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MUDANÇAS CLIMÁTICAS NA AMAZÔNIA ORIENTAL: PERCEPÇÕES E ADAPTAÇÃO DAS COMUNIDADES QUILOMBOLAS DE ALCÂNTARA, MARANHÃO, BRASIL

São Luís - MA
2024

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Mestre em Agroecologia

Engenheiro Agropecuário; Tecnólogo Agroambiental

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Tese apresentada ao Curso de Doutorado do Programa de Pós-Graduação em Agroecologia da Universidade Estadual do Maranhão, para a obtenção do título de Doutor em Agroecologia.

Orientador: Prof. Dr. Guillaume Xavier Rousseau

Co-orientadora: Prof. Dra. Taline Cristina da Silva

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ATA DE DEFESA DE TESE

Aos **26** dias do mês de **março** de **2024**, às **09:00 h**, compareceu ao Auditório do Programa de Pós-Graduação em Agroecologia/PPGA/UEMA, o aluno **Jhonatan Andrés Muñoz Gutiérrez** em **nível de Doutorado**, para apresentar e defender a tese intitulada **"MUDANÇAS CLIMÁTICAS NA AMAZÔNIA ORIENTAL: PERCEPÇÕES E ADAPTAÇÃO DAS COMUNIDADES QUILOMBOLAS DE ALCÂNTARA, MARANHÃO, BRASIL"**, perante a Banca Examinadora abaixo relacionada. Após a apresentação do trabalho e arguição pelos membros da Banca, **o aluno foi considerado**:

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Encerrados os trabalhos, a Coordenação do Programa lavrou a presente ATA que, após lida e aprovada, recebeu a assinatura dos membros da Banca Examinadora.

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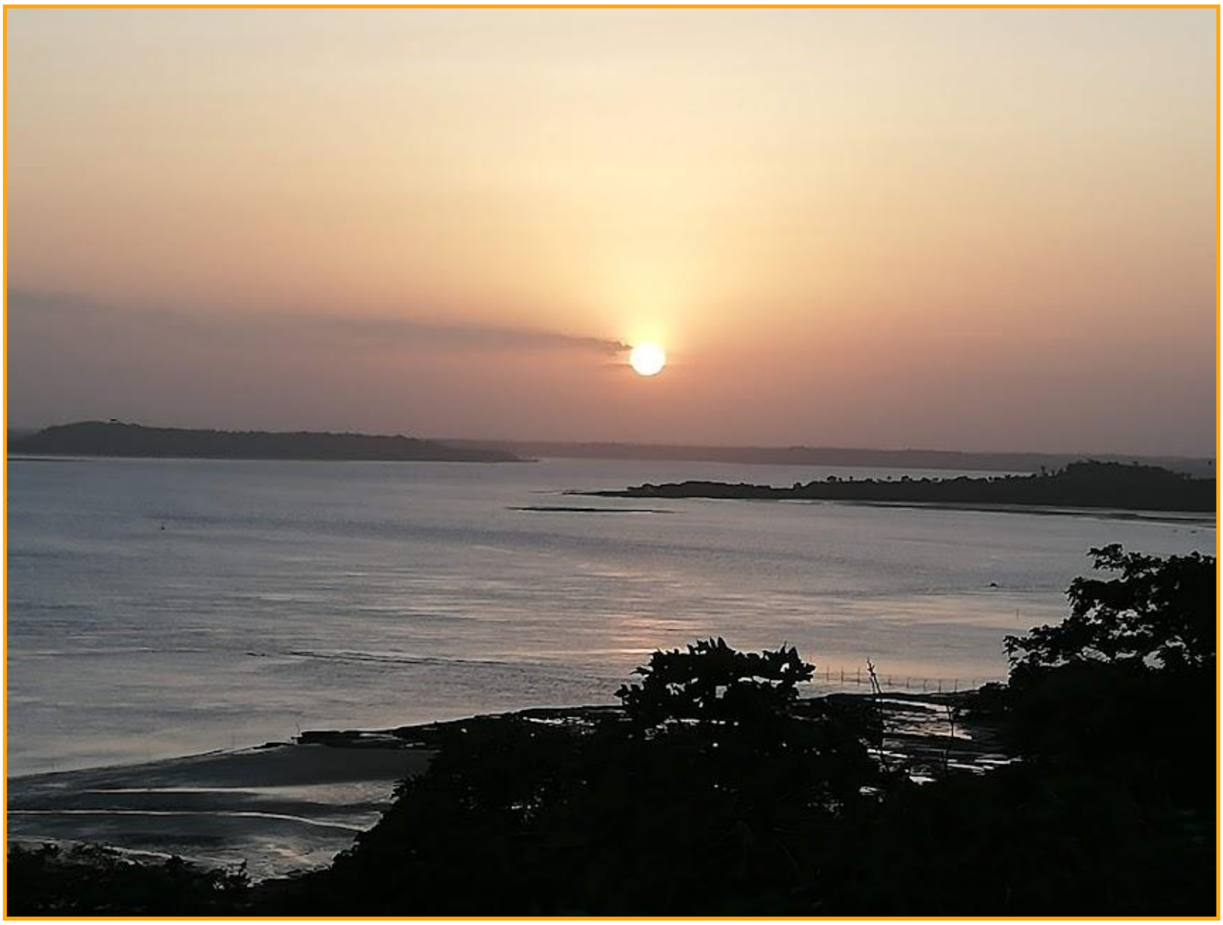

Pôr do sol na Bahia de São Marcos, Alcântara, Maranhão, Brasil. Fonte: Jhonatan Muñoz, 2021.

DEDICO

Aos que encontraram no universo da ciência, a experimentação e a natureza o melhor refúgio para a salvação dos espíritos malignos.

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A transformação das universidades públicas em centros de formação para o trabalho coage a mente humana. A democratização das universidades públicas não deve ser sinônimo de deterioro da qualidade. A baixa qualidade no processo de formação, conduz indubitavelmente ao fracasso das sociedades, em especial daquelas que estão lideradas por políticos ignorantes e corruptos.

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RESUMO

A mudança climática é global, porém, os impactos são locais. Nesse sentido, a adaptação dos agricultores perante às mudanças climáticas é imperativa. A implementação assertiva dos processos de adaptação climática deve considerar as tipologias dos agricultores locais, percepções, o conhecimento, as barreiras e informações climatológicas entre outros**.** Assim, este estudo evidencia na escala local de Alcântara, Maranhão, na Amazônia Oriental, Brasil, como se configuram os tópicos anteriores e subministra informações chaves para a estruturação de políticas públicas e a implementação de processos orientados a incrementar a capacidade adaptativa e diminuição da vulnerabilidade dos agricultores tradicionais que praticam o corte e queima na região Amazônica. A coleta de dados foi realizada com diferentes atores locais (de agricultores a técnicos, n=100) no município de Alcântara. Utilizou-se entrevista semi-estruturada, lista livre, grupos focais de discussão, mapeamento participativo de riscos, regressão logística binária, análise fatorial de dados mistos e análise de agrupamento hierárquico, teste de Mann-Kendall e ANOVA. Os resultados indicam que a idade média dos agricultores foi de 56 anos (±13). O tamanho da família em média é 4,5 (±2,4) integrantes, com 3,5 (±2,8) filhos. A renda familiar é baixa, com 30% sobrevivendo com menos de um salário-mínimo mensal (~US$ 200/mês). A renda provém principalmente de aposentadoria (49,4%) e programas governamentais de assistência social (40,2%). A vulnerabilidade contextual é alta e interfere na capacidade adaptativa dos agricultores. Os estressores mais relevantes foram os não climáticos e divergem entre o público entrevistado, assim como, entre agricultores de diferente idade e gênero. Agricultores que vivem em "Agrovilas" são mais propensos a perceber estressores climáticos ($p < 0.05$). Os agricultores recebem informações climáticas principalmente pela televisão (83%), porém, não conseguem entender claramente os tópicos relacionados às mudanças climáticas. A percepção dos agricultores é convergente com os dados climatológicos que indicam uma tendencia no incremento da temperatura ($p < 0.05$) e uma diminuição da precipitação especialmente na última década. Segundo os agricultores essas mudanças estão gerando impactos negativos como a podridão da mandioca, a alteração da época de plantio, da jornada laboral e da floração de algumas espécies frutíferas. A maioria dos agricultores (86%) tem alterado a época de plantio e menos de 29% implementam ações de adaptação diferentes. Em média implementam 1.6 (±1.3) práticas. Saber o que é o aquecimento global e ter acesso ao crédito, influenciam a implementação de ações de adaptação ($p < 0.05$). Vinte e duas barreiras foram citadas para transitar do sistema de corte e queima para sistemas sem fogo, sendo a falta de assistência técnica a mais proeminente (100%). Três grupos de agricultores foram identificados de acordo às características socioeconômicas, o conhecimento sobre as mudanças climáticas e adaptação ($p<0.05$). Para responder às mudanças climáticas e diminuir a vulnerabilidade contextual é necessária uma resposta coordenada e multinível entre os diferentes atores. A educação ambiental com foco nas mudanças climáticas deve ser implementada.

Palavras-chave: Percepção do risco climático. Vulnerabilidade. Corte e queima. Capacidade adaptativa climática. Meios de vida. Segurança alimentar. Agricultura sem fogo.

ABSTRACT

Climate change is global, but the impacts are local. In this sense, farmers' adaptation to climate change is imperative. The assertive implementation of climate adaptation processes must consider the types of local farmers, as well as, their perceptions, knowledge, barriers and climatological information, among other factors. This study clarifies how these aforementioned aspects manifest themselves at the local scale in Alcântara, Maranhão, in the Eastern Amazon, Brazil, and provides essential insights for the development of public policies and the implementation of initiatives that aim to increase adaptive capacity and reduce vulnerability. of traditional farmers who practice slash-and-burn agriculture in the Amazon region. Data collection was carried out with different local actors (from farmers to public representatives, n=100). Semi-structured interviews, free lists, focus group discussions, participatory risk mapping, binary logistic regression, factorial analysis of mixed data and hierarchical cluster analysis in the principal component were used. The average age of farmers was 56 years (±13). Family size averaged 4.5 (±2.4), with 3.5 (±2.8) children. Family income was low, with 30% surviving on less than a monthly minimum wage (~US$200/month). Household income came mainly from retirement (49.4%) and government social assistance programs (40.2%). The most relevant stressors were non-climatic ones. Farmers living in "Agrovilas" are more likely to perceive the risk of climate stressors ($p < 0.05$). Television (83%) is the most used means of communication to acquire information about climate change. The perception of the farmers is convergent with the meteorological data that indicate a tendency in the increase of the temperature ($p < 0.05$) and a decrease of the precipitation, especially in the last decade. According to farmers, these changes are generating negative impacts such as cassava rot, changes in planting times, working hours and the flowering of some fruit species. Less than 29% of farmers implement different adaptation actions to change the planting season. On average, they implement 1.6 (±1.3) practices. Knowing what global warming is and having access to credit influence the implementation of adaptation actions ($p < 0.05$). A total of 22 barriers to moving from the slash and burn system to fireless systems were cited, with the lack of technical assistance being the most salient (100%). Three groups of farmers were identified according to socioeconomic characteristics and knowledge of climatic changes ($p < 0.05$). To address climate change and mitigate contextual vulnerability, a coordinated response from different stakeholders is required. Implementing environmental education with a focus on climate change is essential.

Keywords: Climate risk perception. Vulnerability. Slash-and-burn. Climate adaptive capacity Livelihoods. Food security. Agriculture without fire.

1. INTRODUÇÃO

A mudança climática é uma das maiores ameaças globais e requer uma resposta coordenada de multinível para ser enfrentada de forma eficaz. Projeções climáticas indicam que as regiões mais vulneráveis na América do Sul são a Amazônia e o Nordeste do Brasil, devido às previsões da redução das chuvas e período de secas mais extensos (Bottino *et al.*, 2024; Reboita *et al.*, 2022). De fato, a região sudeste da Amazônia vem apresentando uma tendência na redução das chuvas e um maior número de dias secos (Marengo *et al.*, 2022; Marengo; Torres; Alves, 2017). Essas alterações têm impactos negativos sobre a agricultura, em especial, a de corte e queima, por ser um sistema que depende dos regimes de precipitação. Na Amazônia o corte e queima é o principal método praticado por comunidades tradicionais para preparar a terra para a agricultura (Jakovac *et al.*, 2017; Villa *et al.*, 2021). No entanto, com as mudanças climáticas e a intensificação do sistema (maior número de ciclos e diminuição do pousio) induzida por fatores como acesso restrito à terra, crescimento populacional e maior acesso ao mercado, o corte e queima pode ser cada vez menos viável (Jakovac *et al.*, 2016, 2017).

Para fazer frente aos desafios das alterações climáticas, combinar o conhecimento e percepções locais com o conhecimento acadêmico é essencial, porque poderia gerar soluções mais especificas às necessidades de cada comunidade (Reyes-García, 2007; Reyes-García *et al.*, 2016; Reyes-García; Ávila; Caviedes, 2022). Os agricultores possuem um conhecimento aprofundado do ambiente e do clima em suas regiões, devido à combinação de experiência prática, observação e troca de informação com outros agricultores.

As investigações sobre percepção das mudanças climáticas são consideradas fundamentais para entender as decisões tomadas pelos agricultores em relação aos processos de adaptação (Deressa; Hassan; Ringler, 2011; Kumar; Gupta, 2021). Contudo, a percepção, as barreiras e fatores que influenciam os agricultores a implementar ações de adaptação tem sido estudado principalmente em países mais industrializados (Dang *et al.*, 2019). Em contraste, na América Latina (Fierros-González; López-Feldman, 2021), especificamente, na Amazônia (Funatsu *et al.*, 2019), existe uma forte necessidade de consolidar essas informações. A percepção dos agricultores sobre as mudanças climáticas pode ser influenciada por diversos fatores como idade, gênero, educação, nível de renda, acesso à informação e tecnologia entre outros (Antwi-Agyei *et al.*, 2017; Carlos; Cunha; Pires, 2019; Etana *et al.*, 2020; Mabe; Sienso; Donkoh, 2014). Por outro lado, o envolvimento dos agricultores em atividades de adaptação pode ser influenciado por fatores e barreiras financeiras, cognitivas, políticas e institucionais (Dang *et al.*, 2019).

No município de Alcântara, Maranhão, na Amazônia oriental se localiza o Território Quilombola de Alcântara. Os quilombolas são descendentes de africanos escravizados, reconhecidos como comunidades tradicionais pela legislação brasileira (Brasil, Decreto 6040/2007). Em Alcântara as comunidades quilombolas sobrevivem principalmente do corte e queima e da pesca artesanal. Contudo, as comunidades enfrentam além das mudanças climáticas diversos desafios como a não titulação da terra, a baixa fertilidade do solo, a diminuição dos recursos hídricos derivado do desmatamento das matas ciliares (Celentano *et al.*, 2017; Loch *et al.*, 2020; Zelarayán *et al.*, 2015), e a constante ameaça da perda do seu território pela expansão do Centro de Lançamento de Alcântara (CLA). Dado os diversos estressores que enfrentam os quilombolas de Alcântara em matéria ambiental, social e econômica e dando resposta aos requerimentos próprios de algumas comunidades realocadas "Agrovilas" pelo CLA desde o ano 2013 iniciou-se um processo de transição agroecológica, promovido pelo hoje denominado Laboratório de Restauração Ecológica (LARECO), do Programa de Pós-graduação em Agroecologia da Universidade Estadual do Maranhão. Não obstante, a não titularidade da terra tem produzido um desestimulo para a multiplicação do processo (Loch *et al.*, 2020). Nesse sentido, o presente estudo se articula aos esforços realizados no território quilombola de Alcântara e em geral da região Amazônica, nesse caminho da consolidação e articulação do conhecimento e percepções locais com as acadêmicas que permitam fazer frente de forma mais eficaz às mudanças climáticas.

Assim, esta tese teve como objetivo geral entender na escala local, como se configuram as percepções e a adaptação das comunidades quilombolas entorno das mudanças climáticas**.** Desse modo, a seguinte tese se divide em cinco (5) Capítulos: No capitulo I se faz uma revisão de literatura na qual se aborda conceitos e elementos nucleares que permitem entender o foco do trabalho, assim como, aqueles que permitem inferir a necessidade do desenvolvimento da pesquisa. No capítulo II é apresentado um artigo já publicado no qual se mapeia com diferentes partes interessadas a vulnerabilidade contextual dos agricultores quilombolas e se discute sobre as implicações desses estressores para responder as mudanças climáticas. Adicionalmente, se identificam os fatores que determinam a percepção dos agricultores sobre os estressores climáticos. No Capítulo III se apresenta uma proposta de artigo que aborda diretamente a percepção e conhecimento dos agricultores sobre a mudança climática, seu acesso as informações relacionadas ao clima, os impactos percebidos derivados das mudanças climáticas, as ações de adaptação implementadas e as barreiras enfrentadas para transitar do sistema com fogo para sistemas sem fogo. Além disso, se identificam grupos de agricultores segundo as características socioeconômicas, cognitivas relacionadas com as mudanças climáticas, e adaptação. No capítulo IV por meio da construção de material didático-pedagógico em conjunto com as comunidades, se integra o conhecimento local e acadêmico como ferramenta para a adaptação dos agricultores à mudança climática. Finalmente, no capítulo V são mencionadas as considerações finais do trabalho como um todo.

É e importante destacar que este trabalho não se limita apenas às Agrovilas, mas se estende a outras comunidades no território quilombola, buscando uma compreensão mais abrangente. Adicionalmente, esta pesquisa foi conduzida durante a pandemia de COVID-19 e, nesse aspecto, com o objetivo de reduzir os riscos para os envolvidos da pesquisa, obter uma visão mais profunda do Território e fortalecer o processo de transição do sistema de corte e queima para sistemas sem fogo de base agroecológica, o pesquisador principal optou por residir em Alcântara durante o início da pesquisa.

Este estudo foi aprovado pelo comitê de ética em pesquisa da Universidade estadual do Maranhão (CAAE 39872720.0.0000.5554). Todos os participantes concordaram em participar da pesquisa e tiveram acesso ao Termo de Consentimento Livre e Esclarecido.

2. CAPITULO I: REFERENCIAL TEÓRICO

2.1 Mudança climática

A mudança climática é um dos desafios mais importantes da sociedade contemporânea em termos ambientais, econômicos e sociais. Diante deste impasse, a emergência climática foi declarada (Ripple *et al.*, 2021). Para tentar compreender o assunto é importante conhecer alguns conceitos básicos (Quadro 1).

Quadro 1 - Alguns conceitos básicos no contexto das mudanças climáticas.

Termo	Conceito	Referência
Clima	Grupo de condições climáticas prevalecentes durante um período normalmente de 30 anos numa dada região. Resumo estadístico das condições do tempo (temperatura, precipitação, ventos...); sendo, o tempo o estado momentâneo da atmosfera.	IPCC (2018, p. 77).
Mudança climática	A Convenção-Quadro sobre Mudanças Climáticas define as mudanças climáticas como: "Mudança do clima atribuída direta o indiretamente à atividade humana que altera a composição da atmosfera global e que se soma à variabilidade natural do clima observado durante períodos de clima comparáveis".	IPCC (2018, p. 75).
Aquecimento Global	"O aumento estimado na Temperatura média global da superfície (GMST) ao longo de um período de 30 anos, ou do período de 30 anos centrado em um determinado ano ou década, expresso em relação aos níveis pré-industriais, a menos que especificado de outra forma".	IPCC (2018, p. 75).
Gases efeito estufa	"Constituintes gasosos da atmosfera, naturais ou antropogênicos, (CH_4, CO_2, N_2O, CFCs, PFC e SF6) que absorvem e emitem radiação em comprimentos de onda específicos dentro do espectro da radiação terrestre emitida pela superfície da Terra, pela própria atmosfera e pelas nuvens. Esta propriedade causa o efeito de estufa".	IPCC (2018, p.82).
Risco climático	Probabilidade de ocorrência de um perigo (evento, ameaça,) relacionado ao clima com potencial de consequências adversas e incertas.	(Smith; Barrett; Box, 2000).
Percepção do risco	Julgamento subjetivo que as pessoas fazem sobre as características e a gravidade de uma ameaça. Adicionalmente, pode ser interpretado como os problemas que as pessoas reconhecem em termos sociais, ambientais e econômicos no local.	(Antwi-Agyei *et al.*, 2017; Smith; Barrett; Box, 2000; Tschakert, 2007).
Vulnerabilidade	"Propensão a ser afetado negativamente. A vulnerabilidade inclui a susceptibilidade ao dano e a falta de capacidade de resposta e adaptação"	IPCC (2018, p. 92).
Vulnerabilidade contextual	Inerente dos sistemas socioecológicos é a incapacidade presente das comunidades ou indivíduos de lidar com estressores externos, como as mudanças climáticas. É gerada por múltiplos estressores socioeconômicos, ambientais, culturais, tecnológicos e políticos.	(O'Brien *et al.*, 2007)
Adaptação	Ajuste ao clima real ou projetado, com o intuito de reduzir o risco nos sistemas naturais e socioecológicos.	IPCC (2018, p. 74).
Resiliência socioecológica	Grau de propensão de um sistema para reter sua estrutura organizacional e sua produtividade após um choque.	(Altieri; Nicholls, 2012)

Fonte: Elaboração própria

Segundo o *Painel Intergovernamental sobre Mudanças Climáticas* (IPCC) (2018) a temperatura média da última década foi 1C° superior à temperatura média da época pré-industrial 1850-1900, e se vaticina que chegue a 1.5 C° entre 2030-2052 (Figura 1). Adicionalmente ao incremento da temperatura, a intensidade e periodicidade de eventos climáticos extremos são mais recorrentes (Fischer; Knutti, 2015). Os eventos extremos estão afetando as regiões tropicais drasticamente (França *et al.*, 2020). Contudo, a vulnerabilidade é mais acentuada nos países em desenvolvimento, onde a pobreza é elevada e os recursos econômicos são limitados (Gideon Onyekachi *et al.*, 2019; Sarkodie; Strezov, 2019).

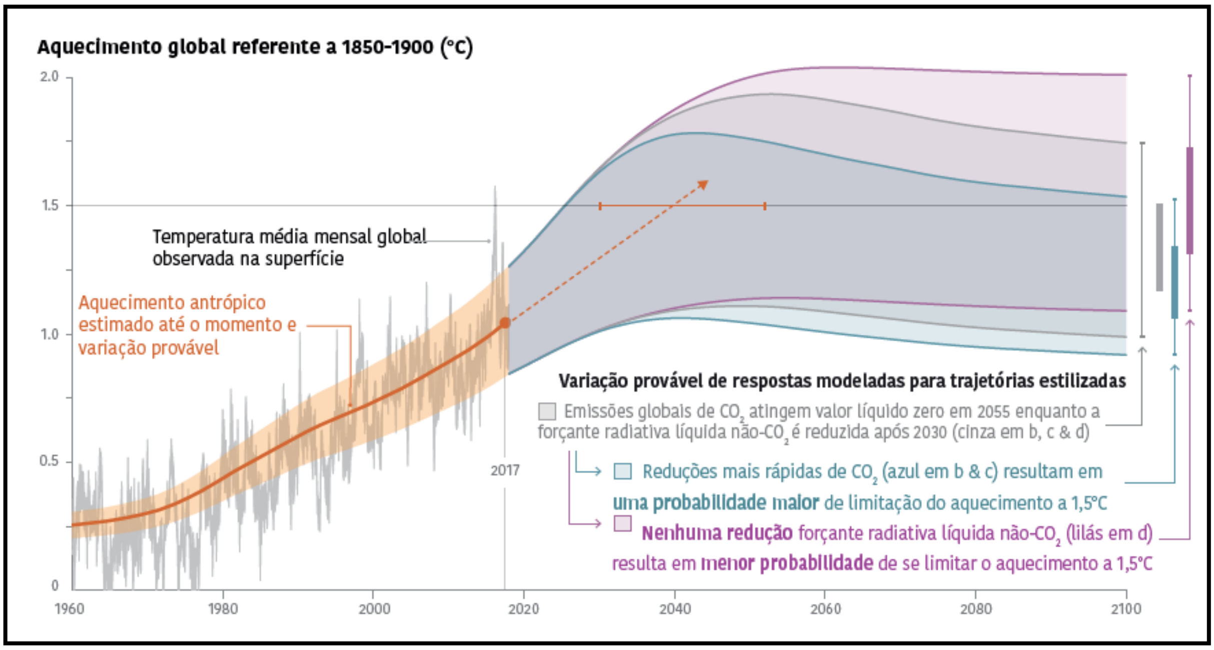

Figura 1 - Mudança global da temperatura em relação ao período 1850-1900.
Fonte: IPCC (2018).

Na Amazônia registrou-se um incremento na temperatura média do ar entre 0.6 - 0.7°C nas últimas quatro (4) décadas (Marengo et al., 2018), e com relação as chuvas no cenário Representative Concentration Pathway 4.5 (RCP4.5) se projeta uma redução das chuvas em mais de 10% para o período 2050-2080, (Reboita et al., 2022).

Para o litoral da Amazonia Oriental (especificamente para o litoral maranhense) as projeções indicam uma diminuição das precipitações entre 50 e 100mm/ano (Figura 2), com incremento da temperatura entre 1-5 e 2°C, diminuição da umidade relativa e aumento da velocidade dos ventos (ver figura 1. Park et al., 2023).

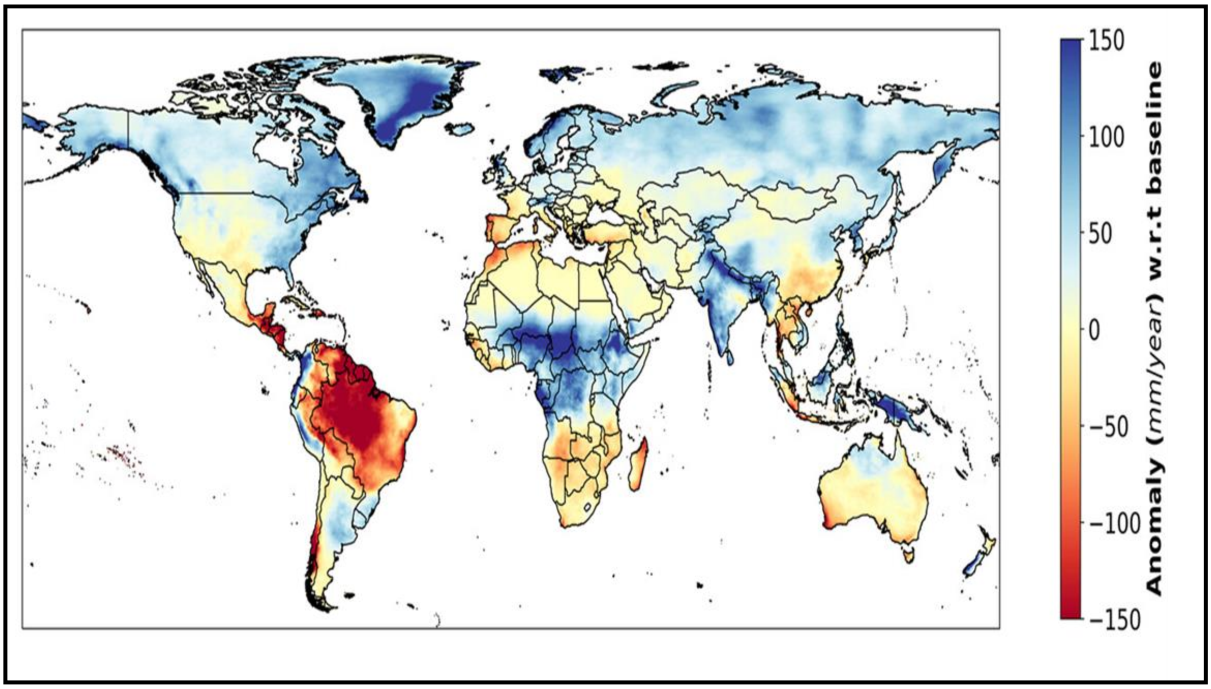

Figura 2 - Padrão espacial (Multimodel ensemble median) de anomalia de precipitação (SSP2-4.5) na década de 2040 em relação à linha 1850-1900.
Fonte: Park *et al*., (2023).

