freedom (subscript), and p value. For property size the effect size is a regression coefficient. For Certification the effect size is the mean ± Standard Deviation of farms with and without certification. The significant values are in bold.

	N° of liabilities	Commitment rate	Execution rate
Property size	**Regr. Coef.: 0.125** **$F_{488,1}$= 76.107 ; p= <0.001**	$F_{431,1}$= 0.252 ; p= 0.616	**Regr. Coef.: 0.037** **$F_{174,1}$= 7.199 ; p= 0.008**
Certification	**With cert.: 17.9 ± 19.3** **Without cert.: 21.6 ± 24.3** **$F_{488,1}$= 12.487 ; p< 0.001**	$F_{431,1}$= 1.947 ; p= 0.164	$F_{174,1}$= 1.300 ; p= 0.256
Interaction	$F_{488,1}$= 0.066 ; p= 0.797	$F_{431,1}$= 0.125 ; p= 0.723	$F_{174,1}$= 0.142 ; p= 0.706

Table 8: Analyzes of Property size and international supply chain Certification for crop and mixed crop-livestock producers and Responsible Production scores. The significant values are in bold. We present the Odds Ratio (OR) and in parentheses the Confidence Interval of the Odds Ratio.

	Score			
	Environmental	**Social**	**Productive**	**Total**
Property size	**OR= 3.045 (2.155 – 4.354)**	OR= 1.134 (0.836 – 1.546)	**OR= 2.409 (1.785 – 3.262)**	**OR= 2.482 (1.787 – 3.484)**
Certification	OR= 2.331 (0.277 – 24.582)	**OR= 8.435 (1.458 - 48.863)**	OR= 0.365 (0.066 – 2.080)	OR= 1.970 (0.250 – 18.690)
Interaction	OR= 1.181 (0.292 – 4.249)	OR= 0.484 (0.171 – 1.384)	OR= 1.925 (0.660 – 5.528)	OR= 1.171 (0.301 – 4.177)

Discussion

We tested how characteristics of rural property, namely property size, predominant production, supply chain certification and neighborhoods' effect, influence sustainable agriculture practices adoption by farmers in Brazil. We rejected our first hypothesis – we did not find neighborhoods' effect in sustainable agriculture – confirmed our second hypothesis – larger properties and crop producers performed better for sustainability than farmers in smaller properties and livestock producers – and partially confirmed our third hypothesis – among crop producers and mixed crop-livestock producers, properties with certification had less liabilities and performed better in social area than properties without certification.

The most prominent result is the effect of property size, with larger farms performing better than small farms. For industrial rural properties (farms that produces commodities using paid labor), we found that larger farms, although have more liabilities to resolve, present higher willing to improve sustainability in their production and have better sustainable agriculture scores for environment, production and total score.

In general, larger properties are commonly associated with more professional agriculture, more investments, more access to financial credits and closely linked to market pressure and policies. Larger farms tend to boost the benefits of sustainable agriculture practices adoption and, consequently, increase the likelihood of adoption (D. J. Pannell et al., 2006). Although this is not a pattern found in everywhere with every practice (e.g. D'Emden et al., 2008; Tavernier & Tolomeo, 2004), we found that property size is a relevant factor in Brazil. The other study for sustainable practices adoption in Brazil, Leite et al. (2014), also found that larger farms perform better and have better adoption rates than smaller farms. Nevertheless, these results should not discourage Brazilian small properties to pursue sustainability. First, the scope of this study is the industrial agriculture properties, and we are not comparing familiar agriculture and industrial agriculture. Additionally, and on the contrary, we are arguing that government and society need to support small properties to achieve a more sustainable production. Usually farmers with small farms have willingness to try sustainable agriculture practices and are awareness of sustainable problems, but they have more difficult to adopt this practices, mainly financial constraints (Perry-Hill & Prokopy, 2014). Financial capacity is one of the variables with largest impact on sustainable practices adoption (Baumgart-Getz et al., 2012). Consequently, public policies need to support small producers, especially farmers with financial constraints, to develop a more sustainable agriculture.

Despite some political efforts to spread to many private properties sustainable agriculture practices, such as Low Carbon Agriculture Plan (Plano ABC, in Portuguese), the results are much worse than expected (ABC, 2015b). The high bureaucracy, effort and time to obtain the credit restrain the access of small producers, benefiting mostly larger producers (ABC, 2015a). Additionally, the lack of juridical safety and the constant changes in policy, including amnesty for illegal deforestation producers, discourage rural producers to invest in sustainable practices (Soares-Filho et al., 2014).

