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ORIGINAL ARTICLE

Development projects for small rural communities in the Brazilian Amazon region as potential strategies and practices of climate change adaptation

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Abstract Climate scenarios for the Amazon region (Brazil) indicate an increase in temperature and a precipitation decrease, affecting society and economic activities, particularly small-scale rural communities. The research aims to identify, describe and evaluate factors present in sustainable development projects for small rural communities (Type- A Demonstration Projects - PDA and Alternatives to Deforestation and Burnt Projects - PADEQ), already implemented, for recognizing its potential use as strategies for adaptation to climate change for small rural communities in the Amazon region. The researches, concerning fifteen projects in Rondonia, Para and Mato Grosso States, were developed through document analysis, technical visits, and interviews with stakeholders of three projects about the community perception, vulnerability and adaptation capacity. The analysis of documents regarding the potential success of the projects highlights their short history, important in the local context, prospects for continuity, and community participation in decision making. Few activities developed in projects could be associated with climate change adaptation practices. Two strategies and practices are the most important: the social organization and the process of awareness and training of the community, and the diversification of the types and forms of agricultural production. The interviews indicate that adaptation is implemented in projects, but without considering the pressures of climate variability and change. While these projects were not planned in the context of climate change, the greatest role of the projects relates to the strengthening of the already existing adaptation capacity, creating good conditions for incorporation of new strategies and adaptation measures, now clearly associated to the objective to reduce the vulnerability to climate change and variability impacts.

Keywords Climate Change · Adaptation strategies · Small rural communities · Vulnerability · Sustainable development projects · Amazon region

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1 Introduction

For the coming years in the Amazon region the climate forecasting models predict decreased rainfall and an increase in temperature (Malhi et al. 2008). The United Nations Intergovernmental Panel on Climate Change (IPCC 2007) reports in the light of the scenarios of increasing climate variability and extreme events; the coastal zones, human health, biodiversity, water resources and in particular the agricultural systems should face more impacts. The climate change can be a unique catalyst of impacts on forest and agricultural areas (Betts et al. 2008).

The effects of climate change could be diminished by reducing greenhouse gas emissions (mitigation strategies) and/or preparing to live with the new climatic conditions (adaptation processes). Until the present, much of the attention has been focused on mitigation. However, the strategies and practices for adaptation have recently acquired a growing importance through the demand of a better adaptation capacity and consequently of a decreasing vulnerability or a increasing resilience of individuals, society, and their productive activities (Guariguata et al. 2008).

There are significant uncertainties regarding global climate change scenarios and impacts Uncertainty in future climate change derives from three main sources: forcing (incomplete knowledge of external factors influencing the climate system), model response (different models may yield different responses to the same external forcing), and internal variability (natural changeability of the climate system that occurs in the absence of external forcing) (Deser et al. 2012).

The doubts grow when the predictions move from global to detailed scales, causing difficulties in the decision-making process (Dessai and Hulme 2007). Then, the design of climate change adaptation strategies and measures, particularly at local scale, is also a complicated task. As one of the consequences of this situation, several adaptation measures, decoupled from development policies, still place individuals, communities, productive activities, and infrastructure in a vulnerable position to cope with climate change and variability risk.

However, Debels et al. (2009) describe that an adaptation practice can be considered successful when it is positively associated in a context of sustainable socioeconomic development, benefiting a whole or part of a society in the occurrence of climatic impacts. In the same line of thought, Twigg (1999) indicates that the existence of a good community organization involved in development projects enables the population to quickly and efficiently cope with disasters.

In Brazil, a wide variety of sustainable development initiatives are well-known, and many of them have been implemented in the Amazon region. Projects included support for extractive reserves (RESEX), environmental management for selected areas, forestry and floodplain management, ecological-economic zoning, demarcation of indigenous land, fire prevention and control, support for science and technology, and protected area planning and creation in "ecological corridors (Fearnside 2009). Some of these initiatives, the "Type-A Demonstration Projects" (PDA) and the "Alternatives to Deforestation and Burnt Projects" (PADEQ) have supported since 1995, with varying degrees of success, activities in five States – Pará, Mato Grosso, Rondonia, Roraima and Tocantins (Fig. 1). The target of the programs is the small rural producer organized in associations, cooperatives and *non-governmental organization*s (NGOs). The programs, part of the PPG7 Pilot Program to Conserve the Brazilian Rainforest (1992–2008), are financed by multilateral development banks (e.g. World Bank; Interamerican Development Bank) and implemented by the Ministry of the Environment of Brazil (MMA), along with the cooperation of several