Na América do Sul, o bioma Amazônico é considerado um dos mais vulneráveis às mudanças climáticas (Debortoli et al., 2017; Reboita et al., 2022) e, as comunidades correm risco de sofrer por desabastecimento de alimento, água e epidemias, (Figura 3) (Hagen et al., 2022). Apesar disso, a região Amazônica do Brasil registrou em 2021 a taxa mais elevada de desmatamento da última década (INPE, 2022). Este fato, se relaciona com o desmonte sistemático das políticas públicas em matéria ambiental ocorridas principalmente no período do governo "Bolsonaro" (Moraes; Azevedo-Ramos; Pacheco, 2021; Sabourin; Craviotti; Milhorance, 2020).

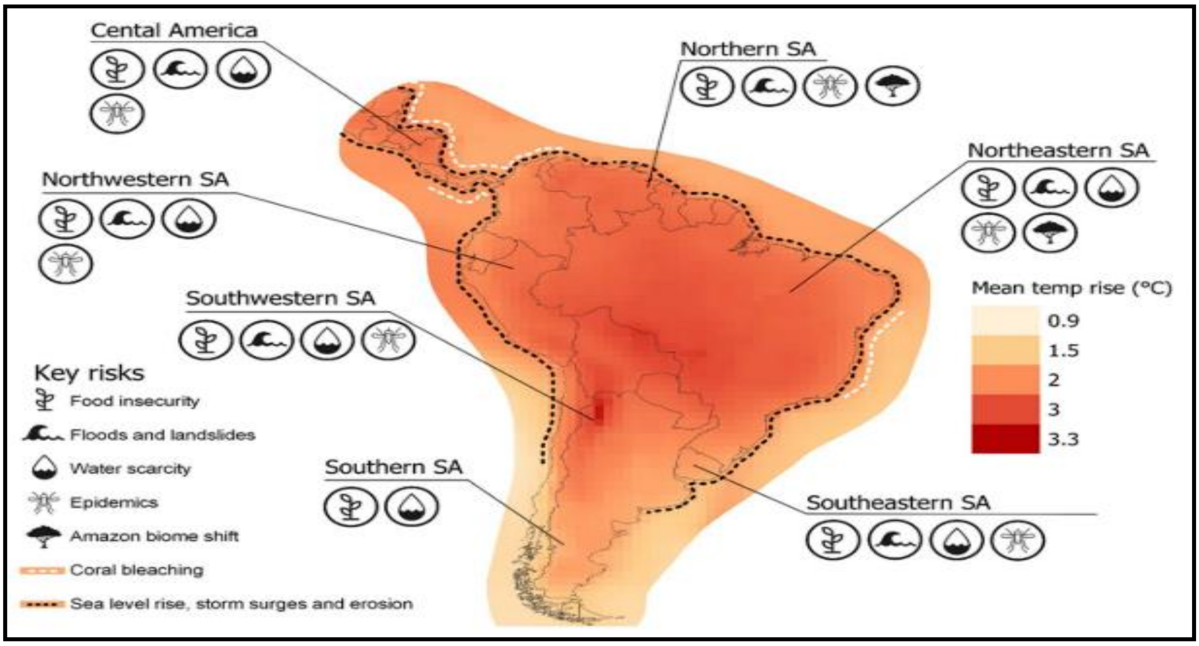

Figura 3 - Distribuição de riscos climáticos severos na região da América Central e do Sul para o século XXI.
Fonte: Hagen *et al.*, (2022).

Particularmente, o estado do Maranhão (MA), onde se desenvolveu o presente trabalho, só resta 24% da vegetação original florestal do bioma Amazônico (Silva-Junior *et al.*, 2020, 2022) (Figura 4), o que poderia intensificar os riscos.

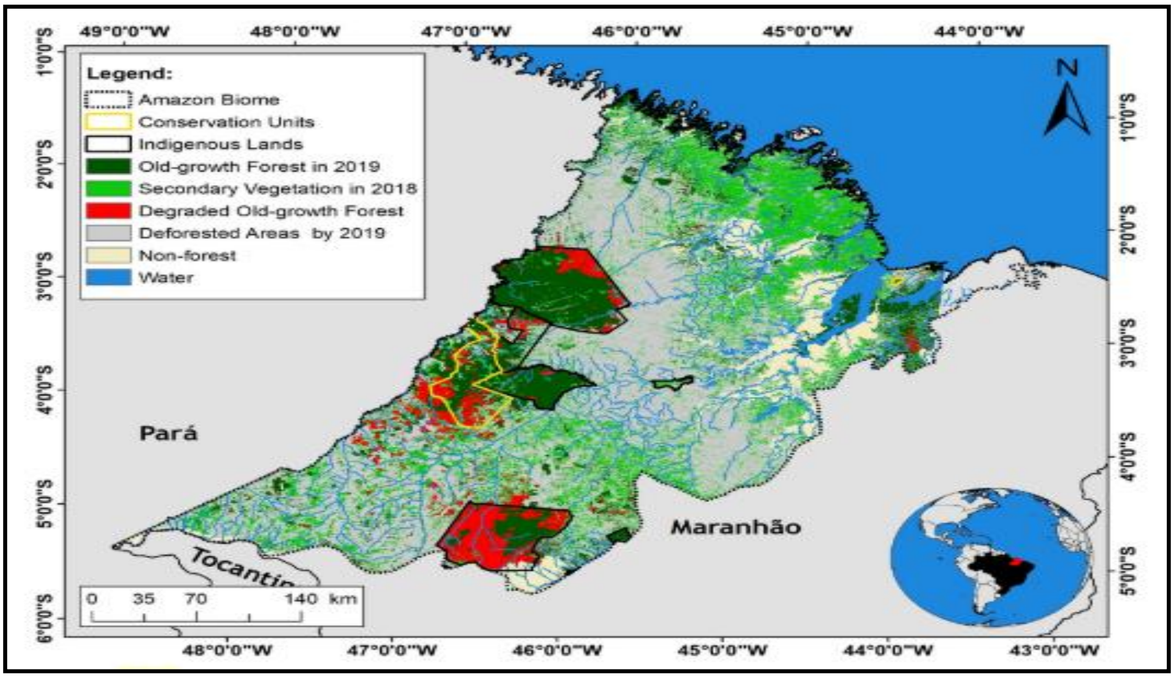

Figura 4 - Cobertura florestal e degradação florestal na região Amazônica do Maranhão.
Fonte: Silva-Junior et al., (2022).

Como mencionado na Figura 3, o desabastecimento de água considerado como um dos principais riscos para a região Amazônica tem se materializado (Figura 5), de fato, a seca ocorrida na Amazônia durante o segundo semestre do ano 2023 tem sido considerada como a pior da história para a região, afetando especialmente às comunidades mais vulneráveis (Figura 6).

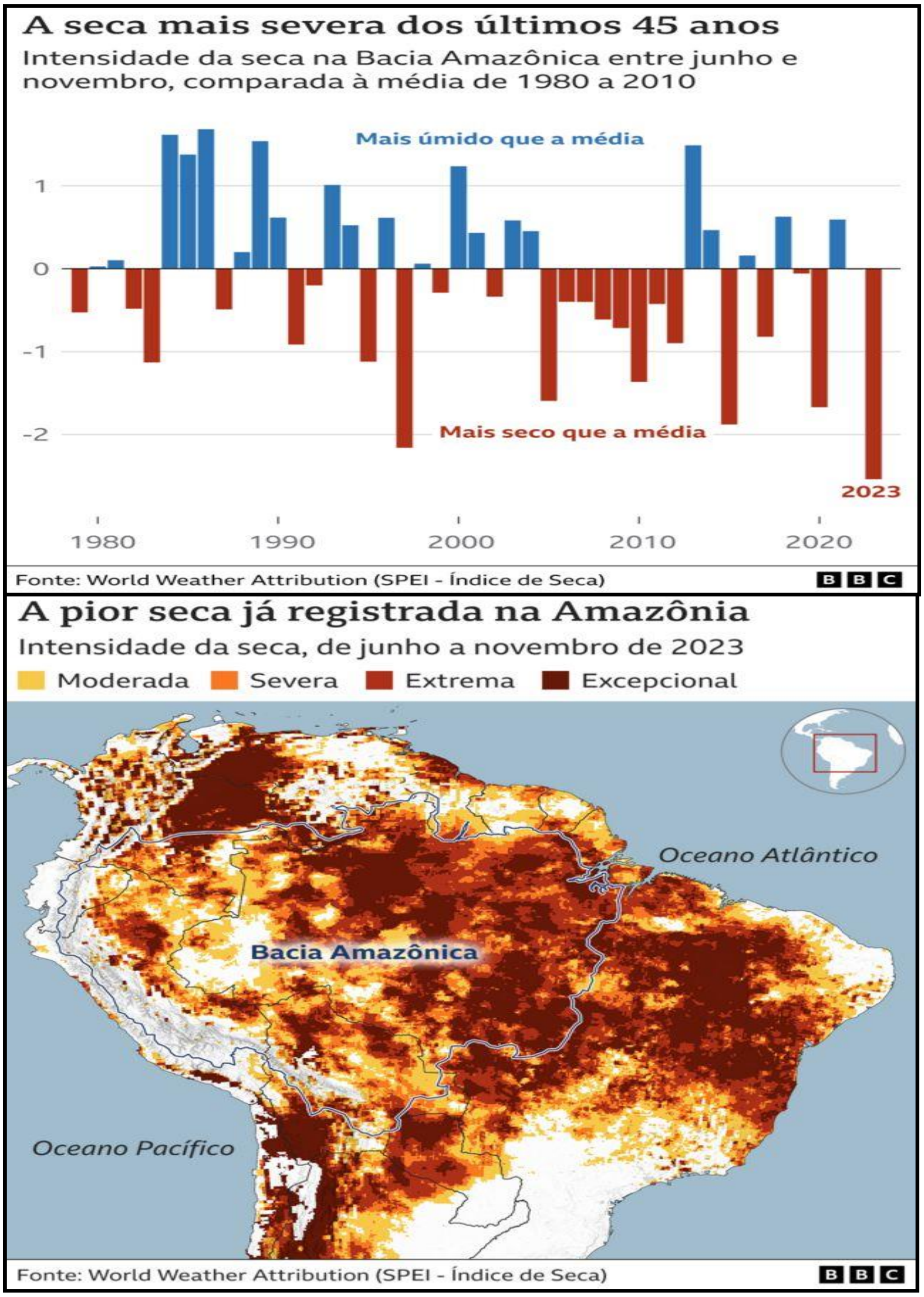

Figura 5 - Estiagem na Amazônia no segundo semestre de 2023.

Fonte: BBC, 2024.

Figura 6 - Estiagem na Amazônia em outubro de 2023 seca rios e lagos e afeta as populações ribeirinhas e a vida aquática.
Fontes: BBC e The Conversation, 2024.

2.2 Estratégias de comunicação das mudanças climáticas

A crise climática é evidente, ainda assim, as pessoas vivem num ambiente de expressa desinformação de diferentes maneiras e, apesar da intenção dos cientistas de informar, ainda não se tem um consenso sobre a melhor estratégia de comunicação (Ceyhan; Saribas, 2022).

Contudo, admite-se que as intervenções informativas devem ser atraentes para o público (Weber, 2010). Além disso, deve-se identificar e entender o público alvo (Leiserowitz *et al.*, 2021), assim como, evitar narrativas polarizadas de preocupação e despreocupação (Lucas, 2022).

Existem diversas maneiras de divulgar informações sobre as mudanças climáticas. A utilização de imagens em redes sociais parece ser boas estratégias. Imagens que transmitam emoções reais, que contenham uma história, com uma conexão local e que mostrem impactos ou ações de pessoas diretamente afetadas, tem se mostrado como uma estratégia positiva (León *et al.*, 2022) (Figura 7). Um exemplo disso é o "*Climate Visuals – a Climate Outreach project*" o único recurso de fotografia climática baseada em evidências na escala global (https://climatevisuals.org/). Por outro lado, as redes sociais que permitem a comunicação bidirecional também podem ser altamente potentes (Lee; Vandyke; Cummins, 2017).

Comunicar e divulgar informações, especialmente sobre o consenso científico e as explicações da ocorrência, pode aumentar a aceitação das pessoas pela ciência (Lewandowsky, 2020). Na região central da Etiópia, África, a comunicação com foco nas evidências locais, causas e consequências, respostas às mudanças climáticas e experiências passadas, tem sido uma boa estratégia (Etana; van Wesenbeeck; de Cock Buning, 2021).

Ações climáticas

Agricultores quilombolas de Alcântara, MA, intercambiam saberes de agricultor (a) para agricultor (a) sobre Sistemas Agroflorestais e outras estratégias como a cobertura do solo. *foto: Jhonatan Muñoz (2021).*

Principios visuais

Pessoas reais, histórias com conexão local, entender o público, mostrar ações ou impactos locais (LEÓN et al., 2022; Climate Visuals, 2022)

Figura 7 - Princípios visuais para comunicação da mudança climática.
Fonte: Elaboração própria.

2.3 Percepção do risco climático e adaptação dos agricultores

A percepção do risco pode ser entendida como o julgamento subjetivo que as pessoas fazem sobre as características e a gravidade de uma ameaça ou problema, que pode ser social, ambiental ou econômico (Antwi-Agyei *et al.*, 2017; Smith; Barrett; Box, 2000; Tschakert, 2007). A percepção do risco climático é mediada por fatores experenciais, cognitivos, sociais, geográficos (Lee *et al.*, 2015; Van der Linden, 2015) e psicológicos (Spence; Poortinga; Pidgeon, 2012) (Figura 8), e pode variar entre indivíduos e grupo de indivíduos (Antwi-Agyei *et al.*, 2017; Wachinger *et al.*, 2013). Por exemplo, na Inglaterra fatores experienciais e socioculturais explicaram significativamente mais do que características cognitivas ou sociodemográficas (van der Linden, 2015). Em contraste, na América Latina (Lee *et al.*, 2015) e na Etiópia (Etana; van Wesenbeeck; de Cock Buning, 2021) fatores cognitivos (compreender as causas e consequências do aquecimento global) são mais destacadas. Um estudo com agricultores na escala local da região do semi-árido brasileiro (região Nordeste), indicou que o tempo de experiência na agricultura combinado com a experiência anterior com riscos foram os únicos fatores preditores da percepção do risco climático (Magalhães *et al.*, 2021).

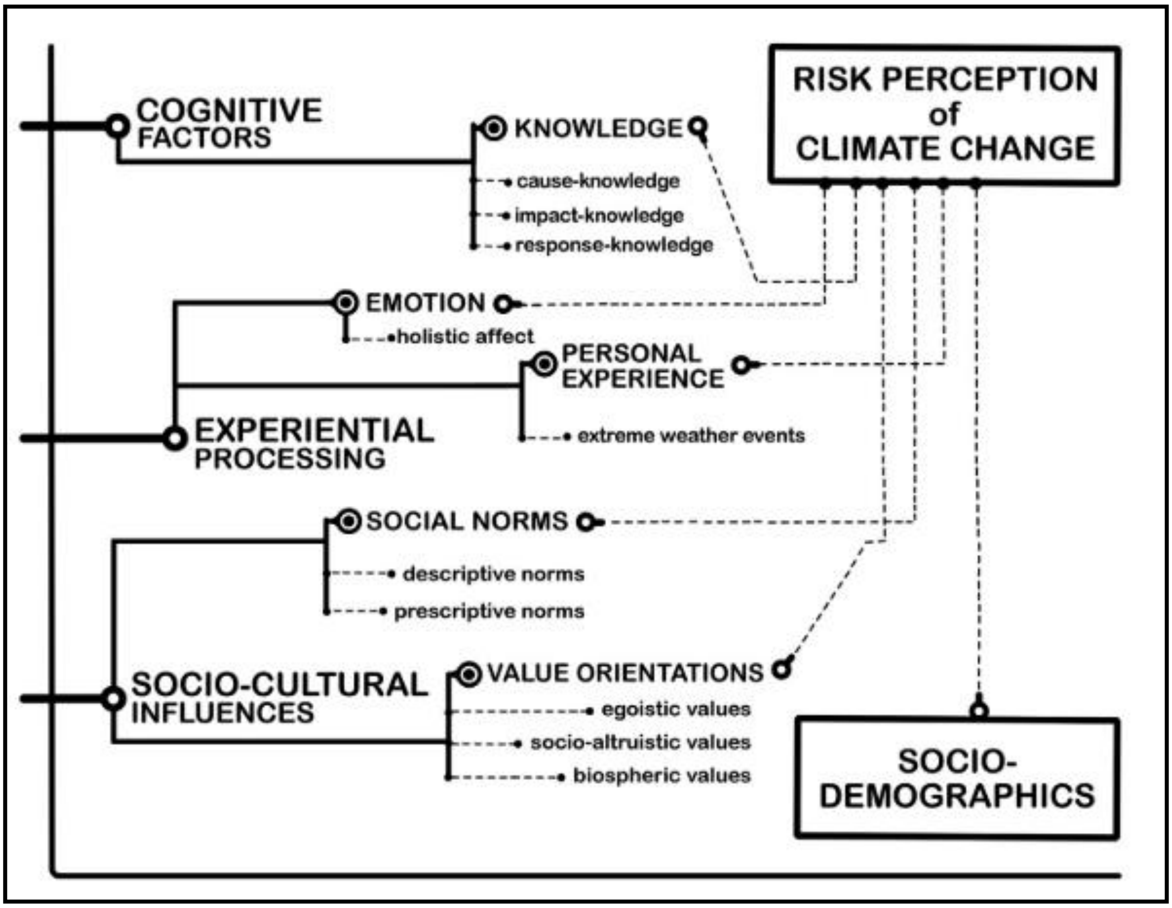

Figura 8 - Modelo da percepção da mudança climática.
Fonte: Van Der Linden (2015).

O setor agrícola é altamente vulnerável aos efeitos da variabilidade e mudança climática, porém, agricultores pobres em países em desenvolvimento são os mais afetados. A adaptação pode ser intencionalmente planejada ou autônoma (Dupuis; Dupuis; Biesbroek, 2013). A adaptação autônoma refere-se as ações implementadas por indivíduos ou grupos de indivíduos sem envolvimento do governo e pode ser motivada por fatores de mercado ou ambientais dentre outros (Lim *et al.*, 2004).

Ao nível global, os desafios mais significativos para a adaptação humana são restrições financeiras, de governança, institucionais e políticas. Para o caso especifico de Centro e Sul América, os principais desafios são financeiros e de governança (Pörtner *et al*., 2022.) (Figura 9).

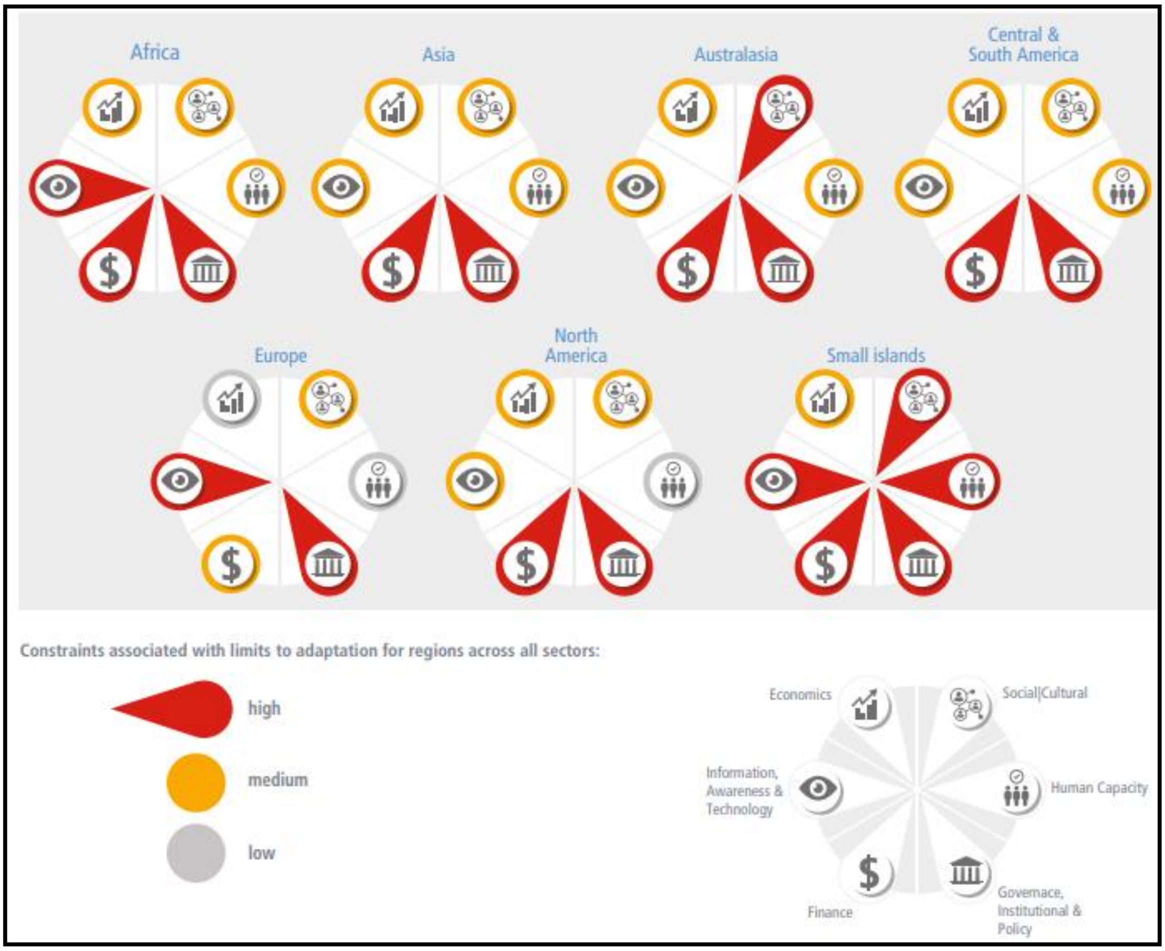

Figura 9 - Barreiras globais para o planejamento e a implementação da adaptação humana às mudanças climáticas.
Fonte: Pörtner *et al*., (2022, p.78)

Além das anteriores barreiras para a implementação de ações de adaptação, nas escalas regionais e locais, tem tido identificados fatores sociais, psicológicos, econômicos específicos que influenciam a adaptação das pessoas às mudanças climáticas (Dang *et al.*, 2019) (Figura 10).

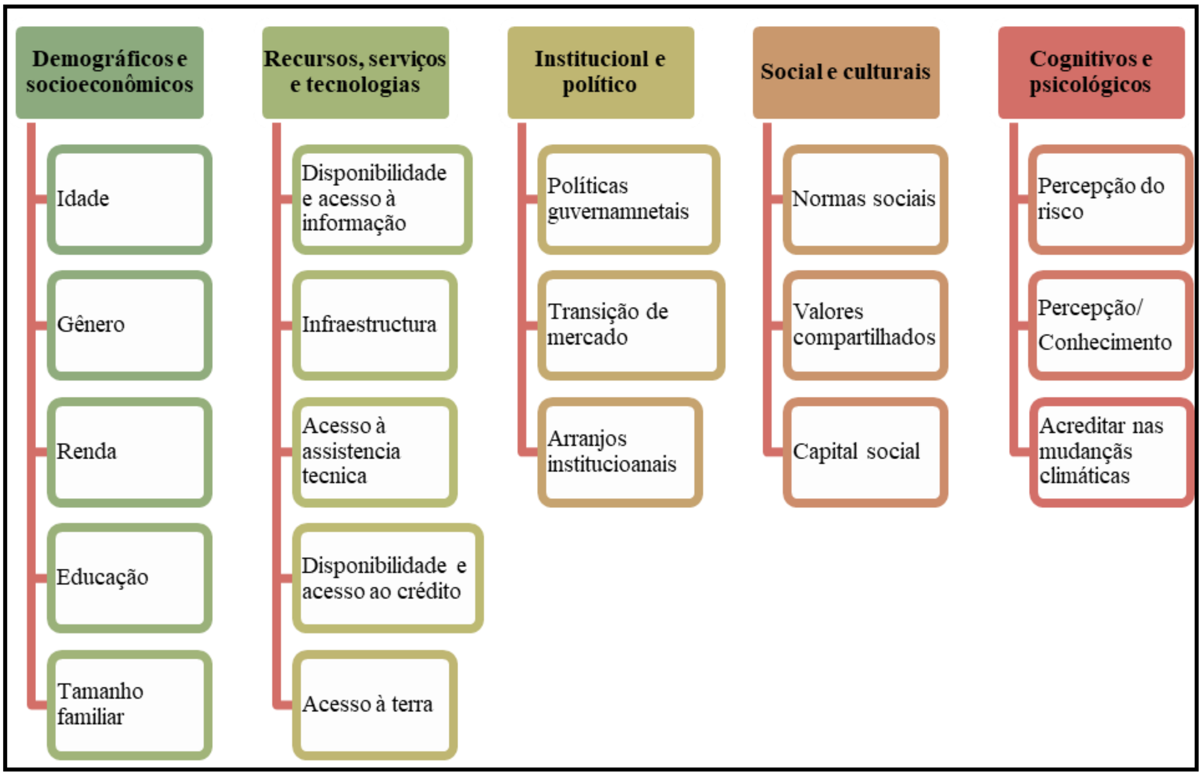

Figura 10 - Fatores que influenciam a adaptação de agricultores às mudanças climáticas.
Fonte: adaptado de Dang et al., (2019).

2.4 Agricultura de corte e queima na Amazônia

O Sistema de corte e queima (SCQ), também conhecida como roça no toco ou agricultura itinerante é uma prática milenar predominante em regiões tropicais do planeta, principalmente, na África, América Latina, Sul e Sudeste Asiático (Pedroso-Junior; Adams; Murrieta, 2008; Tang; Yap, 2020). Estima-se que aproximadamente 280 milhões de hectares são utilizadas no planeta para este fim, porém, espera-se um declínio do sistema para América Central e do Sul entre 60 a 80% para o ano de 2060 (Heinimann *et al.*, 2017).

No bioma Amazônico é uma técnica prática e rápida de preparar e adubar a terra utilizada por pequenos agricultores, assim como, por grandes pecuaristas (Morello *et al.*, 2017), basicamente é a principal pratica utilizada pelas comunidades tradicionais na Amazônia (Carmenta *et al.*, 2013; Jakovac *et al.*, 2017; Villa *et al.*, 2021), convertendo-se em um elemento nuclear de sua subsistência (Coomes; Takasaki; Rhemtulla, 2017). O SCQ aproveita o capital energético (biomassa) da floresta em recomposição e a fertilidade natural do solo (Pedroso-Junior; Adams; Murrieta, 2008). As áreas destinadas ao SCQ por agricultores tradicionais na Amazônia são pequenas, entre 0,5 e 2 hectares (Jakovac *et al.*, 2016, 2017; Loch *et al.*, 2020;

Righi; Gálvez, 2019; Villa *et al.*, 2021), e geralmente fazem entre um (1) e três (3) ciclos por sítio (Broadbent *et al.*, 2014; dos Santos *et al.*, 2018; Jakovac *et al.*, 2015, 2017; Schritt *et al.*, 2020; Villa *et al.*, 2020, 2021) dado que a fertilidade começa a diminuir rapidamente e o solo a ser perdido por erosão (Béliveau *et al.*, 2015; Villa *et al.*, 2021). Na Amazônia a intensificação do SCQ é uma preocupação crescente (Jakovac *et al.*, 2015, 2017; Schritt *et al.*, 2020; Villa *et al.*, 2020, 2021) (Figura 11). A intensificação se refere a um maior número de ciclos e à diminuição do período de pousio ou recuperação da vegetação (Jakovac *et al.*, 2016). A intensificação do SCQ na Amazônia deve-se , principalmente a fatores como acesso à terra (Celentano *et al.*, 2014; Coomes; Takasaki; Rhemtulla, 2017; Jakovac *et al.*, 2015, 2017; Loch *et al.*, 2020; Marquardt; Milestad; Salomonsson, 2013; van Vliet *et al.*, 2013), o crescimento populacional e o acesso ao mercado (Denich *et al.*, 2005; Jakovac *et al.*, 2017; Marquardt; Milestad; Salomonsson, 2013; van Vliet *et al.*, 2012, 2013; Villa *et al.*, 2020). Com a intensificação, a resiliência da vegetação diminui e a sua estrutura em comparação com a sucessão natural é mais distante (Jakovac *et al.*, 2015). Além disso, segundo Villa et al., (2018), expõem que a intensificação gera uma perda de biodiversidade e de serviços ecossistêmicos essenciais.