Crop producers have more sustainable practices than livestock producers (higher intention to change behavior, better environmental and total score). Personal characteristic is a key factor to influence farm decision

(Pannell et al., 2006). Crop producers tend to be more innovators than livestock producers, and innovators are more prone to adopt sustainable agriculture practices. Crop producers are familiarized to take risks and to make high investments. Moreover, uncertainty is recognized as a major impediment to the adoption of sustainable agriculture practices (Pannell, 2003) and crop producers are more familiarized with uncertainty than livestock producers. Public policies and supply chain interventions, such as Soy Moratorium and Cattle Agreement, need not only to pressure producers, but also to create positive incentives to spread the adoption of sustainable practices from both agricultural productions, reducing uncertainty of investment return (Nepstad et al., 2014). Parrá-Lopez (2009) highlighted that rural producers tend to pursue practices that maximizes their private net benefit. Thus, economic benefit is an important topic influencing directly sustainable agriculture practices adoption (Pannell et al., 2006).

Certification, a supply chain intervention, is proposed by many authors and aims to work as a positive incentive, remunerating the rural producer for the sustainable practices adopted (Blackman & Rivera, 2011; Nepstad et al., 2006; Papadopoulos et al., 2015). Clear guidelines and goals in social area are possible reasons of rural properties participants of certification schemes have less liabilities and perform better for social score than rural properties without certification. However, the benefits of certification stay exclusive to social area. Commitment, execution rate, environmental, productive and total scores are similar among properties with and without certification. Certification by itself is not being enough to rural producers adopt sustainable agriculture practices as a holistic system.

A better comprehension of the sustainable practice adoption need to focus not only in economic factors, but also in information. The main reasons to non-adoption or low adoption of sustainable agriculture practices are low relative advantage (particularly in economic terms) and difficult to test the practices (Pannell et al., 2006). All participants of this study were supported by NGO Aliança da Terra, which gives continuously information about sustainable agriculture practices, without any financial support for adoption. Consequently, information gap, an important barrier to sustainable agriculture practices adoption (Baumgart-Getz et al., 2012; Rolfe & Gregg, 2015), does not exist in our sample. Leite et al. (2014) highlighted the importance of extension technical support to achieve success in enhancing adoption of sustainable agricultural in Brazil, whereas Wossen (2013) showed it to Africa.

Notwithstanding decision making is generally a social process, we did not found neighborhoods' effect in sustainable agriculture. Baumgart-Getz et al. (2012) in a review found that network is a significant predictor of sustainable agriculture practices adoption, but they emphasize the high heterogeneity of the results. We elaborate three possible explanations of our results. The first one is that decision making commonly includes family members to participate in the decisions (Pannell et al., 2006). In the past, the neighborhoods were usually members of the family. This is not true nowadays, mainly in central-west region, where were most of our samples. Another possible explanation is methodological. We considered neighborhood not exclusively the neighbors' farmers, and not all neighbors of all farms are analyzed. The third possible explanation is that most of landowners, mainly of larger farms, do not live in the farm. They live in the urban area and have less contact with their neighborhoods. In both cases, farmer network maybe is not their neighbor. Makes sense that the physical proximity of sustainable agriculture practices adopter be positive related to adoption (e.g. D'Emden et al., 2008) where the information is a constraint. For farms sampled in this study, information was not a constraint because the field team of NGO Aliança da Terra presented a document with many suggestions of sustainable agricultural practices specifically to each farm and encourage farmers to adopt it.

A described problem in Brazil is the gap between research, policy and farmers (Ferreira et al., 2012). Responsible Production has the positive feature that engage farmers because it is promoted by a NGO, which includes researchers, policy makers and farmers, narrowing the gap between science and practice. It is not a punitive measure, but an educational strategy.

Concluding remarks

Despite there are no worldwide accepted patterns to adopt sustainable agricultural practices and maybe not even exist such patterns because local context plays key role in sustainable agricultural practices adoption (Knowler & Bradshaw, 2007; Reimer et al., 2014), we found strong evidence in Brazil of some properties features that affect the adoption. Farmers with larger farms and crop producers have better sustainable agricultural practices.

We consider the results found in this study cannot be extrapolated without a careful analyzes. Brazilian farms have some particularities and this information need to be considered. We support that previous studies can guide questions and help to formulate hypothesis, such as we did in this study.

However, authors need to understand the local factors that influence farms adoption decision.