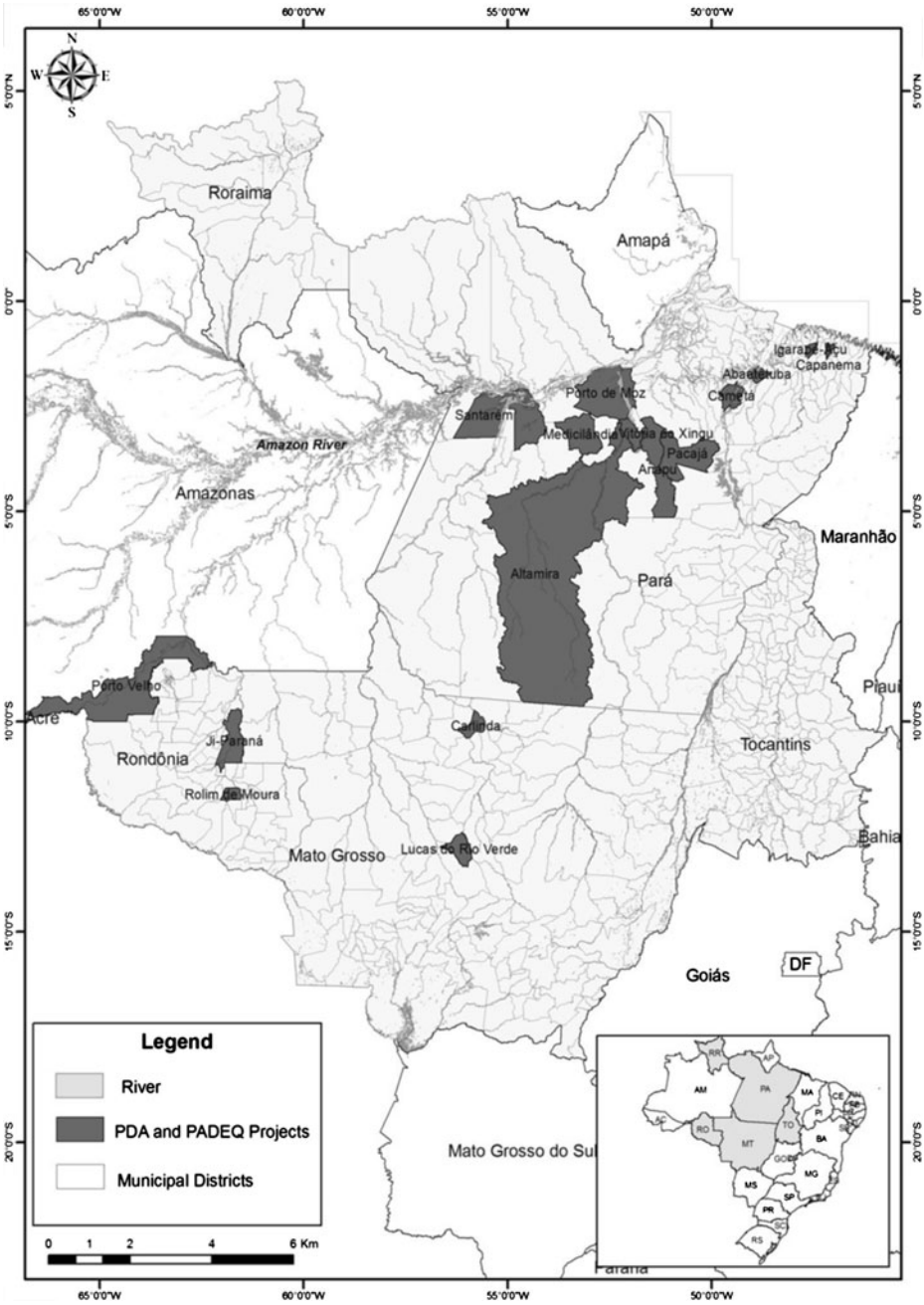

Fig. 1 Municipalities that have PDA/PADEQ projects analyzed in the Amazon region in Brazil

countries and NGOs. Among its main challenges are to demonstrate, through innovative experiences, the possibility of building effective small-scale strategies to promote sustainable development and thus stimulate the formulation of public policies that contribute to the

dissemination and incorporation of these strategies by other communities, organizations, and government institutions. In particular, the PADEQ projects seek to promote the sustainability of rural property reducing or eliminating the use of fire in the agricultural production process through alternatives to deforestation and bushfires.