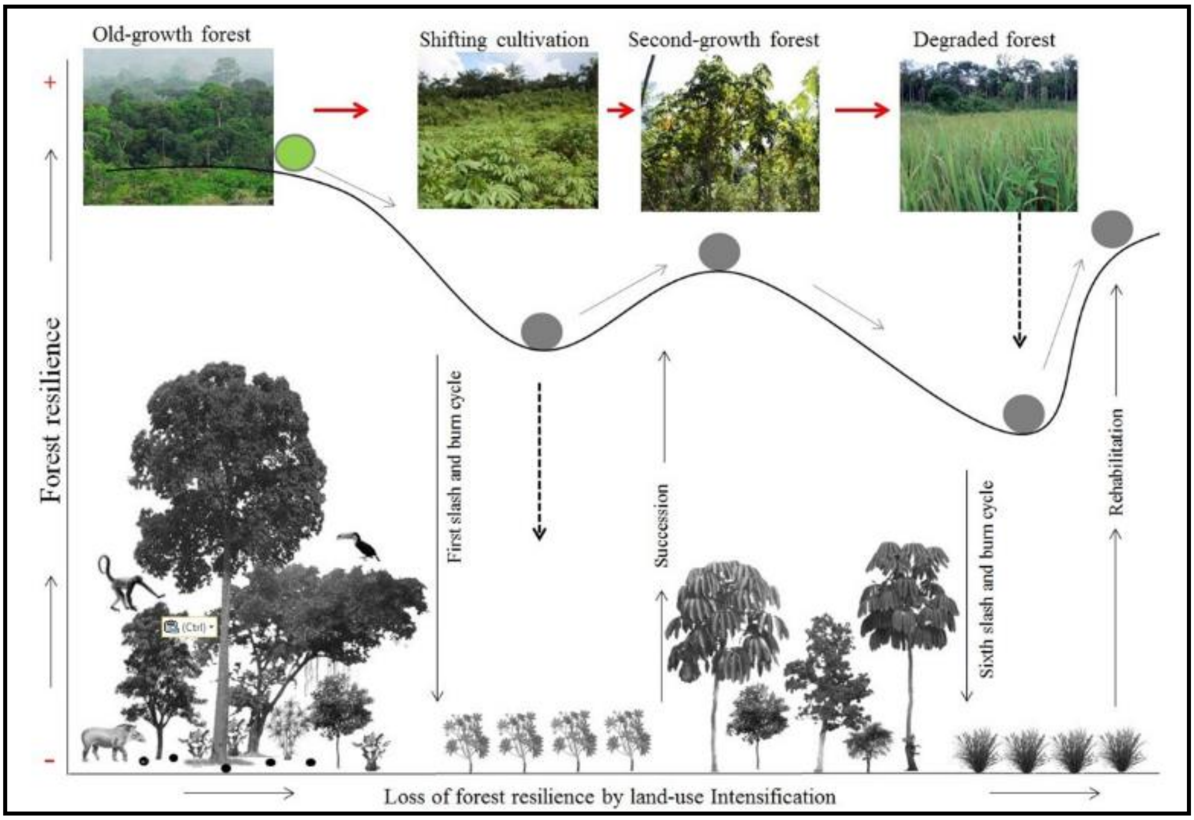

Figura 11 - Dinâmica do uso da terra na Floresta Amazônica.
Floresta antiga, cultivo itinerante, floresta secundaria e transição a floresta degradada.
Fonte: Villa *et al.*, (2020).

Em suma, a intensificação do SCQ, têm conduzido à diminuição no tempo de pousio em torno de 5 a 12 anos limitando a capacidade de regeneração da vegetação secundária (Coomes; Miltner, 2017; Jakovac *et al.*, 2017; Joslin *et al.*, 2016; Loch *et al.*, 2020; Lojka *et al.*, 2012; Righi; Gálvez, 2019; Villa *et al.*, 2018, 2020). Nesse sentido, no existe um consenso no período mínimo de pousio. Por exemplo, na Amazônia peruana, Wood; Rhemtulla; Coomes, (2017) concluíram em seu estudo de caso, que quando se aumenta o número de ciclos, mesmo um pousio mais longo (> 12 anos) não é suficiente para deter o declínio gradual das principais propriedades do solo. Em San Martin (Peru) as comunidades constataram que um tempo de pousio ideal é entre 15 -20 anos (Marquardt; Milestad; Porro, 2013). Por outro lado, existem outros resultados que indicam que esse período deve ser superior aos 20 anos. Por exemplo, Ribeiro Filho *et al.*, (2015) indicam a necessidade de mais de 28 anos para a recuperação das propriedades químicas do solo. Finalmente, o tempo de pousio não necessariamente é o principal fator limitante da sustentabilidade do sistema de corte e queima, fatores edáficos, intensidade de uso, manejo dos sistemas, entre outros podem ter um impacto maior

2.5 Alternativas para redesenhar o sistema de corte e queima no bioma amazônico

A adoção de práticas deve ser um processo gradual**,** porém**,** encontrar alternativas que mantenham a estabilidade socioecológicas e soberania alimentar das comunidades no bioma amazônico é prioritário (Villa *et al.*, 2020). A seguir são descritas algumas das práticas que são utilizadas e/ou propostas para redesenhar os sistemas de corte e queima para sistemas mais sustentáveis no bioma amazônico:

Sistemas Agroflorestais SAF's: constituem sistemas de uso e ocupação do solo onde plantas lenhosas perenes (árvores, arbustos, palmeiras) são associadas a plantas herbáceas, culturas agrícolas e/ou forrageiras e/ou em integração com animais (Altieri; Nicholls, 2012). Os SAF's representam um maior potencial de prestação de serviços ecossistêmicos por possuírem uma estrutura mais semelhante a uma floresta natural (Vasconcellos; Beltrão, 2018). São uma oportunidade de mitigação/adaptação às mudanças climáticas e transversalmente uma fonte de renda para diminuir a pobreza (Celentano *et al.*, 2020). Finalmente, a implementação de SAF's como alternativa ao SCQ na escala local onde a paisagem foi modificada e o sistema intensificado deveria integralizar-se como política pública (Villa *et al.*, 2015, 2020).

Biochar: derivado das florestas por meio da produção de carvão vegetal, é integrado ao ciclo do pousio roçado, e pode ser uma importante correção do solo para ajudar a intensificar e manter a produção agrícola e, potencialmente, aumentar a resiliência das florestas tropicais secundárias (Wood; Rhemtulla; Coomes, 2017).

Corte e cobertura morta "*slash and mulch*": chamada de "*Mulch*", corresponde uma técnica que consiste em distribuir sobre a superfície do solo uma camada de palhas ou outros resíduos vegetais entre as linhas das culturas ((Denich *et al.*, 2004).

Sistema em aléias: este tipo de cultivo conhecido em inglês como "*Alley cropping*" é um tipo de sistema agroflorestal que consiste na associação de árvores e/ou arbustos, geralmente os fixadores de nitrogênio, intercalados em faixas com culturas anuais (Moura *et al.*, 2008). As árvores utilizadas nesse sistema são geralmente leguminosas, por terem a maior capacidade de fixação de nitrogênio e alta produção de biomassa, sendo periodicamente podadas com o objetivo de fornecer adubo orgânico ao solo nas linhas com cultivo agrícola pela decomposição da fitomassa resultante das podas e servindo ainda como controle as plantas daninhas (Vasconcelos; da Silva; Lima, 2012).

No quadro 2, tem-se algumas experiências e estratégias que estão sendo implementadas ou propostas como alternativa na Amazônia para redesenhar os SCQ (Quadro 2).

Quadro 2 - Algumas alternativas para redesenhar o sistema de corte e queima na Amazônia.

Continua...

País	**Estado**	**Localidade**	**Prática**	**Benefícios/ Contribuições**	**Referência**
Brasil	Amapá	Reserva Extrativista (Rio Cajarí)	Enriquecimento capoeira com Castanha *Bertholletia excelsa, Bonpland,* 1808	Reversão da degradação florestal, geração de renda.	(Paiva; Guedes; Funi, 2011)
Brasil	Pará	Marapanim, (Zona bragantina)	Melhoramento de capoeiras com leguminosas	Acúmulo de biomassa; fixação de nitrogênio,	(Rangel-Vasconcelos *et al.*, 2016)
Brasil	Pará	Igarapé Açu, (Zona bragantina)	Sistema de corte e cobertura	Maior número de ciclos, resistente a seca, acúmulo matéria orgânica.	(Davidson *et al.*, 2008)
Brasil	Pará	Igarapé Açu, (Zona bragantina	Melhoramento de capoeiras com porcos ou gado	Os porcos ajudam a diminuir ervas daninhas, acelera a restauração florestal.	(Hohnwald; Kato; Walentowski, 2019).
Brasil	Pará	Tapajós	SAF's sistema bragantino	Maior rentabilidade, bem estar populacional.	(Tremblay *et al.*, 2015).

País	Estado	Localidade	Prática	Benefícios/ Contribuições	Referência
Brasil	Pará	Santarém (Mojú)	Múltiplas usos da floresta; manejo florestal	Incremento da renda, conservação da biodiversidade.	(Sist *et al.*, 2014).
Brasil	Pará	Região Bragantina	Sistema de corte e cobertura	Custo beneficio Incremento biomassa e disponibilidade suficiente para suprir a extração de nutrientes.	(Joslin *et al.*, 2019; Mburu *et al.*, 2007).
Brasil	Maranhão	Alcântara	Sistema de corte e cobertura	Incrementa resiliência dos sistemas, diversidade e composição da macrofauna semelhantes às florestas.	(Rousseau *et al.*, 2022).
Brasil	Maranhão	São Luís	Sistemas em aléias (*Cajanus cajan)*	Reciclagem do N e biomassa.	(Moura *et al.*, 2008).
Brasil	Maranhão	Centro-norte	Usos de leguminosas (*C. spetabilis* e *C. Juncea*)	Supressão de espontâneas e Fixação de nitrogênio.	(Aguiar *et al.*, 2011).
Peru	Lamas	San Martin	Capoeira melhoradas	Conhecimento local ecológico, acumulo de biomassa; incremento da biodiversidade	(Marquardt; Milestad; Salomonsson, 2013).
Peru	Iquitos	Loreto	SAFs “Bora”	Incrementa os ingressos, segurança alimentar e conserva a biodiversidade.	(Cotta, 2017).
Peru	Iquitos	San José	Biochar	Incrementa fertilidade, aumenta o carbono no solo, reduz acidez.	(Coomes; Miltner, 2017)
Peru	Pucallpa		Capoeira melhoradas com *Inga edulis* (leguminosa)	Alta produção biomassa e incrementa teor de N no solo; reduz ervas daninhas.	(Lojka *et al.*, 2008, 2012).

Fonte: Elaboração própria

Em resumem, não existe uma única alternativa para redesenhar o melhorar a pratica milenária do corte e queima realizada pelos agricultores tradicionais e familiares na Amazônia. A implementação de uma ou de várias dessas alternativas dependera de fatores locais sociais y econômicos, bem como, de uma política pública clara e coerente para incentivar os processos de transição socioecológica entorno do corte e queima. Acelerar o processo de transição das comunidades que praticam o SCQ na Amazonia é imprescindível para diminuir os impactos derivados das mudanças climáticas, bem como, as emissões de gases efeito estufa.

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3. CAPITULO II: **PERCEPTION OF THE VULNERABILITY OF QUILOMBOLA FARMERS IN ALCÂNTARA, EASTERN AMAZON, BRAZIL**

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Sistema de corte e queima em Alcântara, Maranhão. Fonte: Jhonatan Muñoz. 2021.

Perception of the vulnerability of quilombola farmers in Alcântara, eastern Amazonia, Brazil

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Abstract

This study addresses the contextual vulnerability of farmers using participatory risk mapping with different stakeholders. Additionally, through logistic regression, it identifies factors that influence the perception of climate risk. The results indicate that the perception and relevance of stressors vary among different stakeholders, as well as among farmers of different genders and ages. Non-climatic stressors are more relevant to farmers' livelihoods than climatic ones, although their interaction can exacerbate the impacts. Non-climate stressors identified in the past in the region continue to exacerbate communities' vulnerability. The lack of technical assistance is the most serious stressor. The lack of land and the delayed rains are the most severe stressors. Farmers' knowledge of climate change did not influence their perception of climate risks. Public climate adaptation policies should consider the local context, as well as the gender and age distributions of the public involved.

Key words: climatic and non-climatic risks, food security, adaptation, climate change, gender, livelihoods, slash-and-burn, Maranhão

Introduction

In the Amazon, the reduction in rainfall, the extension of the dry season (Mu and Jones 2022), the increase in deforestation (INPE 2022), and the socioeconomic fragility have elevated the level of vulnerability of the population to climate change (Debortoli et al. 2017; Reboita et al. 2022). There is evidence that the increasing deforestation in the Brazilian Amazon has contributed to the decrease in precipitation (Leite-Filho et al. 2021).

The development of agricultural activities is directly related to climatic conditions, making this activity highly vulnerable to climate change. The gradual increase in temperature and changes in precipitation levels alter the growth of plants and the dynamics of pollinators, which can have a negative impact on food production and food security in Brazil (Assad, Ribeiro, and Nakai 2018). Recent studies indicate that the decrease in rainfall in the Amazon generates significant damage to agriculture (Leite-Filho et al., 2021; Marengo, et al., 2022a). In the Amazon biome, slash-and-burn is the main technique used by family farmers and indigenous groups to prepare and fertilize areas of land (0.5 to 2 ha), and depends on the precipitation regimes (Villa et al. 2020). Family farmers who practice slash-and-burn in the Amazon are likely to be more affected by climate change, due to limited economic and human resources as well as reduced institutional support, which limit their ability to adapt (Brondizio and Moran 2008). In municipalities of the Brazilian Amazon, such as Alcântara, in the state of Maranhão, the slash-and-burn is the main method used by farmers. This municipality is part of one of the most degraded Amazon regions due to illegal deforestation (Silva Junior et al. 2020), and has one of the worst Human Development Indices in Brazil (HDI = 0.573) (Atlas Brasil 2022). The Quilombola Ethnic Territory (TEQA, from its Portuguese acronym) is located in this municipality, and is recognized on a national and international scale for the struggle that communities have undertaken in defense of their territory. Quilombolas are Afro-Brazilians that escaped from slavery to "Quilombos" settlements, which are recognized as traditional communities by law in Brazil (Brazilian Act 6040/2007). The land conflict in TEQA has intensified since the 1987 expulsion of 312 coastal families, who were randomly relocated into "Agrovilas" (rural villages built for relocated communities by the CLA), as part of the establishment of the Alcântara Launch Center by the military forces (Almeida 2006).

In the TEQA, land use is communal and various forms of use are developed (Araújo and Lima Filho 2006). The main form of land use for agriculture is slash-and-burn (or shifting agriculture), which is carried out in small areas (<1ha). Next, after a crop cycle, this area is typically abandoned, allowing for natural regeneration for approximately 7 years; then, a new cycle of cutting and burning begins. Given the intensification of land use in the agrovilas due to limited land access (Loch et al. 2020, 2023), this system has degraded soils and riparian forests, negatively affecting the provision of ecosystem services such as carbon sequestration (Zelarayán et al. 2015) and conservation of resources water (Celentano et al. 2014). Other stressors identified in the region include family migration to the outskirts of nearby cities, demographic pressure, low soil fertility, lack of land titling, as well as inadequate healthcare and school facilities (Almeida 2006). This reality has stimulated a process of agroecological transition in the region, with the goal of reducing vulnerability. However, challenges arise, such as low adoption by new families due to land insecurity (Loch et al. 2020).

In the present study, we used the concept of contextual vulnerability, as described by O'Brien et al., (2007). This vulnerability, as a characteristic of socio-ecological systems, is generated by multiple socioeconomic, environmental, cultural, technological and political stressors that lead to the current inability of communities or individuals to cope with external stressors such as climate change (O'Brien et al. 2007; Iwama et al. 2016; Siders 2019). Understanding how populations perceive multiple stressors is a prerequisite for reducing vulnerability and strengthening the adaptive capacity of communities in response to climate change (O'Brien et al. 2007; Van Aalst, Cannon, and Burton 2008; Antwi-Agyei et al. 2017). Participatory risk mapping has been an approach utilized to identify stressors that impact vulnerability and adaptive capacity (Nyantakyi-Frimpong and Bezner-Kerr 2015; Gutierrez et al. 2020). Risk perception is influenced by cognitive, social, cultural, sociodemographic and affective factors (Van der Linden 2015; Soucy et al. 2022).

To establish a more comprehensive and contextualized understanding of the challenges faced by a community or region, it is essential to integrate risk perception among diverse stakeholders. This integration enables a more efficient guidance of public policies (Nyantakyi-Frimpong and Bezner-Kerr 2015; Antwi-Agyei et al. 2017) and the development of more effective climate adaptation strategies that consider the complexity of the socio-ecological system (Brondizio and Moran 2008; O'Brien, Quinlan, and Ziervogel 2009; Gutierrez et al. 2020).

In general, there are few studies performing participatory risk mapping with different stakeholders that contribute to the understanding of the contextual vulnerability in agricultural environments. In this sense, three general questions guided this investigation: 1) What climatic and non-climatic stressors operate at the local level, and how do they interrelate to contribute to farmers' vulnerability and responsiveness? 2) How do stressors and their relevance vary between different stakeholders, and according to the gender and age groups of farmers? 3) What factors influence farmers' perception of climate change risks?

The results of this study are significant as they bring together different stakeholders to map the contextual vulnerability that hinders farmers' ability to respond to climate change scenarios. Furthermore, due to the socioeconomic similarity among farmers practicing slash-and-burn agriculture in the Amazon (Brondizio and Moran 2008; Debortoli et al. 2017), the findings contribute at the local and regional levels to current and future planning efforts aimed at enhancing community resilience in the face of climate change.

Methods

Study area

The Alcântara Quilombola Ethnic Territory (TEQA) is located in the municipality of Alcântara, in the northern region of the state of Maranhão, eastern Amazon, Brazil (Figure SOM 01). The region's climate is defined as tropical AS according to the Koppen classification (Alvares et al. 2013), with an average temperature of 27 °C, average rainfall of 1,972 mm/year and a dry season from June to December.

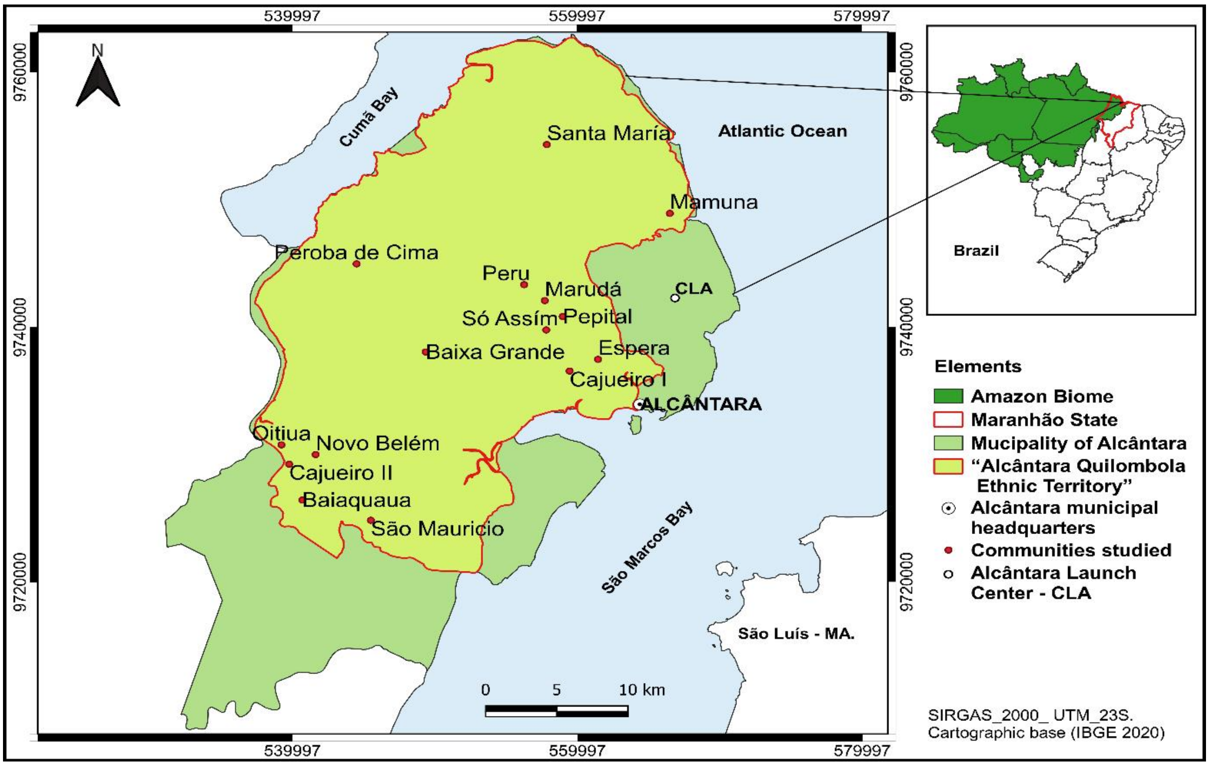

Figure SOM 1. Alcântara Quilombola Ethnic Territory (TEQA), Alcântara, Maranhão, Eastern Amazon, Brazil.

The region was originally inhabited by the Tupinambá indigenous group, whose villages and populations were decimated by the Portuguese shortly after the expulsion of the French in 1615. Continuing under Portuguese rule, in 1756 enslaved Africans began to work in the production of sugarcane, rice and cotton (Dias, Resende and Costa 2020). At the end of the 19th century, with the decline of agriculture and the subsequent abandonment of the land by the Portuguese, slaves began to form the Alcântara Quilombola Ethnic Territory (Almeida 2006). Currently, the municipality of Alcântara has a population of 18,466 people, of which 85% are quilombolas (IBGE 2022), who are distributed in about 200 communities. Together they form one of the largest Quilombola populations in Brazil with 3,350 families. In 2006, 78,105 hectares (67%) of the municipality entered the process of collective land titling by the National Institute of Colonization and Agrarian Reform (INCRA), but to date the process has not been completed (CPISP 2021).

Data collection

The collection of data was conducted with farmers and technical employees between February and April 2021, through semi-structured interviews, freelists and farmer focus groups (Table 1).

Table 1. Characteristics of farmers and technicians interviewed in the TEQA, Maranhão, eastern Amazon, Brazil.

Characteristics	**Mean ± SD or %**	**Characteristics**	**Mean ± SD or %**
Farmers		Incomplete elementary school	29
Demographics		Complete elementary school	13
Female	24	Incomplete high school	10
Male	76	Incomplete high education	10
Age (years)	56 ± 13	Incomplete higher education	2
Agriculture experience (years)	46 ± 15	Complete higher education	3
Number of household member	4.5 ± 2.4	*Characteristic farm*	
Number of children	3.5 ± 2.8	Farm size (ha)	0.7 ± 0.4
Years living in the region	48 ± 16.4	Fallow year	7.3 ± 3.9
Monthly family income		No receipt technical assistance	92
Less than a salary	30.4	**Technicians**	
One salary	47.8	*Demographics*	
A salary and average	2.2	Female	15
two wages	16.3	Male	85
More than two wages	3.3	Age (years)	47.8 ±13
Source of income		*Education level*	
Retirement	49.4	Incomplete elementary school	37.5
Government programs	40.2	Technical or higher education	62.5%
Others	10.4	**Stakeholders**	
Education level		Farmers interviews	N=92
Illiterate	23	Farmers' focus groups for discussion (FGDs)	N= 9
Complete literacy (reads and writes)	10	Technicians	N= 8

We employed the participatory mapping methodology (PRM) (Smith, Barrett, and Box 2000), following a similar approach to that of Antwi-Agyei et al. (2017). The PRM is a method of classifying and scoring (incidence, importance, severity and joint risk) stressors that allows for rapid and low-cost assessment of farmers' vulnerability (Tschakert 2007; Nyantakyi-Frimpong and Bezner-Kerr 2015; Antwi-Agyei et al. 2017). The PRM is easily communicable to decision-makers, allowing for standardized comparisons across locations and different audiences (Webber and Hill 2014). In the present study, the interviewees initially ranked the perceived stressors in order of importance and then scored their severity on a scale of 1 to 10, where 1 is the lowest severity and 10 is the highest severity.

Farmers' interviews

The farmers were interviewed individually (n=92) and in focus groups for discussion (FGDs) (n=9). Initially, 15 Quilombola communities were selected for individual interviews (Santa Maria, Peru, Mamuna, Marudá, Pepital, Só Assím, Cajueiro I, Espera, Baixa Grande, Peroba de Cima, Oitiua, Novo Belém, Cajueiro II, Baiaquaua and São Maurício). These communities were selected not only because they concentrate 40.8% (1,368) of the total number of Quilombola families (3,350) in the municipality, but also due to their agricultural importance, ease of access and previous contact in other works (Celentano et al. 2014; Loch et al. 2020). The selection was carried out with the support of the president of the Union of Alcântara Rural Workers and Family Farmers (STTR), the Secretariat of the of Family Agriculture, Aquaculture, Fishing and Food Supply (SEAPA) and the municipal technician of the Agricultural Research and Extension Agency of Maranhão (AGERP). After selecting the communities and according to the total number of families (1,368), the sample size (farmers) was estimated for a 95% confidence interval and a 10% margin of error. The number of farmers to be interviewed in each community was estimated in proportion to the total number of families (1,368) and the number of families in each community. The participants in each community were selected by the Snowball sampling methodology (Albuquerque et al., 2014). In total, 92 farmers were interviewed individually, all of whom are heads of households, over 18 years of age, and practice agriculture as their main activity: Oitiua (n= 30), Peru (n= 12), Santa Maria (n= 9), Peroba de Cima (n= 6), Marudá (n= 6), Cajueiro I (n= 7), Mamuna (n= 5), Pepital (n= 3), Só Assím (n= 3), Baiaquaua (n = 3), Baixa Grande (n= 2), Novo Belém (n= 2), São Maurício (n= 2) Cajueiro II (n= 1) and Espera (n= 1).

The individual interviews with the farmers were carried out at points in time. At the first time point, we recorded the socioeconomic data of the family. At the second, we followed the previously specified PRM methodology, and asked about the stressors (problems) that affect agricultural activity in the region. At the third time point, we ask if they know what climate change is and its causes.

Farmer focus-group discussions

Nine (n=9) GFDs were formed voluntarily. The number of members per group varied from 4 to 10 (Oitiua, n = 10, Peru, n = 4, Santa Maria, n = 8, Baiaquaua, n = 8, Baixa Grande, n = 5, Cajueiro I, n = 4, Mamuna, n = 3, Novo Belém, n = 7 and Só Assím, = 4), and ages ranged from 30 to 75 years. A majority of group participants (74%) had been interviewed in the individual phase. The activity of the FGDs started with a presentation of the research, followed by the presentation of the members of the group. Subsequently, the participants were encouraged to dialogue on the stressors that affect agricultural activity in the region. Furthermore, notes were recorded by a technical assistant to document the connection between the stressors.

Technicians

Using the same methodology (PRM), seven technicians were interviewed from the Secretariat of Family Agriculture, Aquaculture, Fisheries and Food Supply (n = 3), the Agricultural Research and Extension Agency of Maranhão (n = 1), the Municipal Environmental Department (n = 2), and the State Agricultural Defense Agency (n = 1). Additionally, the president of the Alcântara Rural Workers and Family Farmers Union (n = 1) was interviewed.

Authorizations and security procedures

This study was approved by the Research Ethics Committee of Maranhão State University (CAAE 39872720.0.0000.5554). All the participants agreed to participate in the research and had access to the Free and Informed Consent Form. This study had the collaboration of a student field assistant and resident of the region, trained in the development of interviews and annotations. To reduce the risk of COVID-19 contagion, the principal investigator lived in the region during the research period. Both followed the medical safety protocols suggested by Maranhão State University and the World Health Organization to reduce the risk of contagion (vaccination, distancing, use of masks and 70% alcohol).