We produced background to support polices that promote sustainable agriculture practices adoption and we contribute to a more deeply understand on sustainable agriculture practices adoption. Additionally, presenting a success case of Brazilian farms improving their sustainable agriculture practices, we hope to encourage similar approaches in other countries, with continuous support to rural producers and clearly guidelines of what and how to improve their practices.

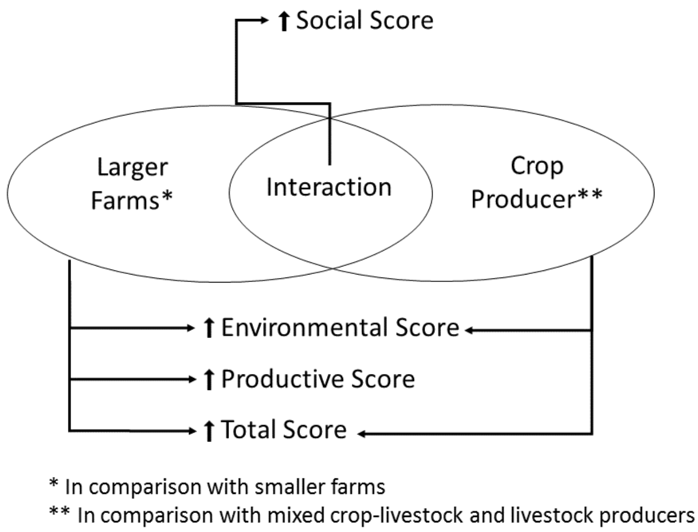

Figure 2: Property size and production affected sustainability scores. Larger farms and crop producers perform better for sustainable agriculture practices than smaller farms and mixed crop-livestock and livestock producers.

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Considerações Finais

A mudança de uso do solo não é um fenômeno novo, mas a rapidez e a escala global que tal conversão está ocorrendo são inéditas, principalmente na conversão de áreas naturais para áreas produtivas (Havlík et al., 2013). Portanto, a ampla adoção de práticas de produção responsável pelos produtores rurais é um tema urgente. Porém, o maior interesse de que todas as propriedades rurais utilizem práticas agropecuárias de produção responsável está no fato de que o principal beneficiário desse processo é a coletividade, pois estão incluídos diversos interesses difusos. Estamos abrangendo temas como qualidade do ar, da água, do solo, dos alimentos produzidos, qualidade de vida dos trabalhadores para efeitos crônicos e até mudanças climáticas. Questões ambientais, sociais e econômicas estão envolvidas e, por isso, uma abordagem abrangente deve ser adotada. Se por um lado isso poderia representar uma atenção maior da sociedade para as práticas responsáveis, há um desafio representado pela dificuldade da sociedade reconhecer os potenciais ganhos decorrentes dessa abordagem. Acreditamos que essa tese foi capaz de vencer, pelo menos em parte, aspectos importantes desse desafio. Nessas considerações finais vamos apresentar uma visão crítica do processo de adoção de práticas agropecuárias sustentáveis e oferecer sugestões diretamente relacionadas aos principais resultados obtidos nesse trabalho.

É importante fazer uma ressalva: nós reconhecemos que as práticas de produção responsável não são uma revolução radical na produção de alimentos. A agricultura sustentável deve incluir um desafio mais profundo e fundamental do que a simples adoção de novas tecnologias e práticas (Pretty, 1995a; Tilzey, 2000). Contudo, a simples adoção das práticas de produção responsável promove um aumento na produtividade e melhora a performance ambiental e social da propriedade rural. Essas práticas precisam ser interpretadas como uma maneira descomplicada e viável de produção de alimentos reduzindo drasticamente as externalidades negativas. Mesmo reconhecendo que as práticas de produção responsável não se aproximam do que os cientistas imaginam de um cenário perfeito (Garnett et al., 2013; Godfray & Garnett, 2014), elas são um primeiro passo para reduzir os impactos ambientais, promover justiça social e aumentar a produtividade – em resumo, uma importante tática para atingir futuramente a sustentabilidade forte e holística (Galford et al., 2013; Soares-Filho et al., 2012).

Uma segunda ressalva fundamental é que esse trabalho avaliou apenas médias e grandes propriedades rurais empresariais, com mão de obra assalariada e sistema produtivo voltado à comercialização. Os resultados aqui obtidos não se referem às pequenas propriedades rurais ou as propriedades familiares. Nós ressaltamos que as propriedades pequenas e familiares são fundamentais para a sociedade por, por exemplo, serem responsáveis por grande parcela da produção de alimentos. Portanto, quando falamos em propriedades "menores", estamos nos referindo a médias propriedades empresariais, e não a propriedades pequenas e familiares.