Data analysis

Risk analyses followed an approach similar to that of Antwi-Agyei et al., (2017) using the adjusted equations from Tschakert, (2007). Initially, the stressors identified by the interviewees were classified into climatic and non-climatic. The climatic stressors, such as wind and temperature, were identified due to their direct relationship with climate formation. On the other hand, non-climatic factors were identified based on their connection to socioeconomic and human aspects. The incidence (I_j), importance (P_j), Severity (S) and joint risk (R_j) indices were calculated and analyzed for each of the following categories: farmer interviews (FI); women farmers (WF); men farmers (MF); young farmers (FY, age 23-40), adult farmers (FA, age 41-61), old farmers (FID, age 62-81), farmer focus group discussions (FGDs), and technicians (TEC). The incidence of risk (Ij) for each identified stressor was estimated by Equation One (1): $I_j = n_r / n_j$, where n_r is the number of times the stressor was mentioned and n_j is the total number of respondents. The scale ranges from 0 to 1. Numbers close to 0 indicate lower frequency whereas 1 indicates that the stressor was mentioned by all respondents. The importance index (P_j) for each identified stressor was estimated by Equation Two (2): $P_j = -1 \times ((r-1) / (n-1)) +1$, where P_j is calculated based on the stressor rating and the number of stressors identified by the same participant, while r is the rating and n is the total number of problems or stressors identified by the interviewee. The scale ranges from 0 to 1. Numbers close to 0 indicate lesser importance and 1 indicates the maximum importance of the risk. In this study, the interviewees scored their severity on a scale of 1 to 10, where 1 is the lowest severity and 10 is the highest severity. The joint risk index (R_j), which represents the most relevant stressor, was estimated by Equation Three (3), $R_j = I_j / (2-P_j)$, which combines equations One (1) and Two (2); the index also varies from 0 to 1. While the joint risk index highlighted the most serious risk, the severity index represented the impact of each stressor on livelihoods (Tschakert 2007; Antwi-Agyei et al. 2017). Data processing for analyses was done via the software Excel, and the figures by the package ggplot2 version 4.2.2 (Wickham et al. 2016) from R Development Core Team.

The data compiled from the FGDs on the perceived relationships between stressors were analyzed using the collective subject discourse (Lefevre and Lefevre 2005; Brito, Lauer-Leite, and Novais 2021). This method allows knowing and organizing individual thoughts that are visualized collectively. Key phrases were extracted from the notes and then synthesized into similar ideas to build the collective discourse.

A binary logistic regression model was utilized to evaluate the effects of independent variables on the farmers perception of climatic stressors: geographical location (belongs to the “Agrovilas” or not), age (years), educational level, gender, family size, agricultural experience (years), knowing what climate change is (0= Not, 1= Yes), knowing the causes of climatic change (0= Not, 1= Yes), less than one minimum wage (0= Not, 1= Yes), one minimum wage (= Not, 1= Yes), two minimum wages (0= Not, 1= Yes), technical assistance (= Not, 1= Yes.) This method is widely used due to its mathematical simplicity for obtaining robust results when the response variable is dichotomous categorical and the explanatory variables are categorical, continuous or discrete (Dang et al. 2019). We used the step function and the "backwards" direction to select the predictor variables, from the package MASS from R (Venables and Ripley 2002).

Results

Stressors present in the study region

The interviewees mentioned a total of 26 stressors that increase farmers' vulnerability. Among these stressors, 20 were non-climatic and six were climatic (Figure 1, Table 2). Thirty-eight percent (38%) of all stressors were common across the analyzed categories. The interviewed farmers reported a total of 17 non-climatic stressors and six climatic stressors. Gender analysis revealed that 78% (18) of the stressors were shared between women and men, while each of the different age categories shared 61% (14) of the stressors, with old farmers perceiving more stressors. The GFDs mentioned 17 stressors, of which the lack of credit, deforestation, and loss of knowledge were not previously mentioned by the interviewed farmers. The loss of ancestral knowledge was only mentioned by GFDs. The technicians observed 12 stressors, without identifying any new ones.

Approximately 46% of the stressors in our sample (26) were considered to be moderately important to very important ($5 \leq P_j \leq 10$) (Figure 1). More than 50% had low incidence ($I_j<0.5$). The two most cited and important stressors were lack of technical assistance ($I_j=0.64$; $P_j=0.63$) and lack of fertilizer and machinery ($I_j=0.51$; $P_j=0.64$). Among the stressors with lesser incidence and importance are the lack of credit, lack of community organization and decreased rainfall, among others ($I_j<0.5$, $P_j<0.5$).

The severity index (S), which represents the impact of each stressor on livelihoods, indicated that the interviewees perceived 100% of the stressors as moderately severe to very severe ($5 \leq S \leq 10$) (Figure 1). Population growth, COVID-19, lack of land, delayed rains, decreased rainfall, lack of water in the dry period, elevated temperature, lack of technical assistance, poor soil fertility, deforestation of riparian forests, unemployment and lack of money received the highest ratings ($8 \leq S \leq 10$). Decreased rainfall received the maximum severity (S=10) weighting by technicians and FGDs. While young and older farmers considered the delay of rains to be more severe (S=10). On the other hand, while phytosanitary issues are highly severe for women farmers (S=10), they represent minimal severity for technicians (S=1) and moderate severity for male farmers (S<7).

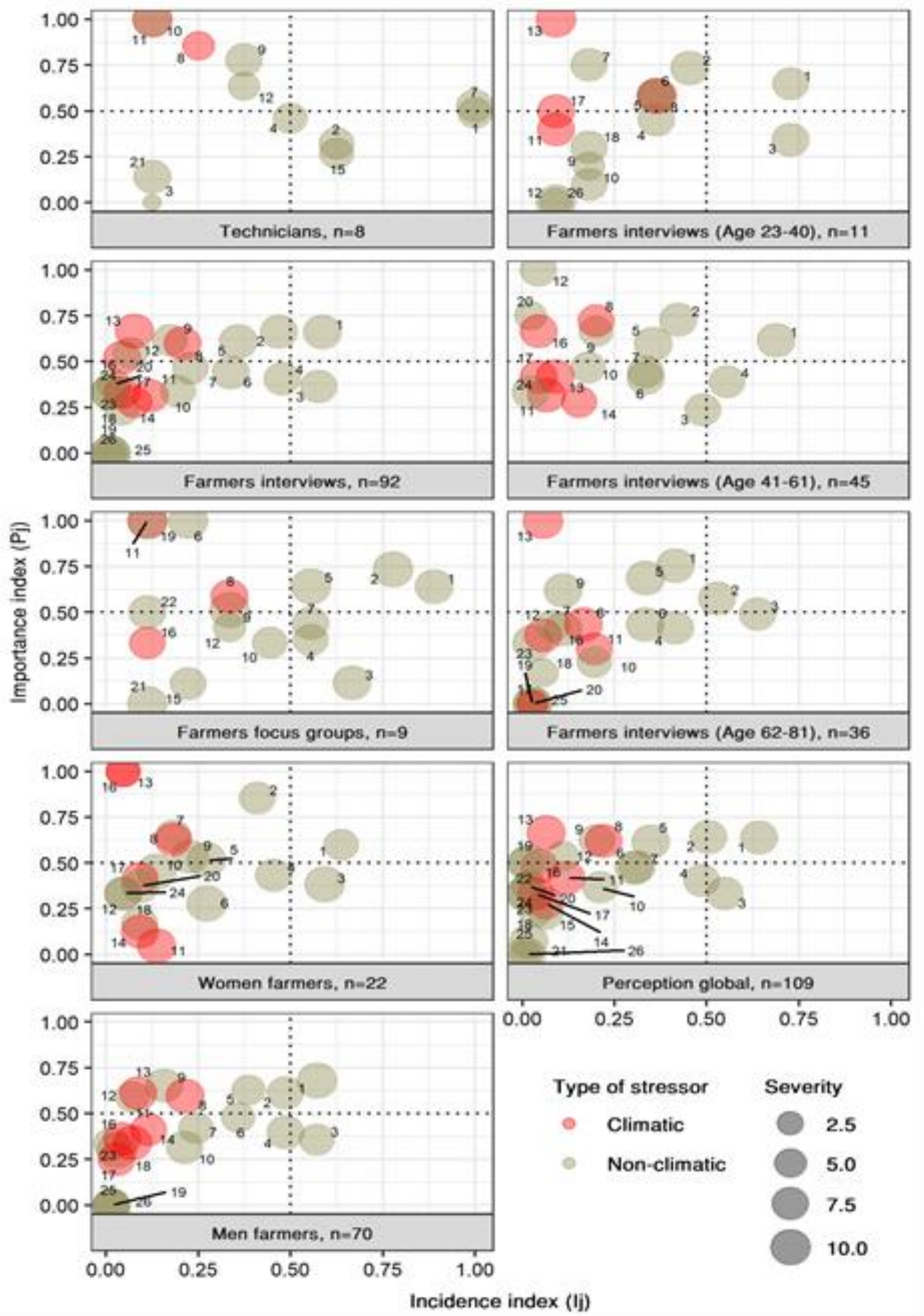

Figure 1 . Classification and participatory scoring of stressors by different stakeholders and at the level of the TEQA, Maranhão, eastern Amazon, Brazil.

1) Lack of technical assistance, 2) Lack of fertilizer and machinery, 3) Phytosanitary problems, 4) Bad roads and transport, 5) Lack of money, 6) Commercialization of products, 7) Poor soil fertility, 8) Lack of water in the dry period, 9) Lack of public investment, 10) Lack of workforce and disinterest of young people, 11) Decreased rainfall, 12) Lack of community organization, 13) Late rains, 14) excessive rain, 15) Lack to credit, 16) Elevated temperature, 17) Stronger drought, 18) Distance away from planting, 19) Lack of land, 20) Advanced age, 21) Deforestation of riparian forest, 22) Loss of ancestral knowledge, 23) Covid -19 pandemic, 24) Unemployment, 25) Low local consumption of regional agricultural products, 26) Population increase.

Variation in the perception of risk among different stakeholders

The joint risk index (R_j), which indicates the most serious or acute stressor, varied among the analyzed categories for the same stressor. Non-climatic stressors were perceived as more serious than climatic stressors. In the study area, the most serious stressor was the lack of technical assistance (R_j= 0.47), followed by the lack of fertilizers and machinery (R_j=0.37) and phytosanitary problems (R_j=0.33). Other stressors considered less acute include unemployment, deforestation of riparian forest, elevated temperature, lack of community organization, lack of credit and advanced age (R_j<0.1). The lack of water in the dry season was identified as the climatic stressor with the highest weighted risk (R_j≤0.16).

In general, both men and women share the main perceived stressors, although there are small differences in the perception of the acuity of the stressor. The lack of money was more acute for men (R_j=0.28) than for women (Rj=0.18). On the other hand, for women the distance away from planting, the increase in temperature and intense droughts were more serious than for men (Table 2).

When comparing young and adult farmers with old farmers, it was found that young adults did not perceive non-climatic stressors such as the lack of land and COVID-19. As for climatic stressors, all three of the age categories perceived the stronger drought, delayed rains, lack of water in the dry period and decreased rainfall. However, young farmers did not perceive a temperature increase or excessive rainfall. The lack of technical assistance was considered more acute for young (R_j=0.54) and adult farmers (R_j=0.50) than for older farmers (R_j= 0.33), while for the older farmers the lack of fertilizer and machinery was more serious (R_j=0.37).

Table 2. Joint risk index (Rj) and severity (S) of perceived stressors on the scale of the TEQA, Maranhão, eastern Amazon, Brazil.

ID	Stressors	WF	MF	FY	FA	FID	FI	FGDs	TEC	OVR	S
1	Lack of technical assistance	0.45	0.43	0.54	0.50	0.33	0.44	0.65	0.66	0.47	8.1
2	Lack of fertilizer and machinery	0.36	0.35	0.36	0.33	0.37	0.35	0.61	0.37	0.37	8.2
3	Phytosanitary problems	0.37	0.35	0.44	0.28	0.42	0.35	0.35	0.06	0.33	7.4
4	Bad roads and transport	0.29	0.30	0.23	0.35	0.26	0.30	0.34	0.32	0.30	7.2
5	Lack of Money	0.18	0.28	0.26	0.25	0.25	0.26	0.41	-	0.25	8.8
6	Commercialization of products	0.13	0.15	0.15	0.21	0.07	0.15	0.36	0.68	0.20	8.2
7	Poor soil fertility	0.16	0.23	0.26	0.21	0.21	0.22	0.22	-	0.19	7.4
8	Lack of water in the dry period	0.13	0.15	0.26	0.16	0.11	0.15	0.24	0.22	0.16	7.9
9	Lack of public investment	0.15	0.12	0.10	0.15	0.08	0.13	0.22	0.31	0.14	7.2
10	Lack of workforce and disinterest of young people	0.09	0.13	0.10	0.12	0.11	0.12	0.27	0.13	0.12	6.8
11	Decreased rainfall	0.07	0.07	0.06	0.04	0.11	0.07	0.11	0.13	0.07	8
12	Lack of community organization	0.03	0.05	0.05	0.04	0.05	0.04	0.21	0.27	0.07	5.7
13	Late rains	0.05	0.06	0.09	0.06	0.06	0.06	-	-	0.05	9
14	excessive rain	0.05	0.04	-	0.09	-	0.04	-	-	0.04	6.8
15	Lack to credit	-	-	-	-	-	-	0.12	0.36	0.04	6.1
16	Elevated temperature	0.05	0.03	-	0.03	0.03	0.03	0.07	-	0.03	7.8
17	Stronger drought	0.06	0.02	0.06	0.03	0.01	0.03	-	-	0.02	7
18	Distance away from planting	0.05	0.02	0.11	-	0.03	0.02	-	-	0.02	6
19	Lack of land	-	0.01	-	-	0.01	0.01	0.11	-	0.01	10
20	Advanced age	0.06	-	-	0.02	0.01	0.01	-	-	0.01	6.5
21	Deforestation of riparian forest	-	-	-	-	-	-	0.06	0.07	0.01	9
22	Loss of ancestral knowledge	-	-	-	-	-	-	0.07	-	0.01	8
23	Covid -19 pandemic	-	0.01	-	-	0.02	0.01	-	-	0.01	10
24	Unemployment	0.03	-	-	0.01	-	0.01	-	-	0.01	8
25	Low local consumption of regional agricultural products	-	0.01	-	-	0.01	0.01	-	-	0.01	5
26	Population increase	-	0.01	0.05	-	-	0.01	-	-	0.01	10

Identity (ID); women farmers (WF), n=22; men farmers (MF), n=70; farmer young (FY, age 23-40), n=11; farmers adult (FA, age 41-61), n= 45; older farmers (FID, age 62-81), n=36; farmers interviews (FI), n=92; farmer focus group discussions (FGDs), n=9; technicians (TEC), n=8; Overall risk (OVR), n=109, Overall severity (S).

Not only did farmers' GFDs identify stressors with a higher risk index than the other analyzed categories, but they also mentioned that there is a relationship between stressors that exacerbate the precarious situation of farmers (Table 3). The two most serious stressors were the lack of technical assistance (R_j=0.65) and the lack of fertilizer and machinery (R_j=0.61). On the other hand, the technicians highlighted the commercialization of products (R_j=0.68), lack of technical assistance (R_j=0.66), and lack of credit (R_j= 0.36). The lack of technical assistance was highly rated by the technicians (R_j=0.66), while the risk index was lower for the old farmers (R_j=0.33).

Table 3. Key expressions and central ideals the DSC from the speeches of the GFDs about the interactions of stressors in the TEQA, Maranhão, eastern Amazon, Brazil.

GFDs	Key expressions	Central ideals
BG, MA, O, AS.	*"In the region, there is little public investment and a lack of training".*	Lack of investments and training.
BQ, BG, CI, MA, NB, O, SM, P.	*"If there were technical assistance, fertilizers and machinery, it would be possible to considerably improve production and generate more income".*	Technical assistance, machinery and supplies.
CI, NB, O, P, SM, MA.	*"Transport is difficult in the region and the roads are so bad, especially in the rainy season, that sometimes it is not possible to carry the products".*	The state of the roads and the flow of products.
CI, NB, O, SM, MA.	*"When we arrive in Alcântara with the production, we have no one to sell to, and those who buy want to import their own payment terms. We need to establish partnerships with new buyers outside Alcântara".*	Difficulties for the commercialization of the production.
CI, NB, O, SM, MA, AS.	*"We face problems with pests, but often we don't know how to deal with them".*	Incidence of pests and training.
CI, NB, BQ, BG, O, AS, MA, P, AS.	*"The climate is important, but we cannot control it. The climate has changed a lot since then; look, it's March and there are still people planting manioc".*	Climate changes affect agricultural production.
BG, MA, SM, O, AS.	*"Deforestation of the riparian forest is because the soils near the river are of better quality, but it is also a lack of community organization and people's awareness. If communities were more organized, it would be possible to solve a series of problems".*	Lack of community organization and environmental awareness.

Oitiua (O), Peru (P), Santa Maria (SM), Baiaquaua (BQ), Baixa Grande (BG), Cajueiro I (CI), Mamuna, Novo Belém (NB), and Só Assím (SA).

Factors that influence the perception of climate risk

The binary logistic regression model indicates that geographic location (X^2= 12.2 $p < 0.001$, $R^2_{Nagelkerke}$ = 0.24) and higher income (X^2= 4.1 $p = 0.04$, $R^2_{Nagelkerke}$ = 0.24) are significant predictors of perceived risk of climate stressors. The probability of perceiving climatic stressors is 7.1 times lower in farmers who live outside the "agrovilas" (OR= 0.14, CI=95%: 0.05 to 0.8), and 4.2 times in those who earn two minimum monthly wages per month (Brazilian R$ 2,600 equivalent to US$ 530) (OR= 0.24 24, CI=95%: 0.04 to 0.38). Technical assistance, age (years), educational level, gender, family size, agricultural experience, and knowledge of what climate change is and its causes were non-predictive variables of the perception of climate stressors ($p > 0.05$).

Discussion

Stressors present in the study region

The findings of this study have important implications for decision-making. The patterns observed in Alcântara reflect the reality of more vulnerable countries and communities, where non-climatic stressors play a dominant role in farmers' livelihoods (Tschakert 2007; Nyantakyi-Frimpong and Bezner-Kerr 2015; Antwi-Agyei et al. 2017; Gutierrez et al. 2020). Therefore, adaptation and mitigation policies and strategies must address these non-climatic factors to ensure the resilience of these communities.

The deprivation of rights of quilombola communities is related to historical and current processes. Stressors such as population growth, low soil fertility, unemployment, poverty, migration to urban areas, lack of land tenure security and land scarcity (particularly in Agrovilas) identified in this study have persisted over time (Almeida 2006). Furthermore, despite the fact that the right to land ownership for quilombola communities is stipulated in by Article 68 of the Brazilian Constitution of 1988, the TEQA has not been titled. In the agrovilas, limited land access has intensified the use of slash-and-burn (Loch et al. 2020), resulting in negative impacts on riparian forests and ecosystem services such as carbon sequestration, soil fertility and water supply (Celentano et al. 2014). Despite the impacts generated by slash-and-burn on a local scale due to the insufficiency of land and technical follow-up, there is clear evidence demonstrating that the slash-and-burn system, on a landscape scale, is more sustainable than conventional farming in environmental, social and economic terms (Padoch and Pinedo-Vasquez 2010). Under the current socioeconomic conditions of the farmers in the study area and the state's inability to provide minimum human and economic resources to improve their living conditions, slash-and-burn will continue to be the most viable option to achieve subsistence and resilience in the face of climate change.

In the study area among the most serious (>Rj) non-climatic stressors perceived by the stakeholders, are the lack of technical assistance, the lack of fertilizer and machinery, phytosanitary problems, bad roads and transport, and lack of money (cash), and the commercialization of products. In addition to these stressors, this study also highlights other factors that have been recognized for their potential to limit the adaptive capacity of farmers in the face of climate change (Brondizio and Moran 2008; Siders 2019; Etongo et al. 2022). In Alcântara, the economic, technological and human resources to serve the rural population are limited. These difficulties hinder the coverage and presence of technicians in rural areas. This partly explains why technicians perceive the lack of technical support as a high-risk stressor compared to other stakeholders. The lack of technical assistance and rural extension (ATER, from its Portuguese acronym) in Brazil is more pronounced in the North and Northeast regions, where in 2017, less than 6% of farmers received this support. (Rocha Junior et al. 2020). In recent studies conducted in Africa, farmers emphasized the significance of coupling ATER with climate information to enhance decision-making (Mulwa et al. 2017; Etongo et al. 2022).

Among the non-climatic stressors, the only health-related stressor was the novel coronavirus (SARS-CoV-2), commonly known as COVID-19. The fact that COVID-19 was perceived as the only health-related stressor may have been a result of the global health crisis. The fact that only this health-related stressor was perceived may suggest the omission of other stressors that would normally be mentioned in normal times. In addition, the fact that it is perceived exclusively by older men may be related to the recognition that they are at greater risk of contracting and progressing to severe cases. (Dryhurst et al. 2020). The low relevance can be partially elucidated by three factors: first, rare events tend to convey a false sense of security (Wachinger et al. 2013); second, the study area is characterized by a difficult-to-reach location, which may have contributed to a sense of security due to transportation restrictions; third, quilombola communities were prioritized in the national vaccination program, and during the development of this study, the communities were vaccinated. To better understand risk perception in relation to COVID-19 in the TEQA it is necessary to address this topic specifically.

Climatic stressors are not considered to be among the highest-risk stressors (R_j). Pahl et al. (2014) indicated that, evolutionarily, human beings have a natural inclination to prioritize immediate situations, while tending to give less importance to long-term consequences, such as those related to climate change. Tvinnereim et al., (2020) in a survey conducted in several countries, reported that respondents perceive climate risk as a more significant threat to others than to themselves. On the other hand, although climatic stressors are not considered the most high-risk stressors, stakeholders acknowledge that the impact of reduced rainfall (S=8), water scarcity during the dry season (S=9), and delayed rains (S=9) are highly severe for the production system and, in general, for farmers' livelihoods. The fact that most climatic stressors are related to water resource availability can be linked to the functioning of the slash-and-burn system itself. This system operates in accordance with rainfall patterns in the Amazon. This means that farmers burn before the onset of rains and start planting with the first rains (Villa et al. 2020). It is clear that climate change alters natural ecosystems and, consequently, affects essential ecosystem services for agriculture, such as water availability (Leite-Filho et al. 2021; Estevo et al. 2022). The decrease in rainfall, changes in precipitation patterns, and rising temperatures in the Amazon pose challenges for farmers, necessitating the adoption of innovative approaches to enhance community resilience (Marengo et al., 2022b), such as the agroforestry systems (Villa et al. 2020). In the TEQA, some farmers in the region are attempting to respond to these stressors through agroecological transition and agroforestry systems. However, the lack of land tenure poses a significant barrier to this process (Loch et al. 2020). The transition processes are slow and require articulation with other public bodies, as well as public policies that guarantee income and technical assistance.

Variation in the perception of risk among different stakeholders

The results indicate that the perception of stressors varies among stakeholders, and converges with Quinn et al. (2003), who suggest that risk perception is related to the role of individuals in society. These results have important implications for risk management and decision-making because they facilitate the articulation of efforts to solve problems that are a priority for communities or implement mitigation or adaptation measures that reduce vulnerability to the effects of climate change. The lack of alignment in the prioritization of perceived risks can generate conflicts and tensions between the interested parties, which can make it difficult to collaborate and implement joint strategies. For example, if farmers perceive a high climate risk and are willing to adopt more resilient agricultural practices, but local governments or organizations do not share the same risk perception, it is possible that the necessary resources are not allocated to support these measures. Therefore, promoting an inclusive and participatory dialogue is essential to understand and address the different perceptions of risk.

Interaction between stressors

The results from the farmers' focus group discussions (FGDs) indicate that the stressors interact with each other. These interactions have implications for food sovereignty and the adaptive capacity of farmers in response to climate change (Antwi-Agyei et al. 2017; Magalhães et al. 2021). The lack of assistance is the most serious stressor, and there is evidence that ATER reduces social and climate vulnerability in communities, as it is associated with increased income (Rocha Junior et al. 2020), poverty eradication, and technology dissemination (Fishlow and Vieira Filho 2017). According to Antwi-Agyei et al. (2017), the lack of road infrastructure and limited access to markets also exacerbate farmers' vulnerability to climate change. In the present and future, the production and commercialization of products may face challenges not only on account of intensified rainfall that degrades the roads during the rainy season, but also due to water availability during the dry season. In the eastern Amazon, a decrease in rainfall is already occurring (Marengo et al., 2022a), and a significant reduction is expected in the near future (Baker et al. 2021). Diminished capacity to produce and market can impact income, food sovereignty and farmers' ability to respond to climate change.

Factors that influence the perception of climate risk

Our results indicate that living in more remote communities (not Agrovilas) and having a higher income (two minimum wages) have a significant negative effect on the likelihood of perceiving climate stressors. On the other hand, unlike the findings of the current study, which suggest that knowledge about climate change is not a predictor of risk perception, a global-scale study reveals that in Latin America, knowledge, particularly regarding the causes of climate change, serves as a robust predictor of risk perception (Lee et al. 2015). The divergence between this result and ours may be related to the scale of analysis, indicating the need for more studies at the local level. Furthermore, since informed farmers increase their perception of climate risk and actively engage in addressing those risks (Schattman, Caswell, and Faulkner 2021), it is necessary to focus our efforts on this group that still does not perceive the importance of climate change for their livelihoods.

Perceiving climate problems does not necessarily lead to the implementation of adaptation actions (Wachinger et al. 2013), because socioeconomic stressors can constrain adaptive capacity (Grothmann and Patt 2005; Zheng and Dallimer 2016; Tripathi and Mishra 2017). However, utilizing a meta-analysis of data from 23 countries, Van Valkengoed and Steg, (2019) found that risk perception motivates individuals to engage in pro-adaptive behavior. For example, Zheng & Dallimer, (2016) in Yunnan province, China, found that the number of adaptation measures was related to the most frequently mentioned risk (droughts). Furthermore, farmers in Kenya are implementing adaptation actions based on the assessment of perceived risks associated with decreased precipitation and rising temperatures (Gbegbelegbe et al. 2018).

Conclusions

This study highlights the significant impact of climatic and non-climatic stressors on the livelihood of quilombola farmers in Alcântara. The study findings demonstrate that the perceived stressors and their significance and severity differ among various stakeholders, as well as across different genders and age groups of farmers, underscoring the importance of integrating risk perception across diverse stakeholders, even at local scales where a level of socioeconomic homogeneity is assumed. Ignoring this heterogeneity can lead to the implementation of policies to reduce vulnerability and adaptation actions that are not aligned with the needs of communities.

Although climate stressors are less relevant, it is essential to recognize the interaction between the two and how this affects the vulnerability of these communities to climate change. Raising awareness among farmers about climate change could highlight its importance for their livelihoods and encourage adaptation.

This study has some limitations. FGDs were not asked directly about interactions between stressors, and health-related stressors may have been overlooked because of the pandemic.

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Conflict of Interest

The authors declare that we have no conflict of interest.

Data availability

The data that support the findings of this study are available from the corresponding author, [J.A.M.G], upon reasonable request.

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4. CAPITULO III: **ADAPTATION TO CLIMATE CHANGE IN THE EASTERN AMAZON: PERCEPTIONS, DETERMINANTS AND BARRIERS AMONG QUILOMBOLA FARMERS IN ALCÁNTARA BRAZIL**

Artigo com intenção de ser submetido na revista

Climate and Development

Percepções dos Agricultores quilombolas de Alcântara, Maranhão, sobre as mudanças da temperatura e chuva. Fonte: Jhonatan Muñoz. 2021.

Adaptation to climate change in the eastern Amazon: perceptions, determinants and barriers among quilombola farmers in Alcántara.

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Abstract

The assertive implementation of climate adaptation processes for farmers must consider perceptions, knowledge, farmer typology, barriers and meteorological data. This study explored these topics through 92 semistructured interviews with quilombola farmers, 9 focus group discussions, and meteorological data. Using mixed data factorial analysis and hierarchical cluster analysis, farmer typologies are identified. Logistic regression was employed to identify the factors influencing farmers' adaptation. The results indicate that television (83%) is the main source of information about climate change; however, more than 50% of those surveyed were unaware of its causes and meaning. The farmers' perceptions aligned with the meteorological data, which revealed a temperature increase ($p < 0.05$) and a decrease in precipitation, with impacts such as cassava rot, changes in the planting period and working hours. Few farmers (<29%) implement adaptation actions other than the planting period. knowledge about global warming and access to credit significantly influences adaptation actions ($p < 0.05$). A lack of technical assistance is the main perceived barrier to abandoning slash-and-burn. Three groups of farmers were identified ($p < 0.05$). Given the socioeconomic similarities among traditional Amazonian slash-and-burn farmers, these results have relevance for local and regional decision-making.

KEYWORDS: adaptive capacity, slash-and-burn, Brazil, climate change impact, Maranhão, farmers' typologies, food security

Introduction

Climate change is generating negative impacts on global food production and the livelihoods of farmers (Farooq et al., 2022). However, the impacts of climate change vary according to the socioecological system (Reyes-García et al., 2022), and traditional farmers are likely to be the most affected by climate change and its intensification.

In the current context and facing climate projections worldwide, adaptation has become a central axis for reducing the impacts of climate change. Climate adaptation refers to local adjustments to cope with modifications within systems that include socioeconomic and political barriers (Smit & Wandel, 2006). Barriers can be interpreted as surmountable challenges (Moser & Ekstrom, 2010).

To promote effective adaptation, it is imperative to consider people's knowledge and perceptions of climate change (Etana, Snelder, et al., 2021; Kumar & Gupta, 2021). In addition, income, family size, and access to credit are identified as barriers and determinants that influence adaptive capacity (Dang et al., 2019; Singh, 2020). Understanding the factors that interfere with farmers' adaptation to climate change is a priority for stimulating more assertive public policies, especially in areas where farmers have a strong dependence on natural resources (Brondízio et al., 2021; De Matos Carlos et al., 2020; Funatsu et al., 2019; Reyes-García et al., 2016).

Previous studies have emphasized that perceptions of climate change, barriers, and factors influencing the adaptation process vary among countries, regions, communities, and individuals (Dang et al., 2019; Shackleton et al., 2015). Recently, systematic reviews have highlighted the need to consolidate information related to farmers' perceptions of climate change in Latin America (Fierros-González and López-Feldman 2021), as well as barriers and factors hindering the adaptation process (Dang et al., 2019). In addition, in Brazil, it is necessary to identify farmers based on their knowledge and/or perception of climate change and socioeconomic profiles (Foguesatto et al., 2019).

In the Amazon, traditional communities mainly use the slash-and-burn agricultural technique, which is dependent on precipitation patterns. Slash-and-burn vegetation involves clearing small areas (<2 ha) of vegetation, followed by burning and utilizing ashes (Villa et al., 2020). Despite its environmental impacts, this approach is more sustainable than conventional methods from social, environmental, and economic perspectives (Padoch & Pinedo-vasquez, 2010). The precarious socio-economic situation of traditional farmers in the Amazon and the lack of state support, slash-and-burn will persist as the most viable option for subsistence and resilience in the face of climate change (Gutiérrez et al., 2023). Specifically, in the eastern Amazon, where climate change manifests as reduced rainfall, prolonged dry seasons, and increased temperatures, agriculture faces considerable challenges (Marengo et al., 2022). In this scenario, there is no doubt that these changes will compromise the food security and sovereignty of traditional farmers practicing slash-and-burn.

Similarly, in various municipalities in the Brazilian Amazon, including Alcântara, Maranhão, slash-and-burn emerges as the predominant technique for land preparation among communities in the Quilombola Territory of Alcântara (TQA). The quilombolas (descendants of enslaved Africans) of the TQA use small land areas (<1 ha) for slash-and-burn, leaving them fallow (Pousio) for an average period of 7 years (± 3.9) after a production cycle (Gutierrez et al., 2023). In the TQA, communities face climate risks such as reduced rainfall, delayed rainy seasons, increased temperature, and non-climatic issues such as land conflicts, low soil fertility, lack of technical assistance, fragile infrastructure, difficulties in marketing agricultural products (Gutierrez et al., 2023), and decreased water resources due to deforestation of riparian forests (Celentano et al., 2014). These problems limit the adaptive capacity of communities. The lack of land titling and security has constrained an agroecological transition process initiated in 2013 in relocated communities (Agrovilas) by the Alcântara Launch Center-CLA (Loch et al., 2020).

Given the presented scenario, this study aimed to obtain information related to the knowledge, perceptions, and adaptation of quilombola farmers regarding climate change. To achieve this goal, in addition to seeking descriptive responses and characterizing farmers based on their knowledge of climate change, adaptation, and socioeconomic aspects, the following two hypotheses were tested: H1 – farmers' perceptions converge with local climatological data. H2 - The implementation of adaptation measures is influenced by factors such as higher income, older age, more years of education, number of children, geographic location, access to credit, family size, perception of climate stressors, and knowledge of climate change.

Methods

Study area

The municipality of Alcântara, located in the northern region of the state of Maranhão in the Eastern Amazon, Brazil (Figure 1), has a tropical climate classified as Aw according to the Köppen classification (Alvares et al., 2013), with an average temperature of 27°C (±0.38) and average precipitation of 1838 (±519) mm/year. The landscape is characterized by the presence of secondary forests (Loch et al., 2023), and the soils are classified as low-fertility Plinthosols (Anjos et al., 1995).

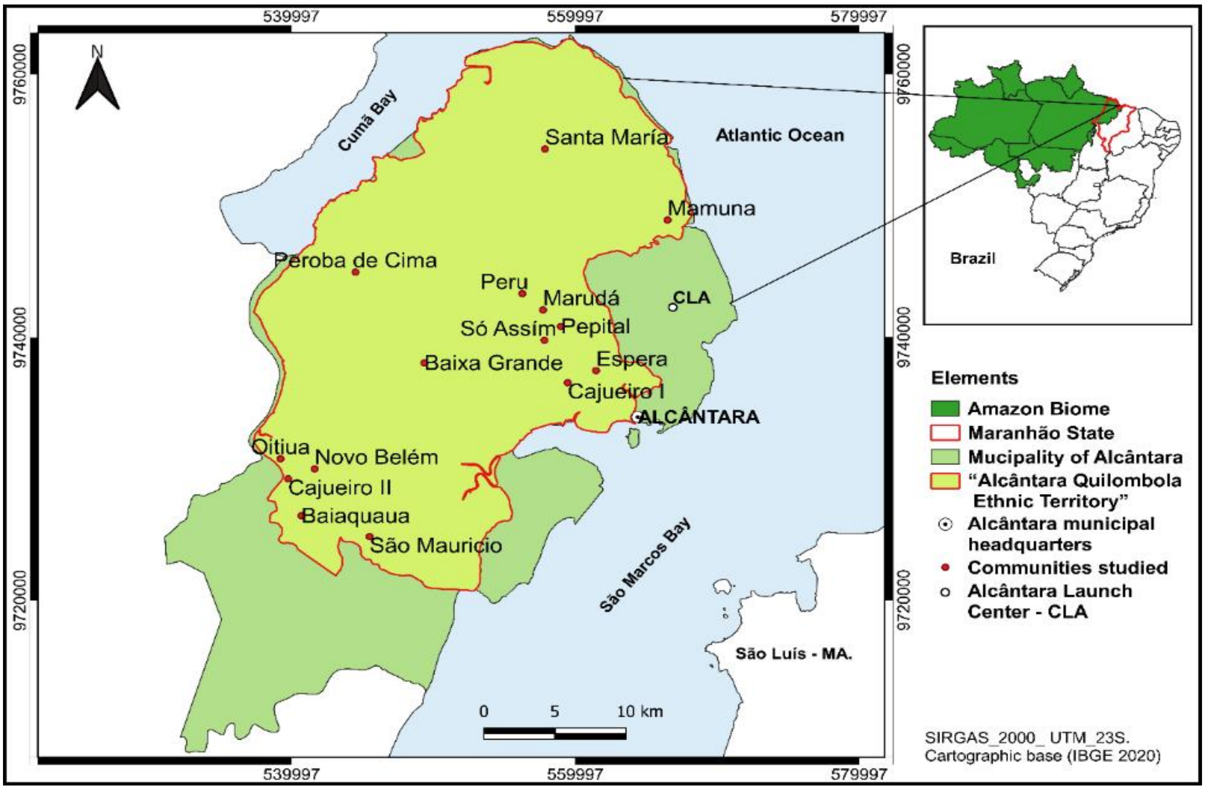

Fig. 1 Alcântara Quilombola Ethnic Territory (TEQA), Alcântara, Maranhão, Eastern Amazon, Brazil.

(Source: Gutiérrez et al., 2023).

Alcântara currently has a population of approximately 18,466 inhabitants, with 15,616 of them being quilombolas (IBGE 2022), distributed across approximately 200 communities. Together, they form one of the largest quilombola territories in Brazil, with 3,350 families. However, as of now, land regularization has not been completed (CPISP 2023).

Despite Alcântara being located near the state capital (São Luís) and having a coastline rich in mangroves and other natural resources, the municipality is considered one of the poorest in the country, with a human development index of 0.57. Recent studies in the region highlight the low level of education and the low monthly income of quilombola families (Gutiérrez et al., 2023; Loch et al., 2020).

Data collection

Data collection was conducted with farmers from 15 communities in TQA (Peru, Marudá, Pepital, Só Assím, Cajueiro I and Espera (Agrovilas), Mamuna, Baixa Grande, Santa Maria, Peroba de Cima, Oitiua, Novo Belém, Cajueiro II, Baiaquaua, and São Maurício) between February 2021 and February 2022 through semistructured interviews, free lists, and the Farmer Focus-Groups Discussion (GFDs) (Albuquerque et al., 2014). The selection of communities received support from the Union of Rural Workers and Family Farmers of Alcântara (STTR), the municipal technician of the Agricultural Research and Extension Agency of Maranhão (AGERP), and the Secretariat of Family Agriculture, Aquaculture, Fisheries, and Supply (SEAPA).

This study was approved by the ethics committee of the State University of Maranhão (CAAE 39872720.0.0000.5554). All participants were provided with the informed consent form prior to their involvement.

The climate data for the 1980-2021 time series regarding air temperature and surface precipitation at 2 meters were obtained from the National Aeronautics and Space Administration/Prediction of Worldwide Energy Resources-NASA/POWER (https://power.larc.nasa.gov/). The POWER single-point function was utilized with the coordinate's latitude -2.296 and longitude -44.492 for the study area.

Interviews of Farmers

A total of 92 farmers were interviewed, 76% male and 24% female. The sample size (n=92) was calculated using the free SurveyMonkey calculator (https://www.surveymonkey.com/mp/sample-size-calculator/), with a 95% confidence interval and a margin of error of 10%. This calculation was based on approximately 1,368 families settled in the 15 communities. The number of participants in each community was proportional to the number of families in each community relative to the total number (1,368). Due to difficulties in accessing and a lack of municipal data on farmers at the local scale, participants were selected using the "snowball" method in each community (Albuquerque et al., 2014). All the interviewees were heads of household aged over 18 years, with agriculture serving as their primary source of income. The age of the interviewees ranged from 23 to 83 years (56±13). Oitiua (n= 30), Peru (n= 12), Santa Maria (n= 9), Peroba de Cima (n= 6), Marudá (n= 6), Cajueiro (n= 7), Mamuna (n= 5), Pepital (n= 3), Só Assím (n= 3), Baiaquaua (n = 3), Baixa Grande (n= 2), Novo Belém (n= 2), São Maurício (n= 2), Cajueiro II (n= 1), and Espera (n= 1).

Individual interviews with farmers were conducted at specific moments. We first recorded the families' socioeconomic data (Gutiérrez et al., 2023), and then we inquired about aspects related to climate change.

Farmer Focus Group Discussions

Voluntarily, seven (n=7) Farmer Focus Groups Discussion (GFDs) were formed (Oitiua, Peru, Santa Maria, Baiaquaua, Baixa Grande, Cajueiro I, Mamuna) to discuss the perceived impacts of climate change. Following the participatory timeline methodology (Sieber et al., 2014), the

GFDs focused on constructing historical perceptions (present and past) of temperature and precipitation changes at the local scale.

On the other hand, two events discussing the "Challenges and Opportunities for Farmers in the Face of Climate Change at the Local Scale of Alcântara" were leveraged. GFDs were formed during these events, openly asking about the barriers farmers face when transitioning from slash-and-burn systems to fire-free systems such as agroforestry. The first meeting was held at the municipal headquarters of Alcântara, and the second was held in the community of Santa Maria. In total, 57 people participated (farmers; members of the STTR, AGERP, and SEAPA from the municipality; professors from the Federal Institute of Maranhão – IFMA; and NGO representatives). The number of members per GFD varied between 4 and 10, with ages ranging from 30 to 75 years. The majority (>70%) of farmers participating in the GFDs were individually interviewed.

Data analysis

Descriptive statistics were used to analyze the data related to access to climate information, perception and knowledge of climate change, and adaptation actions. The information from the GFDs regarding the perception of temperature and precipitation (present-past) and their impacts on agriculture was organized into key expressions using the collective subject discourse method (CSD). This method allows for understanding and organizing individual thoughts that are collectively visualized (Lefevre & Lefevre, 2014). Key phrases were extracted from the notes and synthesized into similar ideas to construct the collective discourse.

To test the convergence between farmers' perceptions and climatological data, the nonparametric Mann–Kendall trend test (Kendall, 1975) was used to determine the significance level ($p \leq 0.05$). Additionally, anomalies, differences between decades, and month-to-month differences between decades were calculated. Climate anomalies were computed according to Equation 1 (Silva Junior et al. (2018).

$$\text{Equation 1: } X_{Anomaly} = (X_i - \bar{x}_{1981-2021})/\sigma_{1981-2021})$$

where X_i is the year under analysis, $\bar{x}$ is the annual mean of the 1981–2021 series, and σ is the standard deviation of the time series. Significant anomalies (95% confidence intervals) were considered ≤ -1.96 and ≥ 1.96 standard deviations. To identify significant differences in temperature and precipitation over the last four (4) decades (1981-2020) before conducting ANOVA ($p \leq 0.05$), the normality of residuals was tested using the Shapiro–Wilk method, and homogeneity of variances was assessed using the Levene method.

To test H2, a binary logistic regression model was employed. Our categorical dependent variable (0=does not implement adaptation actions; 1=implement adaptation actions) was tested against the following explanatory variables: age, education, family size, number of children, geographic location (non-agrovila=0, agrovila=1), access to credit (0=no, 1=yes), know what global warming is (0=not, 1=yes), know what climate change is (0=not, 1=yes), know the causes of global warming (0=not, 1=yes), and perceive climate stressors as risks (0=no, 1=yes). We used the "backward" function to select predictor variables and ANOVA in the model with the Wald statistic to identify significant predictor variables. Logistic regression is widely used in studies that aim to identify factors influencing farmers' adaptation to climate change (Dang et al., 2019), and this method does not require assumptions of normality or homogeneity of variances for quantitative variables (Hosmer & Lemeshow, 2000; Montgomery et al., 1987).

Regarding the barriers faced by farmers in terms of transitioning from slash-and-burn to fire-free systems, the data were analyzed using descriptive statistics, and the R package ggwordcloud (Le Pennec; Slowikowski, 2019) was used to create visual representations of the results. The ggwordcloud is a method that visually identifies the most frequent words in a text. It consists of words of different sizes, with larger words appearing more frequently.

The characterization of farmers based on knowledge of climate change, adaptation, and socioeconomic aspects was carried out through a mixed data analysis factorial (FAMD) approach (Pagès, 2004) as an initial step for the hierarchical cluster analysis on principal components (HCPC) (Kassambara 2017). Both analyses were performed in the R environment using the FactoMineR package (Lê et al., 2008). FAMD is a principal component method that allows categorical and quantitative variables to be analyzed simultaneously, as the variable set is normalized to ensure balance between them (Pagès, 2004). O HCPC identifies and groups similar observations based on the results of the principal components selected in FAMD (Kassambara, 2017). The categorical variables used included gender, education, access to credit, income, perception of climate stressors, knowledge of the causes of global warming, awareness of climate change and global warming, implementation of adaptation actions, type of agricultural system used (with or without fire), and geographic location. The quantitative variables included age, family size, number of children, and years practicing agriculture.

The number of retained components in the FAMD was the first 6 because they had eigenvalues ≥ 1 (Kassambara, 2017), explained more than 50% of the variance, and did not contribute significantly to explaining the variation (Kukielka et al., 2018). The number of clusters in the HCPC cohort was selected based on the inertia gain plot, as suggested for the HCPC cohort. The most important variables in group formation were identified by having a v.test value of |1.96|, which is equivalent to $p < 0.05$ (Kassambara, 2017; Kukielka et al., 2018). The plots were constructed using the ggplot2 package in R (Wickham, 2016).

Results

Access to information related to climate change

The results indicate that television (83%) is the most widely used means of communication by farmers to acquire information about climate change, while other means (radio, friends, church, union) account for 17%. Despite the majority receiving information, 73% were unaware of the meaning of global warming, 51.09% did not understand the concept of climate change, and 64% did not know its causes.

Convergence between farmers' perceptions and meteorological data

All the farmers (100%) interviewed noticed an increase in temperature and a decrease in precipitation, especially in the last 9.1 years (±5.7). These results substantiate H1, indicating a convergence in farmers' perceptions concerning the decrease and alteration of precipitation, as well as an increase in temperature, particularly over the past decade. The Mann–Kendall test showed a significant trend ($p \leq 0.001$) in the increase in the average annual temperature at the local scale (Figure 2A). The average temperature for the analyzed period (1981-2021) was 27°C (±0.38). The average temperature for the period 2011-2020 was 0.47°C higher than the average temperature for the period 1981-2010 (26.85±0.35), and there was a significant difference in temperature over the last four decades ($F=10.33$; $p<0.001$), as well as between months, especially in the dry period (June-December) (Figure 2 B-C). Positive temperature anomalies were more frequent and intense in the last decade (2011-2020) (Figure 2D).

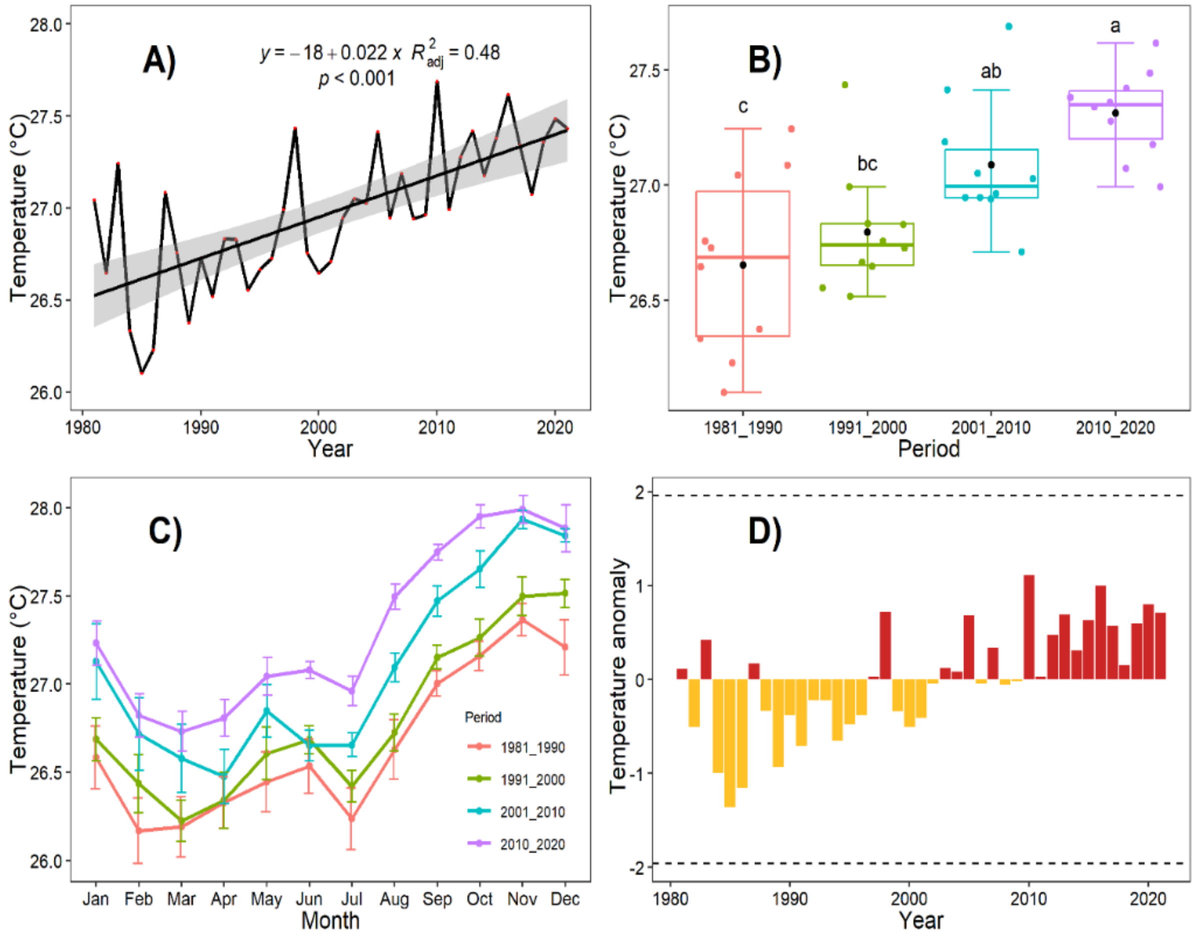

Fig. 2 The temperature trends observed during the period 1980-2020 in the municipality of Alcântara, MA, Eastern Amazon, Brazil.

(A) Time series of temperature, (B) temperature comparison per decade. Different lowercase letters indicate significant differences by Tukey's test ($p < 0.05$), (C) average temperature month by decade, (D) anomalies. Red bars indicate positive anomalies, and yellow bars indicate negative anomalies. Dashed lines (>2σ<).

The average precipitation for the period 1981-2021 was 1838 mm (±519). The Mann–Kendall test did not reveal a significant trend in precipitation at the local scale (Figure 3A). There was no significant difference in the precipitation in the last four decades ($P > 0.05$). However, the average precipitation in the last decade decreased by 22% (435 mm) (1532±325) compared to the average precipitation for the period 1980-1990 (1967±721) and has proven to be the least rainy of the last four decades (Figure 3B). This decrease was more evident during the peak of rain between February and April (Figure 3C). On the other hand, the data indicates a change in the rainy season, particularly with the onset of rains. The average precipitation in the decade 2011-2020 for November was greater (16.84 mm) than that in the other decades: 2001-2010 (2.9 mm), 1991-2000 (8.9 mm), and 1981-1990 (13.4 mm). For December, the average precipitation in the decade 2011-2020 (38.2 mm) was lower than that in the decades 1991-2000 (61.99 mm) and 1981-1990 (92.8 mm) and slightly greater than that in the decade 2001-2010 (35.3 mm). Significant positive anomalies (>2σ) were more frequent in the period 1981-2010 (Figure 3D). In contrast, negative anomalies were more recurrent in the last decade (<2σ).

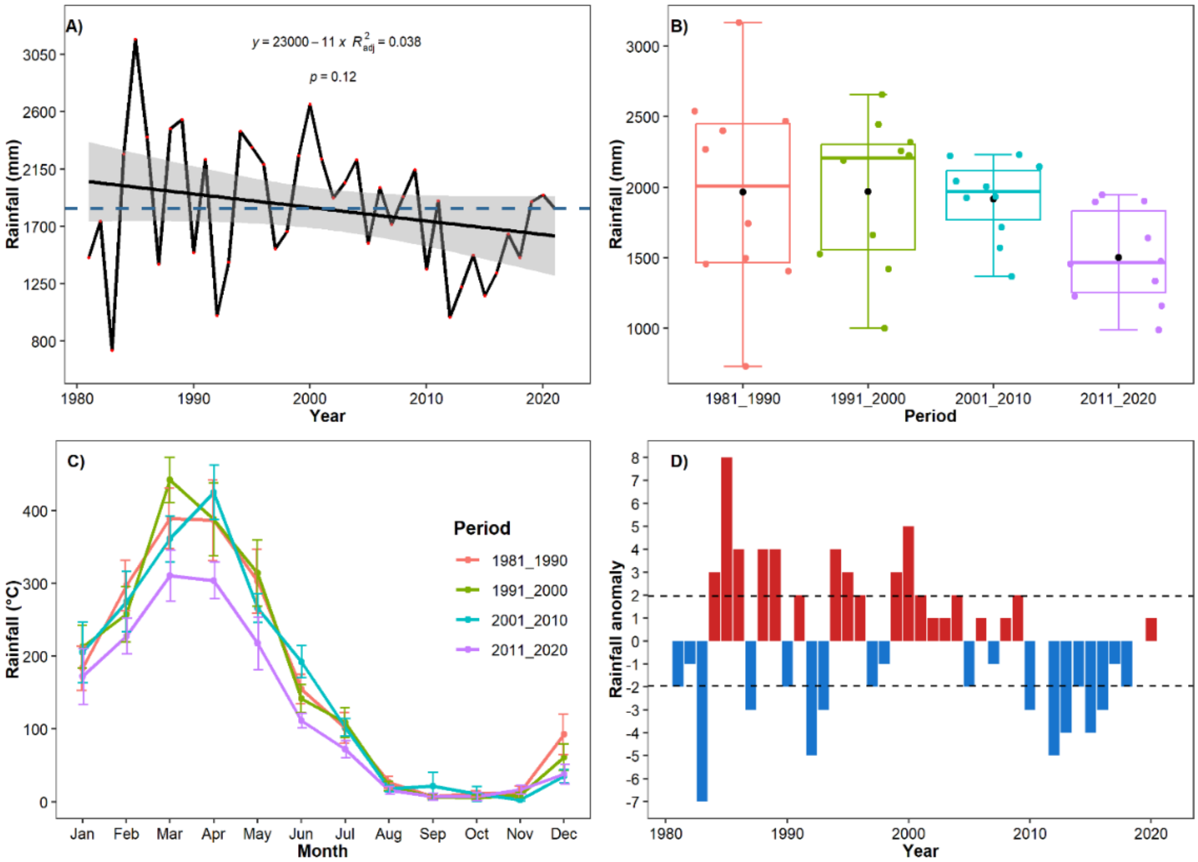

Fig. 3 Rainfall behavior for the period 1980-2020 in the municipality of Alcântara, MA, Eastern Amazon, Brazil.

(A) Time series of rainfall, (B) rainfall comparison per decade. (C) average precipitation month by decade, (D) anomalies. Red bars indicate positive anomalies, and yellow bars indicate negative anomalies. Dashed lines (>2σ<).

Perceptions, impacts and Adaptation of Quilombola Farmers to Climate Change

Approximately 50% of the respondents noted changes in the flowering period of certain species of regional economic importance, with Mango (Mangifera sp.) and Cashew (*Anacardium occidentale*) mentioned by 30.4%, Citrus species such as Lemon and Orange (Citrus spp.) by 28.2%, Bacurí (*Platonia insignis*) by 13%, and Buriti (*Mauritia flexuosa* L.F.) by 6.2%. Other species, such as Acerola (Malpighia sp.), Jambo (*Syzygium jambos* (L.)), and Pitomba (*Talisia esculenta*), were mentioned less often (1%). Farmers reported that agriculture in the region is mainly affected by drought (80%). Events such as excessive rainfall (11%), floods, and winds are less relevant (9%). Farmers believe that as climate change continues, the most impacted resource will be water (43%), followed by agriculture (23%), soil (9%), and forests (4%), all of the previous ones (16%), don't know (5%).

The GFDs reinforced individuals' perceptions of temperature changes and decreased rainfall (supplement 2) and additionally, mentioned other impacts (Table 1).

Tab 1. Key expressions and central ideas of the CSD of farmers' GFDs in Alcântara, Maranhão, Eastern Amazon, Brazil.