A população se beneficiará de diversas formas quando as práticas de produção responsável forem amplamente adotadas, até com a maior preservação de recursos genéticos e dos processos ecológicos (De Marco & Coelho, 2004; David Tilman et al., 2002). Porém essa percepção não é clara e direta para grande parte da população, dificultando seu apelo para o grande público urbano. A situação é ainda pior, pois grandes indústrias podem ter interesse contrário ao das boas práticas. Por exemplo, cuidar do solo evitando sua erosão e realizando plantio direto, uma simples prática de produção responsável, deixa o solo naturalmente mais rico e reduz a necessidade de suplementação com produtos químicos. Certamente as empresas de adubação não gostam da ideia.

Uma alternativa, considerando trabalhar dentro da lógica capitalista vigente, é que a adoção de práticas sustentáveis na agricultura possa gerar lucro para empresas, ou ao menos para os produtores rurais. Assim, o interesse privado se aproximará do interesse coletivo, facilitando e acelerando o processo de mudança. Nesse ponto reside o mérito do trabalho aqui apresentado. Entendermos como as práticas de produção responsável podem ser adotadas, suas variações de acordo com perfis de produtores e de características das propriedades rurais, podem tornar o processo de difusão muito mais eficiente.

Após a investigação apresentadas nos capítulos anteriores, fica evidente que o método “one size fits all” não pode ser aplicado para a adoção de práticas de produção responsável pelos produtores rurais industriais no Brasil. Em resumo, temos uma lista de sugestões:

(1) Porque encontramos que produtores rurais não executam prioritariamente práticas de alta inovação e baixa relação com produtividade, mesmo que obrigatórias por lei, sugerimos: Criar novas estratégias para adoção de práticas de produção responsável mais caras e com menor relação com produtividade, pois comando e controle não está sendo capaz de fazer produtores rurais priorizarem tais ações;

(2) Porque encontramos que a informação e grau de escolaridade obtiveram efeito direto na adoção de práticas de agricultura responsável sugerimos: Ampliar acesso a informação aos produtores rurais de práticas de produção responsável baratas e com retorno em aumento de produtividade, pois serão facilmente adotadas (mesmo sem incentivos financeiros ou obrigatoriedade);

(3) Porque encontramos que produtores rurais que sentem maior pressão de sindicatos e associações têm melhores práticas ambientais sugerimos: Incentivar a criação e fortalecimento de sindicatos e associações, assim como a participação dos produtores rurais em tais entidades;

(4) Porque encontramos que produtores de maior escolaridade têm melhores práticas sustentáveis sugerimos: Incentivar aumento da escolaridade no meio rural, incluindo escolas, cursos técnicos e de nível superior nas áreas rurais, facilitando o acesso das comunidades locais;

(5) Porque encontramos que propriedades exclusivamente agrícolas têm melhores práticas sustentáveis do que propriedades pecuárias sugerimos: Planejar ações diferentes para agricultura e pecuária, com maior enfoque na adoção de práticas de produção responsável pelos pecuaristas;

(6) Porque encontramos que propriedades com certificação possuem melhores práticas sociais sugerimos: Incentivar a adoção de certificados pelos produtores rurais e de seu reconhecimento e valorização pelo grande público.

Existem três abordagens para implementar a agricultura sustentável: (i) regulações, forçado por leis e penalidades, (ii) baseada na comunidade, com trabalho coletivo, e (iii) instrumentos econômicos, com pagamentos aos produtores rurais (Tanentzap et al., 2015). Apesar das especificidades espaciais e temporais, o melhor a se fazer é utilizarmos uma mistura das abordagens. As três alternativas quando consideradas separadamente são incompletas, mas em conjunto, com um planejamento claro por trás e um objetivo bem definido, podem fazer com que as ações convirjam para uma maior adoção de práticas de produção responsável.

Porém resta uma reflexão final: será que nosso padrão de consumo, mesmo com práticas mais sustentáveis, conseguirá atingir a real sustentabilidade? Nesse trabalhou abordamos produtores agrícolas industriais, que visam produzir commodities. Algo simples, como a redução do consumo de proteína animal e a escolha consciente de produtos de menor impacto ambiental e social, iriam gerar menor demanda por esses produtos de propriedades agrícolas industriais e abririam uma possibilidade para o crescimento de propriedades familiares e/ou propriedades mais sustentáveis. A mudança no padrão de consumo, realizada pela população, irá gerar efeitos na produção agropecuária, e poderá se tornar um caminho para a sustentabilidade.

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