GFDs	Key expressions	Central ideals
O, P, SM, BQ, BG, CI, MA	*"In the years 81-83, the temperature was normal, not as hot as today (2021). The temperature has increased significantly. the climate has been getting warmer from 2010 onwards. The years 2010-11 were very hot indeed".*	**(A)** Temperature increase
O, P, SM, BQ, BG, CI, MA	*"In the past, it used to rain more. Currently, the rainfall is intermittent and does not start at the right time".*	**(B)** Decrease and change in the rainy season
O, P, M, BQ, BG, CI, MA	*"The planting season has changed".*	**(C)** Impacts on local agricultural activity
BQ	*"The juçara palms (Euterpe edulis) are dying because the rivers are drying up, and the sea is encroaching".*	
O, P, M, BQ, BG, MA	*"Today, it is impossible to work after 11, it is too hot".*	
O, P, BQ, BG, MA	*"For the past 10-15 years, we no longer plant rice because it rains less".*	
O, P, SM, BQ, BG, CI, MA	*"Sometimes the day gets too hot, and suddenly it rains. This cooks the cassava (Manihot esculenta)".*	
Oitiua (O), Peru (P), Santa Maria (SM), Baiaquaua (BQ), Baixa Grande (BG), Cajueiro I (CI), and Mamuna (MA).		

Regarding adaptation actions, the majority of farmers (86%) adjusted their planting season, while less than half (29%) implemented additional measures. On average, farmers implement 1.6 (±1.3) practices. The implemented practices included ground cover (44%), chicken manure (37%), tree planting (26%), farming without fire (13%), rainwater harvesting (11%), irrigation system (11%), crop rotation (11%), deforestation prevention (7%), agroforestry system adoption (AFS) (7%), composting (7%), and legume planting (7%).

The influence of socioeconomic factors and knowledge related to climate change on the implementation of adaptation actions.

The results obtained in the logistic regression model confirm that the knowledge about global warming ($X_2 = 6.6$; $p < 0.01$) and access to credit ($X_2 = 8.9$; $p < 0.001$; $R_{2Nagelkerke} = 0.214$) are significant predictors of the implementation of adaptation actions. In our sample, farmers who are aware of global warming (Odds = 4.0; 95% CI) and have access to credit (Odds = 5.0; 95% CI) are more likely to implement adaptation measures

Barriers to the process of transitioning from slash-and-burn agriculture to fireless systems

The GFDs reported 22 barriers that hinder the transition process from a slash-and-burn system to fire-free systems such as agroforestry systems in the region (Figure 4). A lack of technical assistance was the most mentioned barrier (100%), followed by the cultural barrier of slash-and-burn (80%). Among the less relevant barriers mentioned were the lack of water and low levels of cooperativism (20%).

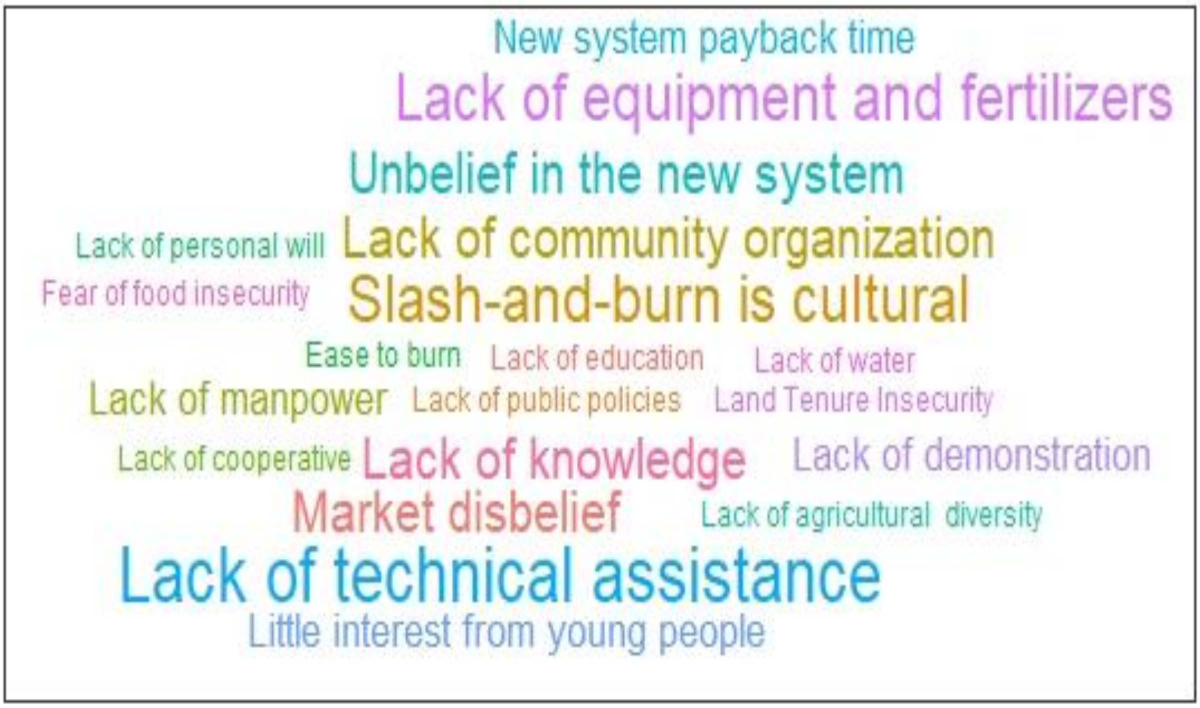

Fig. 4 Barriers second to the GFDs of farmers for the transition process from slash-and-burn to without-fire in Alcântara, Maranhão, Eastern Amazon, Brazil.

*The size of the letter in the graphic indicates the frequency of citation.

Typologies of farmers differentiated by socioeconomic aspects, adaptation, and knowledge about climate change

According to the FAMD analyses, the first six (6) components explained 51.72% of the total variance (supplement 2). The HCPC indicated three (3) groups of farmers (Figure 5). The quantitative variables that defined the partition of the groups were age, number of children, years practicing agriculture, and family nucleus size ($P<0.001$). The categorical variables ($P<0.001$) included education, income, gender, access to credit, implementation of adaptation actions, type of productive system, and cognitive factors (knowledge of the causes of global warming, understanding the meaning of climate change and global warming).

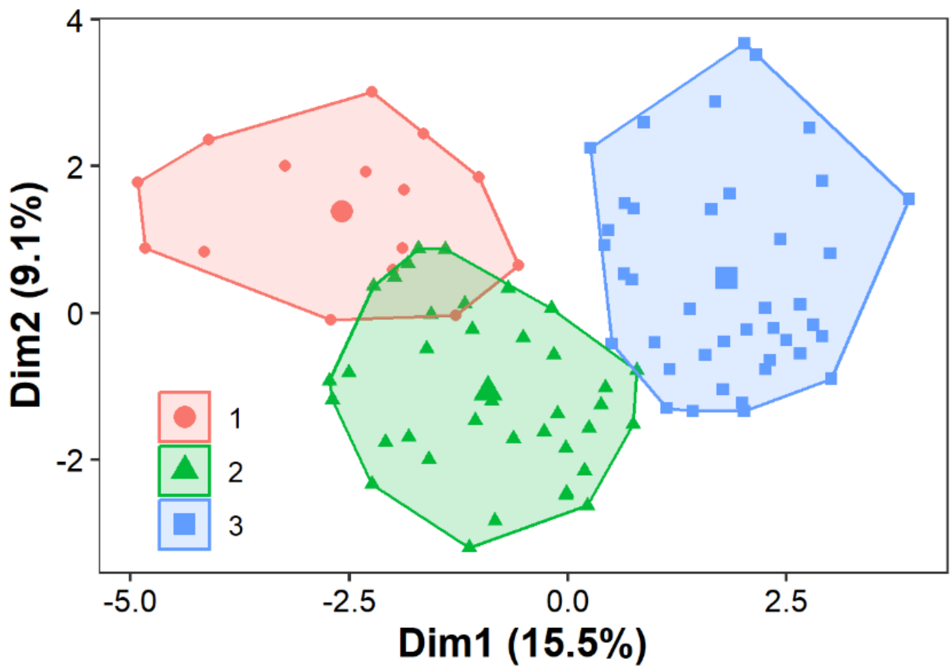

Fig. 5 Groups of farmers (1, 2, 3) in the Quilombola Territory of Alcântara, MA, differentiated by socioeconomic characteristics, adaptation, and knowledge about climate change.

Group 1) consists of a balanced proportion of farmers, both men and women, under the age of 50, with high school or incomplete higher education, a small family nucleus, fewer children, access to credit, and a monthly income of one minimum wage (US$ 220). Overall, they knew about climate change and implemented adaptation measures, including fire-free systems (supplement 2). Group 2) is composed mainly of farmers under the age of 40, with family nuclei and a number of children below the global average. Some have completed high school, while others were illiterate. The majority of this group has an income below one minimum monthly wage (US$ 220), lacks access to credit, does not implement adaptation actions, and primarily practices slash-and-burn agriculture. Group 3) is a group of older farmers with family nuclei and a number of children above the global average, with a monthly income between one and two times the minimum wage, which comes from retirement. The literacy level is minimal (they can read and write). They do not implement adaptation actions, and their knowledge related to climate change is incipient.

Discussion

Access to information related to climate change

Farmers must comprehend climate change, its causes, and its consequences to be encouraged to implement adaptation practices. Our results indicate that, despite television being the primary communication medium used by farmers to receive information about climate and climate change, more than 70% of them were unaware of the meaning of global warming, climate change, and its causes. This suggests that the information provided by TV may not be effective enough to inform and educate individuals on the subject. Studies suggest that understanding academic information related to climate and climate change conveyed through the media is hindered by barriers such as the low level of education among farmers and the language used by broadcasters, which often differs from the language of the audience (Antwi-agyei et al., 2021; Mushagalusa et al., 2023). According to Weber (2010), informational interventions related to climate change must engage and stimulate images that convey real emotions, with stories having a local connection and showing the impacts or actions of people directly affected (León et al., 2022). Bidirectional communication through social media can also be highly effective (Lee et al., 2017).

Convergence between farmers' perceptions and meteorological data

The results of this study generally indicate that farmers' perceptions align with meteorological data showing changes in the rainy season, decreased rainfall, higher temperatures, and more frequent droughts in the Eastern Amazon. (Marengo et al., 2017, 2022). In the Amazônia (Dubreuil et al., 2017), as in other regions of the planet, communities also perceive the decrease and alteration of the rainy season, and their perceptions align with meteorological data (Fernández-Llamazares et al., 2017; Hasan & Kumar, 2020; Roy et al., 2021). Therefore, the integration of farmers' local knowledge about their environment and climate in their regions, coupled with academic information, can contribute to the implementation of more effective and specific adaptation measures (Brondízio et al., 2021; Funatsu et al., 2019; Reyes-García et al., 2016).

Perceptions, impacts and Adaptation of Quilombola Farmers to Climate Change

The Farmers' perceptions concerning the increase in temperature and decrease in precipitation, particularly in the last decade, may be correlated with the negative precipitation anomalies observed in 2010, 2012, 2015, and 2016 which are associated with the El Niño phenomenon (Marengo et al., 2017; Silva Junior et al., 2019). Additionally, the period from 2015 to 2021 has been globally recorded as a remarkably warm period compared to the average from 1850 to 1900 (Berkeley Earth, 2022). With climate change, agricultural activity in the region is being negatively impacted, and the food security of families is at risk. For instance, sudden weather changes such as unexpected rains on very hot days, seem to contribute to the rotting of yucca plants such as unexpected rainfall after sunlight, seem to contribute to the rotting of cassava plants. The occurrence of cassava rot has also been reported in the central region of the Solimões River basin in the Amazon (Da Cunha Ávila et al., 2021). The production of cassava for flour production is the mainstay of slash-and-burn agriculture and is a core element in families and communities. Losses in yield can have highly negative impacts on food security and family income.

With the reduction in working hours due to high temperatures, both the cultivated area and crop care may be diminished, consequently impacting productivity and income. During the extreme drought in the Amazon in the second half of 2023, women farmers from the upper Negro River reported that high temperatures are affecting the health of women, and some are unable to cultivate (BBC, 2024). According to Vargas Zeppetello et al. (2022), even if the global temperature increase is limited to 2°C, a significant increase of 50-100% in the risk of heat exposure is expected in many tropical regions by the year 2050. In Brazil, several studies warn about the high vulnerability of rural workers to heat stress and the resulting negative impacts on their health, well-being, and economy (Alves de Oliveira et al., 2021; Pires Bitencourt et al., 2019, 2020). Furthermore, in Amazon regions with greater deforestation, the risk of heat stress is even greater than that in other regions and is similar to the effect of climate change in a representative concentration pathway scenario, RCP8.5 (Alves de Oliveira et al., 2021).

Climate change not only affects human activities but also exerts influence on the growth and development of plants, as well as the dynamics of pollinators, potentially compromising food production (Assad et al., 2018). Phenological changes in plants due to climate change are occurring rapidly and have repercussions on ecosystem functioning and ecosystem services (Liu et al., 2022).

The change in the planting season due to the alteration in the rainy season identified in this study is possibly an adaptation practice directly influenced by climate change. In the Amazon (Altea, 2019; Da Cunha Ávila et al., 2021; Funatsu et al., 2019), as well as in Africa and Asia (Chimi et al., 2022; Etana, van Wesenbeeck, et al., 2021; Tripathi & Mishra, 2017), other farmers have been forced to modify their agricultural calendars. Changes in agricultural calendars have repercussions throughout the entire agri-food system.

The impacts of climate change on agriculture, coupled with non-climatic local risks in Alcântara (Gutiérrez et al., 2023), exacerbate the issues of hunger and the migration of farmers to urban centers. Thus, initiatives such as empowerment and environmental education, enhanced technical assistance in the region, promotion, and access to agroclimatic technology (e.g., risk zoning) can reduce the negative impacts resulting from climate change. In the Amazon, some communities already integrate local ecological knowledge with agroclimatic information to mitigate the negative impacts of climate change (Funatsu et al., 2019), and there are initiatives by indigenous communities that could serve as a model for other communities (socio-environmental institute-ISA 2023).

The influence of socioeconomic factors and knowledge related to climate change on the implementation of adaptation actions.

The results of this study indicated that the likelihood of a farmer implementing adaptation actions is significantly higher when they are aware of global warming and have access to credit. However, Van Valkengoed and Steg (2019), in their meta-analysis, suggested that perception, knowledge, and experience with climate change do not seem to be the factors that most influence farmers in implementing adaptation actions, emphasizing that positive community results may be more relevant. Specifically, in the “Agrovilas” of Alcântara, the exchange of knowledge is positively related to the implementation of fire-free systems, such as agroforestry systems (SAFs), while a higher income and academic level are negatively related to the implementation of fire-free systems. fire (Loch et al., 2020).

In contrast to this study, which indicated that variables such as age, education, and income did not influence decision-making, other studies in various regions of the world suggest that these factors are relevant for taking action (Tadese et al., 2021). For example, in a study by Kumar and Gupta (2021) in India, younger farmers were more open to integrating adaptation strategies than older farmers were, and additionally, farmers with a higher level of education were more receptive to information about climate change and new technologies.

Barriers to the process of transitioning from slash-and-burn agriculture to fireless systems

Twenty-two barriers hinder the transition from slash-and-burn to fire-free systems, with the lack of technical assistance and the culture of fire being among the most significant barriers. Many of the mentioned barriers were perceived as issues that increase the vulnerability of the quilombola communities in Alcântara (Gutiérrez et al., 2023). The lack of technical assistance is a critical problem for family farmers in northern and northeastern Brazil (Rocha Junior et al., 2020), hindering the implementation of adaptation actions, as many people are unaware of alternative production methods (De Matos Carlos et al., 2020). On the other hand, equally significant, land tenure insecurity is an additional barrier to the implementation of actions, such as the adoption of agroforestry systems in Alcântara, where land conflicts have intensified with the expansion of the Space Launch Center (CLA) within the Quilombola Territory of Alcântara (TQA) (Loch et al., 2020; Nunes, 2015).

To overcome these barriers, governmental support is deemed necessary, alongside coordination and dialogue among various stakeholders at all levels of intervention (Milhorance et al., 2022). Proactive, coordinated, and structured mobilization of communities is essential. It is important to emphasize the need for grassroots organizations, collective work, and the revival of traditional knowledge. Consequently, measures need to be implemented to address the cultural aspects of using fire in agriculture.

Typologies of farmers differentiated by socioeconomic aspects, adaptation, and knowledge about climate change

The results of the HCPC indicated the existence of groups of farmers differentiated by socioeconomic aspects, adaptation, and knowledge about climate change on the scale of Alcântara. This result is valuable for the climate adaptation process because part of the success of a process begins with the recognition of differences among those involved and their local realities.

In the regional context, aiming at farmers' adaptation to the new climate reality, implementing and strengthening environmental education, creating pedagogical strategies in the context of climate change tailored to different age groups, and providing programs that encourage younger farmers through extension services (ATERs) and economic incentives during the transition and stabilization of new productive systems could be viable strategies.

Conclusions

This study revealed that communication strategies related to the topic of climate change should be reassessed and tailored for diverse audiences. The convergence between meteorological data and local perceptions suggests that the integration of both types of knowledge is imperative to effectively enhance adaptation strategies.

The limited adaptation measures implemented by farmers may not be sufficient to minimize the negative effects of local climate change. In this context, the inclusion, reinforcement, and promotion of adaptation actions should account for the typologies of farmers in the region, as well as the influencing factors and barriers.

Finally, the implementation of environmental education in the territory, alongside community organization and mobilization, is deemed essential.

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Disclosure statement

The authors declare that we have no conflicts of interest.

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Material suplementar

Tabela 2. SM 1: Questionário socioeconômico e climático

Continua...

DADOS DO QUESTIONÁRIO	**QUESTIONÁRIO N°:**
Data:	
Município:	
Comunidade	Coordenadas:

A. INFORMAÇÕES GERAIS:			
1. Nome do Produtor:		**2.** M ( ) F ( )	
3. Idade e /ou data de nascimento (anos):	**4**. Tempo de residência no local	**5.** Local de nascimento:	**6.** Anos que pratica a agricultura

7. Escolaridade:		
Analfabeto	Ensino Fundamental Completo	Ensino Superior Incompleto
Alfabetização Incompleta lê e escreve	Ensino Médio Incompleto	Ensino Superior Completo
Ensino Fundamental Incompleto	Ensino Médio Completo	Pós-Graduação

8. **Núcleo Familiar**	**Número de membros da Família:**		
Idade	**Frequenta escola (Sim) (Não)**	**Ajuda no sistema produtivo (Sim) (Não)**	**Ajuda no sistema produtivo (Sim) (Não)**

9. Emigração de membros da família nos últimos 10 anos para cidade	Sim ( )	Não ( )
Motivo:		

B. ASPECTOS ECONÔMICOS		
Você tem fontes de renda externa à propriedade? Sim ( ) Não ( )		
Qual a fonte de renda externa a propriedade é a mais importante?	Aposentadoria	Prestação de Serviços na Cidade
Programas Sociais do Governo	Funcionário do Estado	Outros

Renda familiar mensal:				
Menos de um salário mínimo (MUM)	1 Salário mínimo (UM)	1,5 Salários mínimos	2 Salários mínimos	> de 2.5 salários mínimos
Você teve acesso a fontes de financiamento nos últimos cinco anos? Sim ( ) Não ( )				
Qual?	Pronaf	Banco privado	Credito informal	Outros

Quais são é a principal dificuldade em conseguir empréstimo o financiamento	Nenhuma	Não sabe como acessar	Falta assessoria técnica na elaboração projeto
Receio com dividas	Burocracia	Outro	

C ASPECTOS SOCIAIS	
Participa de algum grupo?	Sim ( ) Não ( )

Qual?		
Cooperativa	Sindicato	Movimento social
Grupo religioso	Grupo de estudo agroecológico	Outro:
Exerce Liderança em algum destes?	Sim ( )	Não ( )

D. ASPECTOS CLIMÁTICOS			
Você sabe quê é o aquecimento global?	Sim ( )	Não ( )	
Você sabe o conhece as causas que gera o aquecimento global	Sim ( )	Não ( )	Quais conhece:
Você já ouviu falar da mudança climática	Sim ( )	Não ( )	
Onde você obteve esta informação?			

Associação	Sindicato	Televisão	Radio	Internet	Igreja	Agentes do estado	Amigos	Família	Outro

Você sabe o quê são as mudanças climáticas?	Sim	Não	O que você entendi por mudanças climáticas?
Você tem percebido alguma mudança no clima?	Sim ( )	Não ( )	Há quantos anos você vem percebendo?
Considera a mudança do clima um problema para produzir?	Sim ( )	Não ( )	

Qual é o principal evento climático que afeta as culturas e sua atividade agrícola				
Seca	Chuvas	Inundações	Excesso de chuvas	Ventos
Quais são as culturas mais afetadas:				
Milho	Feijão	Hortaliças	Frutíferas	Outras

Você notou mudança na época de florir de alguma planta?	Sim ( ) Não ( )
Qual espécie mudou a época da floração?	

O problema mais preocupante para seu sistema produtivo qual é?				
Migração pra a cidade	Problemas Financeiros	Variabilidade e mudança climática	Pouco interesse na agricultura pelos mais jovens	Outros:
Se as mudanças no clima continuarem, qual seria o recurso mais afetado?				
O solo	A água	A floresta	As culturas	Outros

Conhece às propostas do governo no plano ABC? Sim (   )   Não (   )
Conhece a Política Nacional sobre Mudança do Clima? Sim (   )   Não (   )
Você já implementou alguma medida para diminuir os efeitos das mudanças no clima? Sim (   )   Não (   )

Você utiliza alguma das seguintes praticas?				
Planta arvores	Roça sem fogo	SAF's	Variedades resistentes à seca	Irrigação
Proteção do solo por resíduos vegetais	Hortas caseiras	Captação água chuva	Fertilização orgânica	Integração lavoura pecuária
Culturas mistas (diversificação culturas)	Rotação de culturas	Adubação verde	Plantas leguminosas para FNB	Outros:
implementou alguma mudança nas datas de plantio por causa da mudança do clima? Sim ( ) Não ( )				

Perguntas para os grupos focais de discussão de agricultores

Como vocês percebem a temperatura e precipitação no presente com relação ao passado?

O recorte temporal foi a própria lembrança dos entrevistados.

Quais os impactos ou problemas percebidos para a agricultura local derivados dessas mudanças no clima?

Tabela 3. SM 2: Contribuição das variáveis em % na formação dos 6 componentes ou dimensões no FAMD.

Variáveis	Dim.1	Dim.2	Dim.3	Dim.4	Dim.5	Dim.6
Idade	18.4035031	3.0449522	1.0608098	0.2791608	0.7606658	0.5407738
Anos praticando a agricultura	16.0583213	5.9235715	0.5434939	0.1154228	0.0433084	2.1474971
Tamanho núcleo familiar	1.8181918	7.9722463	0.1738893	0.4214391	14.2318329	0.0343689
Número de filhos	7.4568311	4.2933860	2.3459255	1.5793015	0.0010399	3.7293237
Escolaridade	16.4155483	16.1884512	19.8344937	26.9024425	36.5220311	22.6979726
Renda	5.0200513	8.5610646	22.5287497	26.2130801	28.3870181	22.1465150
Gênero	2.7124269	0.0309478	0.1637629	7.5991267	0.0634807	9.0147926
Acesso ao crédito	0.8426157	9.0921491	11.2189396	1.8913981	3.0899250	0.0000032
sabe que é o aquecimento global	6.7374794	3.4131273	12.0943972	3.1770211	0.7147544	1.0161804
Sabe das causas do aquecimento global	9.6716300	4.4359700	5.4857186	3.9678783	0.2374080	2.0481576
Sabe que são as mudanças climáticas	8.8254444	8.0907759	2.2455086	0.9057814	5.7335526	2.3625549
Tipo de sistema produtivo (com o sem fogo)	3.0223286	6.5481048	12.9717690	1.0474071	3.0741953	2.6848550
Localização geográfica	0.0350766	0.0523418	4.3665309	21.9058419	1.2793065	10.7871807
Percepção de risco por estressores climáticos	0.0358256	7.5254878	3.8755560	1.6353619	2.7098890	20.7898120
Implementa ações de adaptação	2.9447259	14.8274238	1.0904553	2.3593368	3.1515922	0.0000123

Tabela 4. SM 3: Descrição dos grupos de agricultores por variáveis quantitativas

Grupo ou cluster 1						
Variáveis	**v.test**	**Media na categoria**	**Média global**	**Desvio na categoria**	**Desvio global**	**p. valor**
Número de filhos	-2.320422	1.933333	3.478261	1.651935	2.803252	0.0203181
Anos praticando a agricultura	-3.060307	34.866667	45.576087	10.032392	14.734044	0.0022111
Idade	-3.949651	43.800000	56.065217	8.908423	13.074872	0.0000783

Grupo ou cluster 2						
Variáveis	**v.test**	**Media na categoria**	**Média global**	**Desvio na categoria**	**Desvio global**	**p.valor**
Tamanho núcleo familiar	-2.303698	3.810811	4.532609	1.411111	2.451491	0.0212396
Número de filhos	-2.843594	2.459459	3.478261	2.237211	2.803252	0.0044608
Idade	-4.470536	48.594595	56.065217	8.524874	13.074872	0.0000078
Anos praticando a agricultura	-4.783785	36.567568	45.576087	11.093072	14.734044	0.0000017

Grupo ou cluster 3						
Variáveis	**v.test**	**Media na categoria**	**Média global**	**Desvio na categoria**	**Desvio global**	**p. valor**
Idade	7.365101	67.575	56.065217	7.462866	13.074872	0.0000000
Anos praticando a agricultura	7.012224	57.925	45.576087	8.784610	14.734044	0.0000000
Número de filhos	4.541790	5.000	3.478261	2.872281	2.803252	0.0000056
Tamanho núcleo familiar	2.704322	5.325	4.532609	3.093441	2.451491	0.0068444

Tabela 5. SM 4: Descrição dos grupos por variáveis qualitativas

Cla/mod (Porcentagem da mostra no grupo) = % de indivíduos com resultado da categoria de saída na população de estudo que estão no conglomerado grupo: 52% dos agricultores da amostra (92) que tiveram acesso ao crédito estão neste conglomerado.

Mod/cla (Porcentagem da categoria no grupo) = % de indivíduos no grupo da categoria de saída: 86.6% de dos agricultores no clúster tiveram acesso ao credito.

Global (Porcentagem da categoria na amostra) = % da variável na população de estudo ex: do 100 dos agricultores entrevistados (n=92), 27.1% tiveram acesso ao credito.
v.test |1.96|**:** equivale a p < 0.05, entre > v.test mayor la significancia.

Tabela 5 Descrição das variáveis por grupo

Grupo	Variável	Categoria de saída	Cla/Mod	Mod/Cla	Global	v.test
G1	Acesso ao crédito	Não	2.9	13.3	72.8	-5,21
		Sim	52.0	86.6	27.1	5,21
	Escolaridade	EFI	3.7	6.6	29.3	-2,15
		EMI	55.5	33.3	9.7	2,77
		ESI	100	13.3	2.1	2,24
	Gênero	F	31.8	46.6	23.9	2,07
		M	11.4	53.3	76	-2,07
	Implementa ações de adaptação	Não	3.0	13.3	70.6	-4,97
		Sim	48.1	86.6	29.3	4,97
	Renda	UM	100	13.3	2.1	2,24
	Sabe das causas do aquecimento global	Não	8.1	33.3	66.3	-2,77
		Sim	32.2	66.6	33.6	2,77
	Sabe que são as mudanças climáticas	Não	4.4	13.3	48.9	-3,01
		Sim	27.7	86.6	51	3,01
	Tipo de sistema produtivo	RF	7.5	40.0	86.9	-4,88
		SF	75	60.0	13	4,88
G2	Acesso ao crédito	Não	5.2	94.5	72.8	3,99
		Sim	8.0	5.4	27.1	-3,99
	Escolaridade	A	9.5	5.4	22.8	-3,36
		EMC	7.7	18.1	9.7	2,28
	Implementa ações de adaptação	Não	5.2	91.8	70.6	3,76
		Sim	1.1	8.1	29.3	-3,76
	Renda	MUS	8.2	62.1	30.4	5,38
		UM	2.5	29.7	47.8	-2,81
	Tipo de sistema produtivo	RF	4.6	100.0	86.9	3,24
		SF	0.0	0.0	13	-3,24
G3	Escolaridade	A	85.7	45.0	22.8	4,42
		AI	88.8	20.0	9.7	2,79
		EFC	8.3	2.5	13	-2,66
		EMC	0.0	0.0	9.7	-2,86
		EMI	0.0	0.0	9.7	-2,86
	Renda	Dois	73.3	27.5	16.3	2,46
		MUS	0.0	0.0	30.4	-6,06
		UM	61.3	67.5	47.8	3,27
	Sabe das causas do aquecimento global	Não	57.3	87.5	66.3	3,80
		Sim	16.1	12.5	33.6	-3,80
	Sabe que é o aquecimento global	Não	52.2	87.5	72.8	2,77
		S	20.0	12.5	27.1	-2,77
	Sabe que são as mudanças climáticas	Não	64.4	72.5	48.9	3,94
		Sim	23.4	27.5	51	-3,94

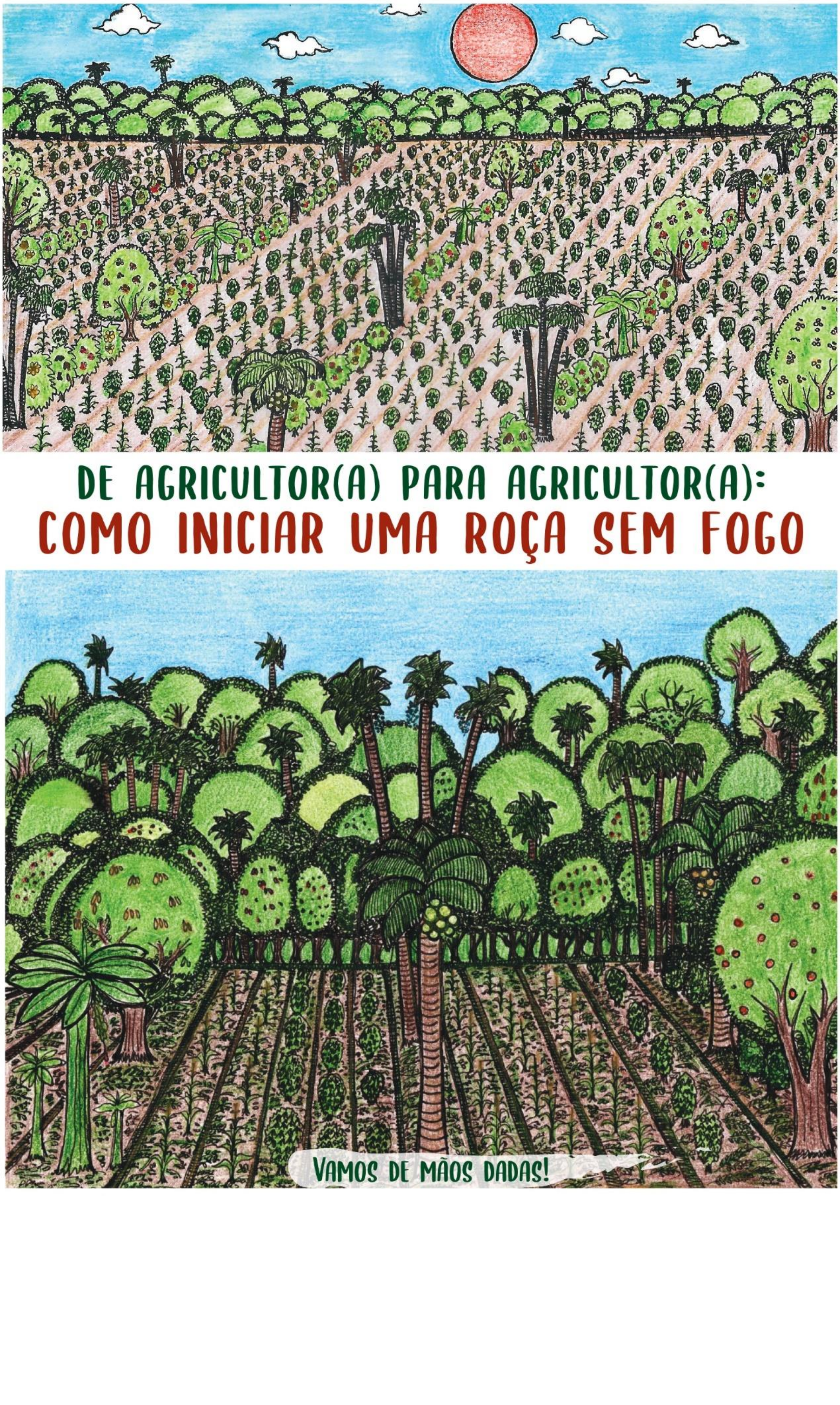
5. CAPITULO IV: **INTEGRANDO SABERES COMO ESTRATÉGIA DE ADAPTAÇÃO CLIMÁTICA**

Enfrentar as mudanças climáticas requer da articulação dos saberes acadêmicos e locais. Integrar ambos conhecimentos pode ser complexo e lento, porém, necessário para responder aos desafios impostos pelas mudanças climáticas. Essa convergência entre diferentes sistemas de saberes não apenas proporciona a acessibilidade, mas também o sucesso na implementação de estratégias de adaptação às mudanças climáticas. O diálogo entre pesquisadores, agricultores e outras partes interessadas, permite a co-criação de materiais educativos e/ou técnicos mais acessíveis para o público, em especial, para os agricultores que são os verdadeiros gestores dos recursos naturais.

O repensar sobre o sistema de cultivo por parte dos agricultores e a adoção de práticas alternativas de produção visando a diminuição dos impactos derivados das mudanças climáticas, podem ser atingidas pelas co-criacao de material didático-pedagógico, e, é nesse sentido, que o pesquisador principal e a equipe do presente estudo, aproveitaram o trabalho prático e coletivo com agricultores de Alcântara durante o estabelecimento de sistemas agroflorestais experimentais como alternativa ao corte e queima. Além disso, a representatividade local foi possível com ilustrações produzidas por um jovem morador da comunidade de Alcântara, que retratou o cenário local bem como valiosas informações dos agricultores das comunidades que permitiram organizar uma proposta viável de uma forma alternativa de produzir sem queimar.

Nesse sentido, como produtos finais, além dos artigos produzidos, apresentamos duas cartilhas didático-pedagógicos: I) **De agricultor(a) para agricultor(a): como iniciar uma roça sem fogo**; e II) **Fique por dentro do aquecimento global**. Estes resultados se somam ao fortalecimento do "*processo de transição de roça com fogo para sistemas sem fogo, como os agroflorestais*", iniciado há quase uma década com o projeto Pepital "Floresta no solo - Água no rio" pelo hoje denominado "Laboratório de Restauração Ecológica (LARECO)", do Programa de Pós-graduação em Agroecologia da UEMA, em parceria com OCA - Maranhão, Praia do Barco e comunidades da região.

5.1 De agricultor(a) para agricultor(a): como iniciar uma roça sem fogo



FICHA TÉCNICA

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Agricultores Familiares Quilombolas de Alcântara - MA.

Projeto Gráfico
Raíssa Barbosa Machado de Souza

Ilustrações
Pablo Monteiro Reis

Nota:
Esta cartilha faz parte do material produzido dentro do projeto Cátedra Itinerante Inclusão Produtiva no Brasil Rural e Interiorano, promovido pela CEBRAP Sustentabilidade. Adicionalmente, é a continuação do fortalecimento do processo de "Transição de roça com fogo para sistemas agroflorestais", iniciado há cerca de 10 anos com o projeto Pepital, "Floresta no solo - Água no Rio", pelo LAReco, em parceria com OCA Maranhão - Praia do Barco e comunidades da região.

Todas as ilustrações dessa cartilha foram feitas e pintadas à mão.

Maranhão, 2021.

APRESENTAÇÃO

Olá agricultoras e agricultores de Alcântara-MA!

É com felicidade que apresentamos aqui, o fruto das conversas e diálogos durante nosso trabalho prático e coletivo de implementação de Sistemas Agroflorestais em algumas comunidades de Alcântara (São Mauricio, Baiaquaua, Oitiua, Santa Maria, Mamuna, Peru, Só Assim, Espera e Marudá) durante o primeiro trimestre de 2021.

Esta cartilha enfatiza em um tipo de sistema agroflorestal denominado “sistema em aleias com adubadeiras”, como o primeiro passo para iniciar um processo de transição de roças com fogo para sistemas agroflorestais. Este tipo de sistema foi estabelecido com os agricultores(as) em pequenas áreas de experimentação e aprendizagem comunitária no processo de fortalecimento da Rede de Sistemas Agroflorestais de Alcântara – RedeSAFAL.

Alguns de vocês estiveram na fase prática, e a partir deste momento, se tornam promotores(as) experientes nesse primeiro passo de motivar e ajudar aos demais agricultores(as) no estabelecimento de novas áreas. Ou seja, continuem transmitindo de agricultor(a) para agricultor(a) o conhecimento adquirido de uma alternativa que vai melhorar a economia, a produção e as relações com a própria natureza.

O SOLO ESTÁ VIVO! VAMOS CONSERVÁ-LO!

ROÇA SEM FOGO

TRABALHANDO MENOS, GANHANDO MAIS.

SEU ZÉ E DONA NEIDE, SÃO TRABALHADORES RURAIS COMO TANTOS OUTROS DA ZONA RURAL DO MUNICÍPIO DE ALCÂNTARA, QUE ADOTAM O SISTEMA DE ROÇA TRADICIONAL, CONHECIDO COMO *ROÇA NO TOCO* OU *CORTE E QUEIMA*. MAS QUE, DIANTE DA DEGRADAÇÃO DO SOLO E BAIXA PRODUTIVIDADE, COMEÇAM A DAR ATENÇÃO PARA OUTRAS FORMAS DE CULTIVAR QUE PROPORCIONAM BENEFÍCIOS DE ORDEM NATURAL, ECONÔMICA E SOCIAL.

VOU TE EXPLICAR O QUE SÃO OS SISTEMAS AGROFLORESTAIS...

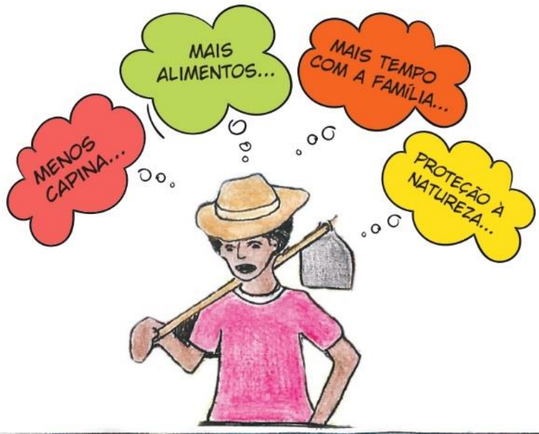
SISTEMAS AGROFLORESTAIS - SAF'S

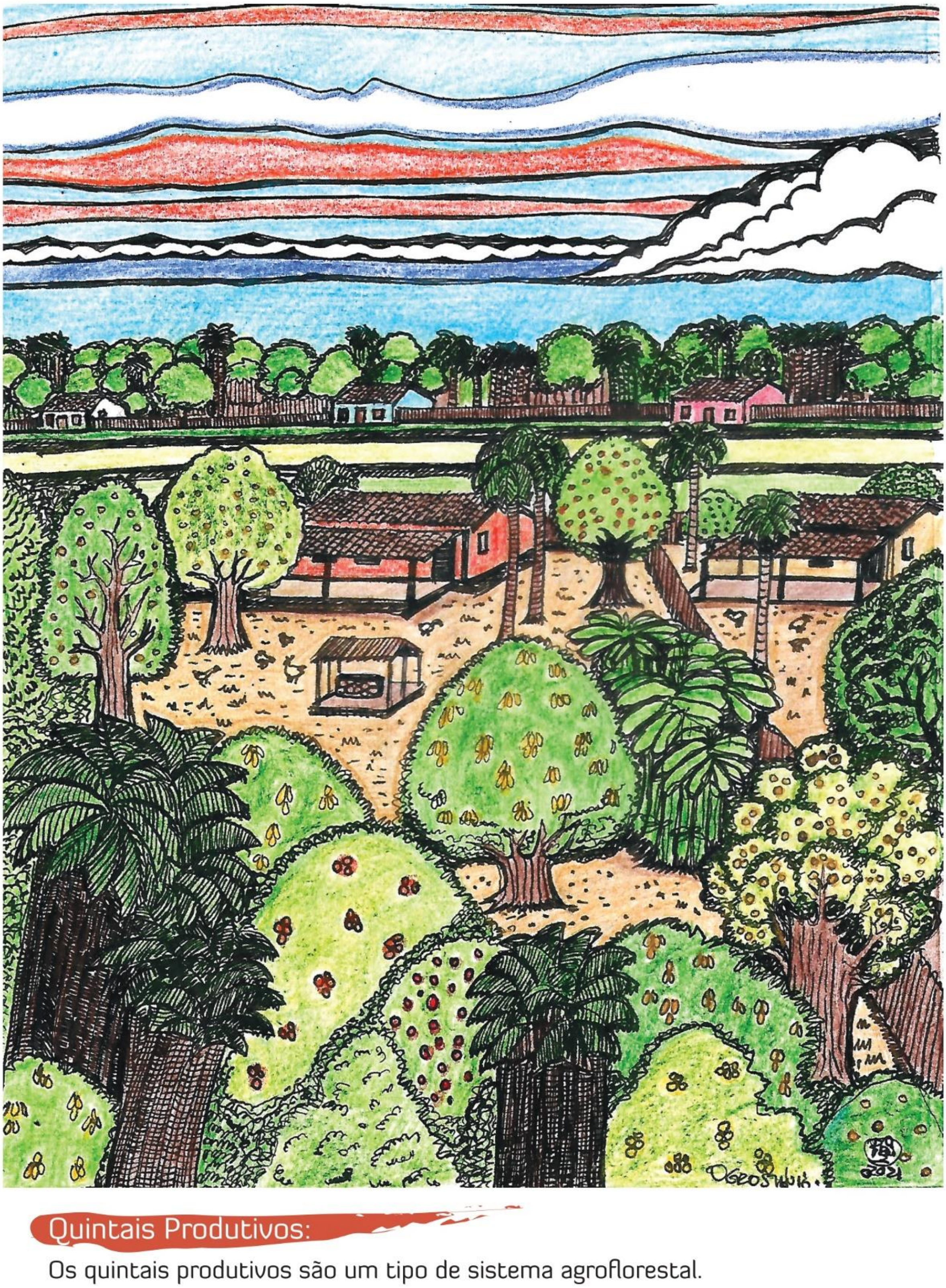
O QUE SÃO?

OS SISTEMAS AGROFLORESTAIS - SAF'S, PODEM SER DEFINIDOS COMO UMA FORMA DE PRODUZIR; ONDE SÃO COMBINADAS ÁRVORES (MADEIRÁVEIS E FRUTÍFERAS) E CULTIVOS AGRÍCOLAS (MILHOS, MANDIOCA, MAXIXE, ENTRE OUTROS). É UMA PRÁTICA MILENAR, QUE PRODUZ MELHORES BENEFÍCIOS ECONÔMICOS, AMBIENTAIS E SOCIAIS.

- OU SEJA, ZÉ, NÓS PODEMOS TER A NOSSSA ROÇA DENTRO DO SISTEMA AGROFLORESTAL!

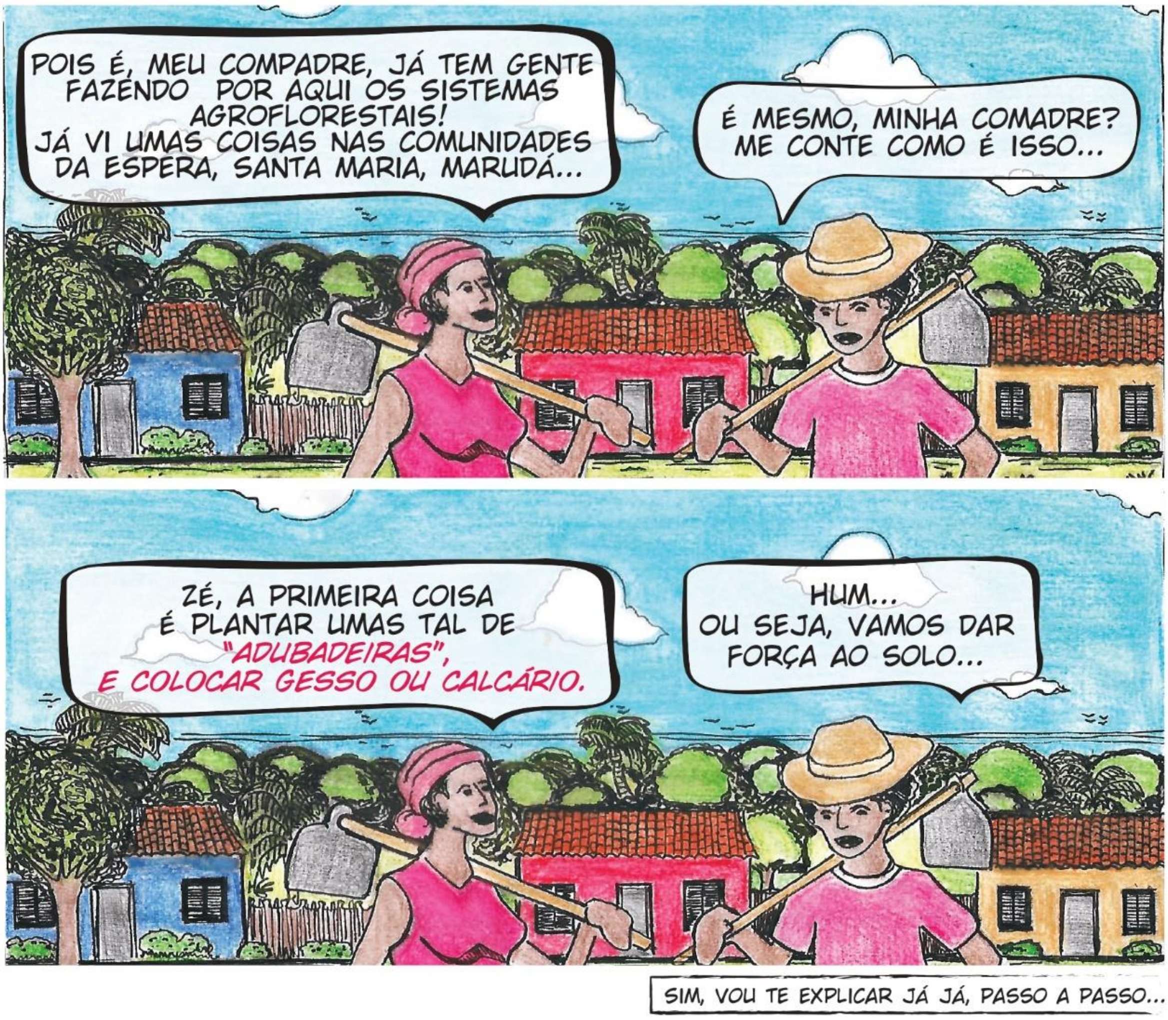
AHHH... QUE LEGAL...!





Quintais Produtivos:

Os quintais produtivos são um tipo de sistema agroflorestal.



VOU TE EXPLICAR O QUE SÃO AS ADUBADEIRAS...

- ENTÃO ZÉ, AS ADUBADEIRAS SÃO PLANTAS CONHECIDAS COMO DE ADUBAÇÃO VERDE E DE COBERTURA, FORNECEM BIOMASSA (FOLHAS E GALHOS) E ALGUMAS DO TIPO LEGUMINOSAS, FORNECEM NITROGÊNIO. OU SEJA, AJUDAM A MELHORAR A QUALIDADE DO SOLO, "DÃO FORÇA".

- O NITROGÊNIO É MUITO IMPORTANTE; SEM NITROGÊNIO, NOSSAS CULTURAS NÃO DÃO CERTO. ALGUNS DE VOCÊS COMPRAM COM O NOME DE *URÉIA*, MAS SE PLANTAREM ADUBADEIRAS - LEGUMINOSAS (SOMBREIRO, LEUCENA, INGÁ, CROTALÁRIA, FEIJÃO-GUANDU, ETC), ELAS, COM AJUDA DAS BACTÉRIAS, FORTALECEM O SOLO COM NITROGÊNIO, FAZEM POR NÓS.

Adubadeiras recomendadas para a região

Sombreiro

Nc: *Clitoria fairchildiana*
Pr: Semente
A: Biomassa e Nitrogênio
Oe: Cajueiro I, Pepital, Peru
Dp: 1m-2m

Leucena

Nc: *Leucaena leucocephala* (Lam.)
Pr: Semente
A: Biomassa e Nitrogênio
Oe: Sede de Alcântara
Dp: 1m-5m

Ingá

NC: *Inga sp.*
Pr: Sementes
A: biomassa e nitrogênio
Oe: Toda a região
Dp: 1.5m

Margaridão

Nc:*Tithonia diversifolia* (Hemsl)
Pr: Estacas de 20-25cm.
A: Biomassa
Oe: Espera, Peru, Santa Maria, Oitiua, Mamuna, São Maurício.
Dp: 70cm

Urucum

Nc: *Bixa orellana L.*
Pr: Semente
A: Biomassa
Oe: Toda a região
Dp: 1.5m

Chocalho de cobra

Nc: *Crotalária sp.*
P: Sementes
A: Biomassa e nitrogênio
Oe: Toda a região
Dp: 70cm

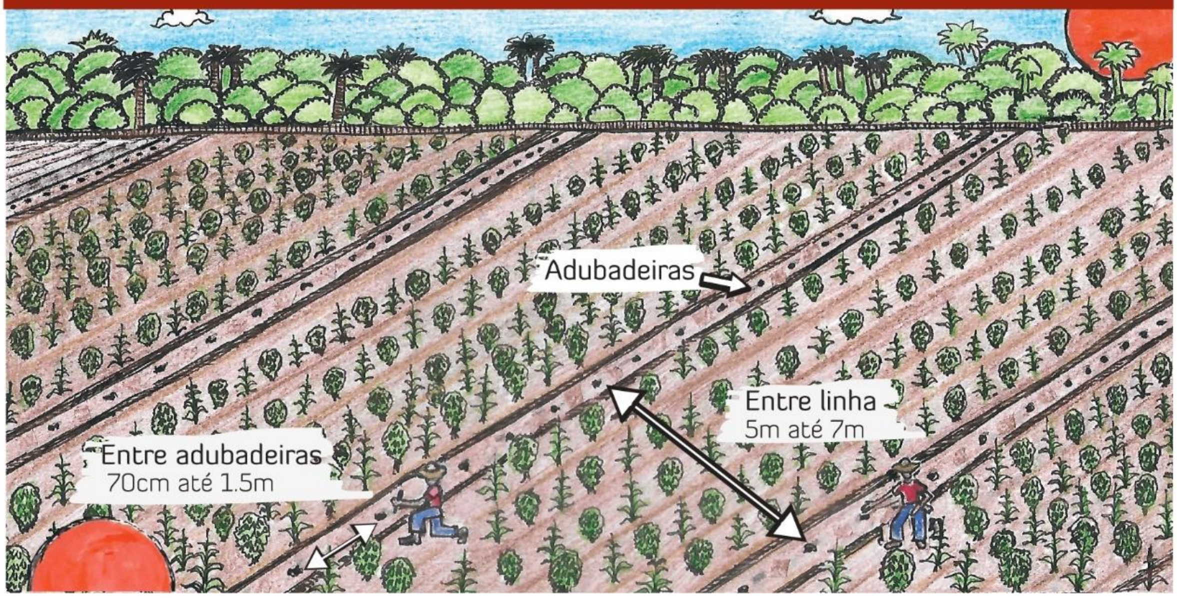
Nc: Nome Científico | Pr: Propagação | A: Aporte | Oe: Onde encontrar | Dp: Distância entre plantas

Outras adubadeiras: Feijão-guandu (*Cajanus cajan (L.) Millsp*) e Gliricídia (*Gliricidia sepium*).

- AGORA QUE JÁ TE CONTEI SOBRE ALGUMAS ADUBADEIRAS, VOU TE MOSTRAR COMO COMEÇA...

Passo 1: Desenho / Planejamento

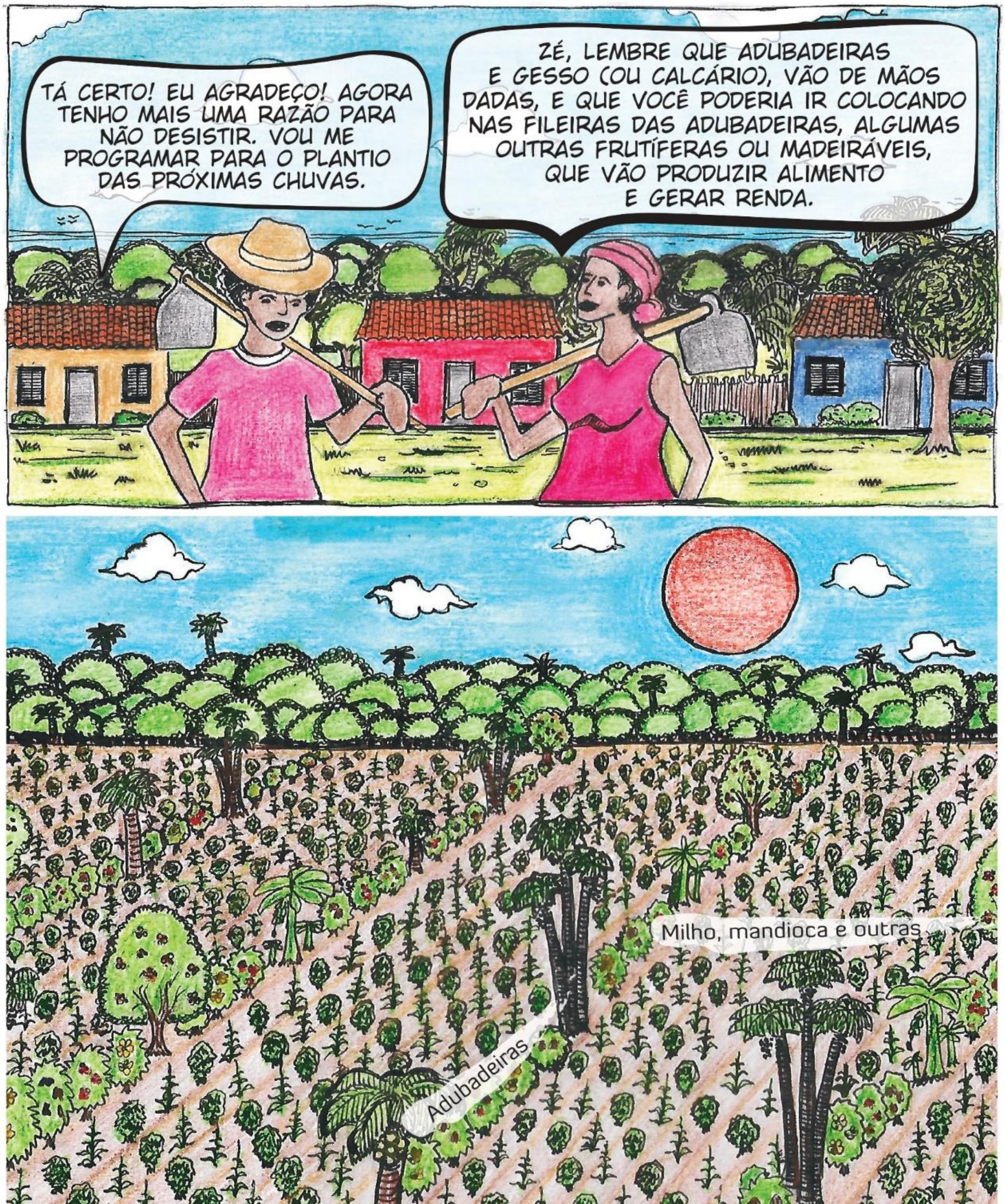
- Linhas de adubadeiras, de preferência seguir a direção do sol;
- Distanciamento entre linhas de adubadeiras: de 5m até 7m;
- Distanciamento entre adubadeiras: Margaridão e crotalária: 70cm entre plantas; Sombreiro, Leucena, Urucum, Feijão-Guandu e Gliricídia; 1.5m entre plantas;
- Diversificar tipos de adubadeiras nas linhas;
- Distribuir à lanço, por linha (linha=0.33ha), 1.5 toneladas (37.5 sacos de 40kg) de gesso e calcário, ou apenas gesso;
- Plantar milho, mandioca e as demais culturas, entre as linhas de adubadeiras;
- Se puder, coloque adubo de gado ou galinha.



AGORA VOU TE EXPLICAR O PASSO NÚMERO DOIS;
FAZER A PODA PARA NÃO ATRAPALHAR O PLANTIO.

Passo 2: Poda das adubadeiras

- Podar a cada 90-120 dias;
- Altura da poda: 15cm do solo;
- Espalhar e cobrir o solo com palha das adubadeiras e outros resíduos vegetais;



Sistema em aleias enriquecido com outras espécies.

Agricultores(as)

Lembrem que podem se aproximar do Programa de pós graduação em Agroecologia da UEMA, para conhecer e receber orientações sobre alternativas de produção de base agroecológica.

AGRADECIMENTOS

Aos agricultores(as) das comunidades quilombolas de Alcântara, que proativamente participaram nos diferentes momentos;
Ao CENTRO BRASILEIRO DE ANÁLISE E PLANEJAMENTO – CEBRAP em parceria com a Aliança Inclusão Produtiva e Geração de Renda via Empreendedorismo, formada pela Fundação Arymax, pelo Instituto Humanize e pela Fundação Tide Setubal, através do projeto Cátedra Itinerante Inclusão Produtiva no Brasil Rural e Interiorano, pelo financiamento;
Ao Sindicato dos Trabalhadores e Trabalhadoras Rurais de Alcântara (STTR);
Aos amigos e colegas, Vivian do Carmo Loch, Marilda Mascarenhas, Aniceto Araújo Pereira e Valdirene Ferreira Mendonça, que voluntariamente revisaram o material para torná-lo melhor;
Ao Programa de Pós-graduação em Agroecologia (PPGA) da Universidade Estadual do Maranhão (UEMA).
À Coordenação de Aperfeiçoamento de Pessoal de Nivel Superior (CAPES), pela bolsa concebida.

Vamos de mãos dadas!

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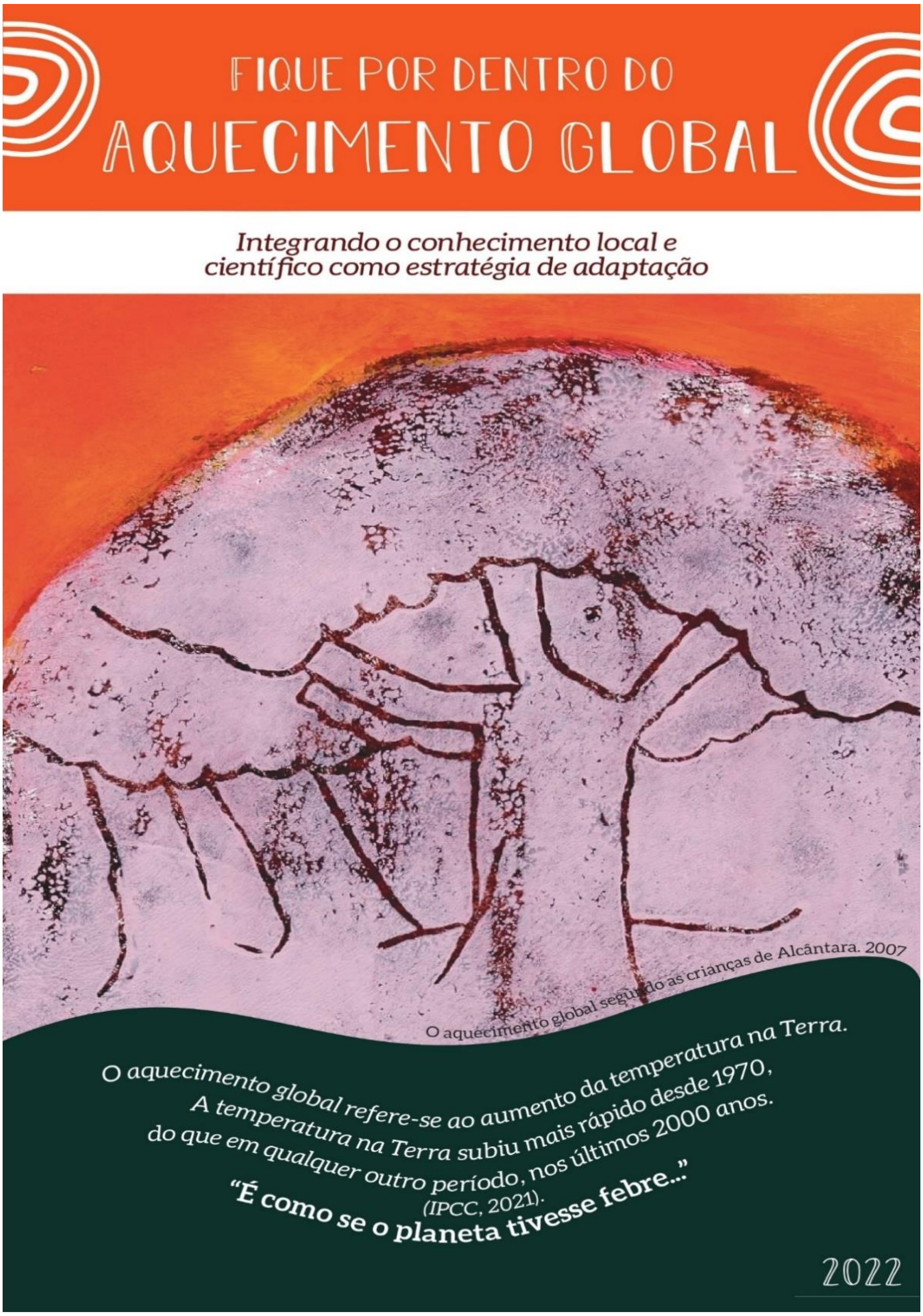
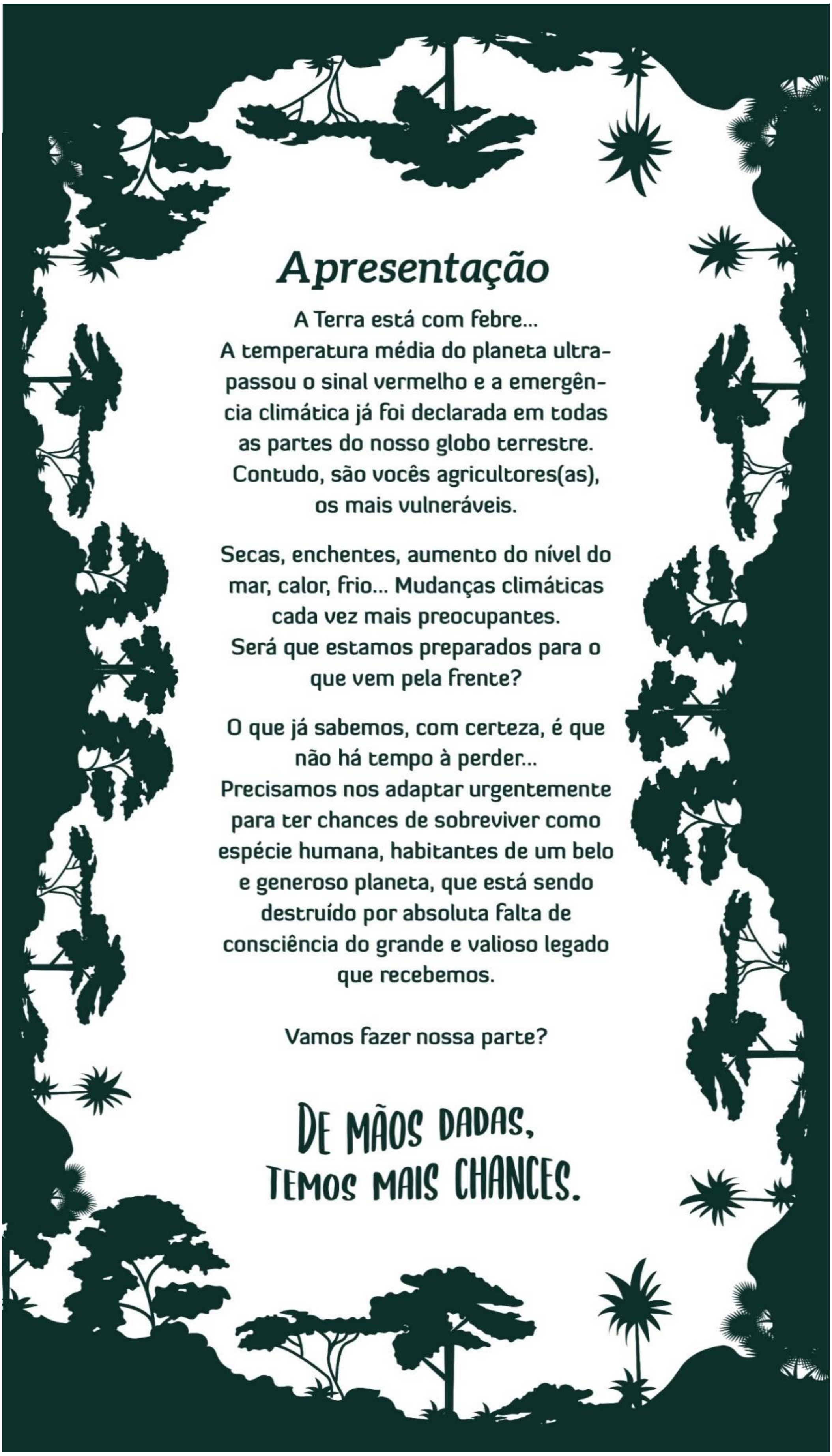
Apoio

5.2 Fique por dentro do aquecimento global





Apresentação

A Terra está com febre...
A temperatura média do planeta ultrapassou o sinal vermelho e a emergência climática já foi declarada em todas as partes do nosso globo terrestre.
Contudo, são vocês agricultores(as), os mais vulneráveis.

Secas, enchentes, aumento do nível do mar, calor, frio... Mudanças climáticas cada vez mais preocupantes.
Será que estamos preparados para o que vem pela frente?

O que já sabemos, com certeza, é que não há tempo à perder...
Precisamos nos adaptar urgentemente para ter chances de sobreviver como espécie humana, habitantes de um belo e generoso planeta, que está sendo destruído por absoluta falta de consciência do grande e valioso legado que recebemos.

Vamos fazer nossa parte?

DE MÃOS DADAS,
TEMOS MAIS CHANCES.

Das causas do aquecimento global

O aquecimento acelerado do planeta é causado por gases do efeito estufa, como o dióxido de carbono (CO^2), o Metano (CH^4), óxido nitroso (N^2O) entre outros, que não deixam sair o calor do sol que a Terra recebe. Assim, como numa estufa, o planeta fica cada dia mais quente.

Foto Tony Webster_Flickr

Geração de energia

US_Wikimedia Commons

Indústria petroleira

© Victor Moriyama Greenpeace

Desmatamento e queimadas

CC BY-SA 4.0

Fumaça dos carros

Credit: Andreas Habich

Indústrias

fonte: GestAgro

Agropecuária

A mudança climática e suas consequências

Com o aumento da temperatura, temos gerado a **mudança climática**. A mudança climática, são alterações nos padrões normais de temperatura, secas, chuvas e outros fatores do clima. Como consequência das alterações do clima, eventos climáticos cada vez mais fortes e frequentes estão acontecendo.

Getty Images via BBC

Seca Rio Paraná - 2021

Nicollas Witzel - Folhapress

Casas destruídas pelo aumento do nível do mar
Atafona, RJ - 2021

Allison Pereira reproducao - TV Globo

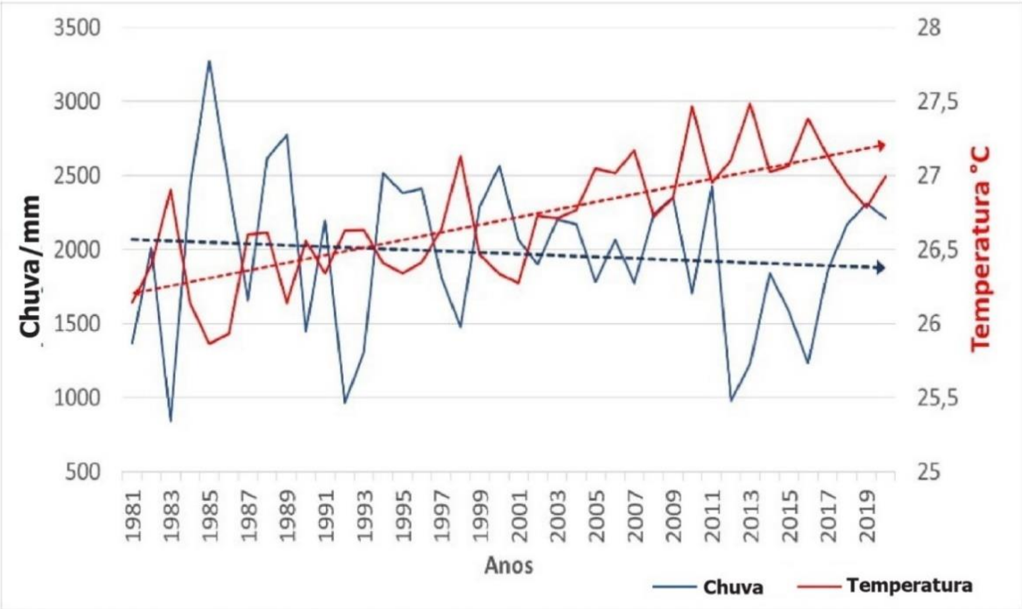
Enchente | Santa Luzia, MG - 2021

Fonte - AFP via BB

Altas temperaturas mais frequentes

COMO ESTAMOS EM ALCÂNTARA?

Em Alcântara, segundo os registros climatológicos, a temperatura está aumentando e as chuvas estão diminuindo.



Registro da temperatura e da chuva média, no município de Alcântara–MA, 1981–2019.

E O QUE PERCEBEM OS AGRICULTORES(AS) DE ALCÂNTARA?

"CHOVE MENOS, E À CADA DIA, MAIS QUENTE".

"TEMOS ESCASSEZ DE ÁGUA NAS COMUNIDADES, NO PERÍODO SECO".

"AS CHUVAS NÃO ESTÃO COMEÇANDO NO TEMPO CERTO, AÍ, DÁ PREJUÍZO PRA GENTE."

"ANTES, A GENTE TRABALHAVA O DIA TODO NA ROÇA. HOJE NÃO DÁ DEPOIS DAS 11HS, FICA QUENTE DEMAIS. A GENTE SÓ VOLTA DEPOIS DAS 15HS"

"As secas são mais fortes e frequentes".

"O mar está comendo algumas praias".

"Tem partes que o mar está entrando,
e os juçarais estão morrendo.
Acho que é pelo sal do mar."

"Às vezes chove, e logo esquenta demais.
Isso cozinha, escalda a maniva, e ela estraga".

"Arroz, basicamente não se planta mais,
porque as chuvas são intermitentes e chove menos.
Com pouca chuva, não enche o arroz".

Depoimentos de agricultores(as) das comunidades de Santa Maria, Mamuna, Peru, Só Assim, Cajueiro I, Baixa grande, Oitiua e Baiquaua.

AINDA HÁ TEMPO!

Para reduzir o impacto humano no clima, temos que mudar nossa forma de produzir e nos relacionar com a natureza. Em Alcântara, desde 2011, o Programa de pós graduação em Agroecologia da Universidade Estadual do Maranhão (UEMA), vem estimulando práticas de agricultura sustentável, como a 'Roça sem Fogo' e os Sistemas Agroflorestais (SAFs). Estas práticas, ganharam reforço com a criação de uma rede, onde a proposta é que o conhecimento sobre como produzir sem destruir a natureza, seja repassado de agricultor para agricultor, de agricultora para agricultora.

Com isso, estaremos contribuindo para amenizar os efeitos, entre nós, do aquecimento global e das mudanças climáticas.

BOAS PRÁTICAS PARA DIMINUIR OS IMPACTOS DA MUDANÇA CLIMÁTICA

Parar de queimar
Porque emite gases de efeito estufa; com mais seca e mais calor, tem mais fogo descontrolado.

Fazer roça sem fogo
Porque protege o solo da seca e chuvas intensas; dá força (nutre) o solo; diminui o número de capinas.

Use e guarde sementes crioulas
Colham, conservem e troquem sementes crioulas; dessa maneira, suas roças e quintais produtivos serão mais resistentes às mudanças do clima.

Proteger as matas ciliares
Porque elas garantem a água no presente e no futuro, para nossos filhos, netos e à cumunidade em geral. Além disso, elas produzem frutas como juçara e buriti, que geram renda e fazem parte da nossa identidade.

Proteger as matas e plantar árvores;
Porque reduz o calor; aumenta a umidade e protegem os bichos que comem as pragas.

Sistemas agroflorestais
Porque geram maior renda, protegem o solo; ajudam a conservar a água e diminuir a temperatura local ...

Tudo isso melhora a qualidade de vida e nos ajuda a aguentar as mudanças climáticas.

Estimado agricultor(a)

Lembrem-se que podem se aproximar do Programa de Pós graduação em Agroecologia da UEMA para conhecer e receber orientações sobre alternativas de produção de base agroecológica.
Se tiver mais interesse, pode entrar em contato com o Laboratório de Restauração Ecológica - LARECO - PPGA -UEMA.
Email: guillaumerousseau@professor.uema.br

Ficha Técnica
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E-mail: jhonatanmunoz.gu@gmail.com | Coordenador: Prof. Dr. Guillaume Xavier Rousseau
PPGA - UEMA - Email: guillaumerousseau@professor.uema.br
Colaboradora: Marilda Mascarenhas - OCA - Praia do Barco - MA | Projeto Gráfico: Raíssa B. M. Souza.
Agradecimento
Aos agricultores(as) de Alcântara, ao Sindicato dos Trabalhadores rurais, à Secretaria de Agricultura do município de Alcântara, e ao técnico da AGERP.

Apoio

CNPq · CÁTEDRA ITINERANTE Inclusão Produtiva Rural · CEBRAP Sustentabilidade · fundação arymax · humanize · Fundação Tide Setubal · LAReco Laboratório de Restauração Ecológica · OCA

6. CAPITULO V: **CONSIDERAÇÕES FINAIS**

Com as alterações climáticas e os problemas econômicos e sociais que enfrentam os agricultores quilombolas de Alcântara, a pratica do corte e queima como meio de subsistência se torna cada vez menos viável. Evitar a catástrofe da fome na região e da migração dos agricultores para a cidade, requer urgentemente a implementação de ações articuladas numa escala multinível de atores (comunidades-públicos-privados) que concebam a resolução de problemas estruturais como o acesso à terra, a falta de assistência técnica, o limitado acesso à educação, a dificuldade de comercialização justa dos produtos agrícolas, e a falta de organização comunitária. A resolução desses problemas certamente incrementara a capacidade adaptativa das comunidades.

Ainda que os agricultores percebam as alterações do clima e os impactos nas suas atividades agrícolas, poucos tomam medidas para minimizar os impactos. De fato, a prática que possivelmente se relaciona diretamente com as mudanças climáticas é a mudança da época de plantio, as demais ações adaptativas são motivadas pelo interesse de incrementar a renda e manter a segurança alimentar. O anterior quer dizer, que perceber as mudanças climáticas e seus impactos não necessariamente implica a implementação de ações de adaptação. As barreiras culturais, financeiras, de conhecimento e de acesso à informação também são relevantes.

Dado que a materialização das políticas públicas climáticas nos territórios é incipiente, lenta e as vezes não atendem as necessidades locais, é prioritário que as organizações comunitárias fortaleçam as redes comunitárias. O poder de transformação que tem as mulheres deve ser potencializado para encorajar outros agricultores.

As comunidades organizadas podem agilizar a implementação e multiplicação de ações de adaptação que visem a sustentabilidade ambiental, social e econômica sem comprometer a identidade cultural. Adicionalmente, em consequência da heterogeneidade socioeconômica e de conhecimentos relacionados às mudanças climáticas dos agricultores quilombolas de Alcântara, fortalecer o processo de educação ambiental é indubitavelmente necessário para o empoderamento e engajamento dos agricultores.

Integrar os conhecimentos locais com os acadêmicos é um trabalho que deve ser feito. Os cientistas-acadêmicos devem fazer o esforço para que as informações sejam transmitidas em uma linguagem simples que possa ser de utilidade para os agricultores.

APÊNDICES A – Questionário percepção do risco

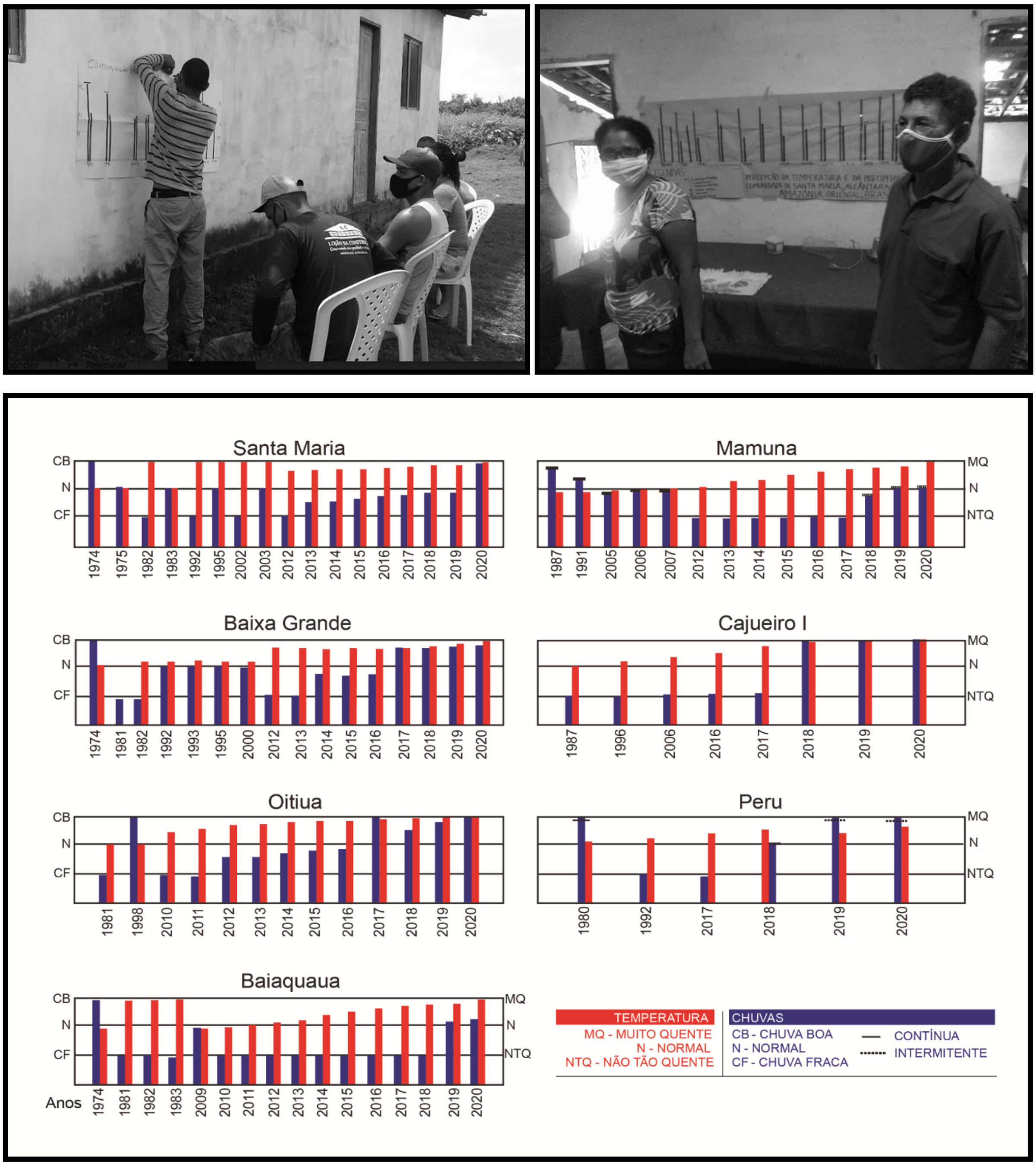
Percepção do risco dos agricultores

Passo 1: Quais os problemas que você percebe para sua atividade como agricultor (a)?	Passo 2: Organize os problemas do passo 1 de maior a menor importância.	Passo 3: Em uma escala de 1 a 10, quão sério ou grave é esse problema? 1 **pouco grave**, grave= 3; **moderadamente grave** = 5, **grave** = 8 **e muito grave** = 10.
n....		

APÊNDICES B - Registro fotográfico

Socialização de resultados parciais e dialogo sobre os "Desafios e oportunidades para os agricultores, diante as mudanças climáticas na escala local de Alcântara" (2021-2022).

Intercâmbio de saberes e implementação de rocas sem fogo com adubadeiras com agricultores e agricultoras quilombolas de Alcântara (2021).



Percepção dos grupos de discussão de agricultores sobre as mudanças na temperatura e precipitação na região de Alcântara.

ANEXO A - Parecer do comitê de ética de pesquisa com pessoas

Este parecer foi elaborado baseado nos documentos abaixo relacionados:

Tipo Documento	Arquivo	Postagem	Autor	Situação
Informações Básicas do Projeto	PB_INFORMAÇÕES_BÁSICAS_DO_PROJETO_1651797.pdf	04/12/2020 16:57:12		Aceito
Outros	CRONOGRAMAAJUSTADO.pdf	04/12/2020 16:39:31	Jhonatan Andrés Muñoz Gutiérrez	Aceito
Outros	Coletadadosreprestadoagricul.pdf	04/12/2020 16:29:44	Jhonatan Andrés Muñoz Gutiérrez	Aceito
Outros	DECLARACAOSINDICATO.pdf	04/12/2020 16:25:22	Jhonatan Andrés Muñoz Gutiérrez	Aceito

Endereço: Rua Quinhinha Pires, 743
Bairro: Centro **CEP:** 70.255-010
UF: MA **Município:** CAXIAS
Telefone: (99)3251-3938 **Fax:** (99)3251-3938 **E-mail:** cepe@cesc.uema.br

Declaração de Pesquisadores	DECLRAPESQUISADRS.pdf	07/11/2020 11:04:11	Jhonatan Andrés Muñoz Gutiérrez	Aceito
Declaração de Instituição e Infraestrutura	DECLARACAOAUTORIZACAOINSTITUICAO.pdf	04/11/2020 13:52:53	Jhonatan Andrés Muñoz Gutiérrez	Aceito
Folha de Rosto	folhaDeRosto.pdf	04/11/2020 13:50:11	Jhonatan Andrés Muñoz Gutiérrez	Aceito
Orçamento	ORCAMENTO.pdf	03/11/2020 14:40:09	Jhonatan Andrés Muñoz Gutiérrez	Aceito
TCLE / Termos de Assentimento / Justificativa de Ausência	TCLE.pdf	03/11/2020 14:37:01	Jhonatan Andrés Muñoz Gutiérrez	Aceito
Projeto Detalhado / Brochura Investigador	Projeto.pdf	03/11/2020 14:34:15	Jhonatan Andrés Muñoz Gutiérrez	Aceito

Situação do Parecer:
Aprovado

Necessita Apreciação da CONEP:
Não

CAXIAS, 27 de Fevereiro de 2021

Assinado por:
FRANCIDALMA SOARES SOUSA CARVALHO FILHA
(Coordenador(a))

ANEXO B – Instruções para autores da revista Climate and Dvelopment: referente com o artigo do Capítulo III

Climate and Development

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3. Format-Free Submission

Authors may submit their paper in any scholarly format or layout. Manuscripts may be supplied as single or multiple files. These can be Word, rich text format (rtf), open document format (odt), or PDF files. Figures and tables can be placed within the text or submitted as separate documents. Figures should be of sufficient resolution to enable refereeing.There are no strict formatting requirements, but all manuscripts must contain the essential elements needed to evaluate a manuscript: abstract, author affiliation, figures, tables, funder information, references. Further details may be requested upon acceptance.

- References can be in any style or format, so long as a consistent scholarly citation format is applied. Author name(s), journal or book title, article or chapter title, year of publication, volume and issue (where appropriate) and page numbers are essential. All bibliographic entries must contain a corresponding in-text citation. The addition of DOI (Digital Object Identifier) numbers is recommended but not essential.
- The journal reference style will be applied to the paper post-acceptance by Taylor & Francis.