While sustainable development programs are well known, very few practices are officially recognized as climate change adaptation strategies. In this sense, sustainable development projects, as PADEQ and PDA, can play the role of adaptation strategies for small rural communities in the Amazon region and integrate the portfolio of existing adaptation measures and implemented in Brazil? Whereas PDA and PADEQ projects were created and implemented for other purposes, which is the perception of its members on the potential use of these projects as adaptation strategies?

In this sense, the research aims to identify, describe and evaluate factors present in PDA and PADEQ sustainable development projects, already implemented, for recognizing its potential use as strategies for adaptation to climate change for small rural communities in the Amazon region. Thus, it is intend to contribute significantly to the formulation of public policies and support decision-making at different levels of government, especially in the ability to pursue step up investment in sustainable development projects in Brazil.

2 Initial considerations

2.1 The climate change, potential impacts and small rural communities' vulnerability in the Amazon region

Even with the lack of long-term and well spatially distributed records, all models project in the Amazon region an increase in temperature, but do not agree among themselves with respect to changes in rainfall for future years (Li et al. 2006). In order to promote the construction of climate change scenarios of higher spatial resolution, Marengo et al. (2012) used regional models showing that the results are not homogenous throughout the Amazon basin and design an average increase of temperature from 1.9° to 4.9 ° C and precipitation decrease of 0.7 to 1.2 mm/day towards the end of the 21st century.

According to Torres et al. (2012), the Amazon region is one of the Brazilian so-called "climate change impacts hot spots". In this region, the decrease of rainfall induced by global climate change and local deforestation increases greatly the ecosystems susceptibility to fire (Nepstad et al. 2004), probably causing the reduction of the number of species less tolerant to drought, the "savannization" of the east and southeast regions (Nobre et al. 2005), the decline of forest areas or its full collapse (Cox et al. 2004). Simulations of Miles et al. (2004) showed that 43 % of a set of 69 tree species analyzed would be non-viable in 2095. The hydrological cycle in the Amazon region is also affected by deforestation and climate change, increasing the incidence and characteristics of floods and drought; and influencing the tele-connections on the global atmospheric circulation patterns (Nijssen et al. 2001).

A special attention should be given to the impacts on small agricultural production (Lindoso et al. 2009). According to Verchot et al. (2007), climate change potentially affects several factors in small-scale agriculture in developing countries, such as (i) the availability of water for irrigation, (ii) the unusual occurrence of floods and dry periods, (iii) the soil fertility, and (iv) the proliferation of pests and diseases. The impacts of climate extreme events can generate not only production loss during a given year, but also the likely loss of productive capacity in subsequent years. Thus, their impacts go beyond immediate effects. In the Amazon region, Brondizio and Moran (2008) describe the consequences of prolonged

droughts, extreme variation in floods, and accidental fires on small rural communities - the decline of water and biodiversity resources, the loss of invested capital, the reduction in productivity, the changes in land use and in residences' construction patterns, the increased food security risk, as well as augmented reliance on the social insurance system and credit debts.

A system (individual, community, socioeconomic activity) vulnerability to climate variability, extreme events, and change is defined as the aptitude to tolerate and the capacity to respond to tensions imposed by their adverse effects (Adger et al. 2007). Some of the factors that influence the vulnerability are the degree of physical exposure, the system fragility (e.g. the level of development, the existence and distribution of resources), and the adaptation capacity (e.g. the social institutions and government network) (Smit and Wandel 2006).

All societies have inherent abilities to deal with climate variability; however these adaptation capacities are not uniformly spatial and temporally distributed (Leichenko and O'Brien 2001). In the Amazon region, the small farmers' populations are particularly susceptible to environmental conditions associated with climate variability and extreme events, in particular the prolonged droughts and floods, and the dispersion of accidental fire (Brondizio and Moran 2008; Moran et al. 2006). Factors contributing to the definition of the vulnerability of this group are: (i) The poor agricultural technical extension services for the adoption of new farming practices; (ii) The deficiency of relevant climate information for decision-making at the local scale and the little confidence of Amazonian small farmers on climate forecasting models due to the use of information of low spatial resolution and difficult comprehension; (iii) The poor infrastructure - people and products transportation to industrial and commercial centers, as well as the quality provision of water and energy are very poor and easily affected by extreme climatic events; (iv) The limited access to technologies, loans, and government programs resources; (v) The disparity between the perception and scientific scenarios of climate change in the population - most small rural communities have a local spatial and short-term temporal perspective, based on own experiences of changes; and (vi) The precarious economic situation. Without major financial resources, the communities feel enormous difficulties to absorb and recover from the impacts quickly.

2.2 Adaptation strategies and measures for climate change and variability in small rural communities

Climate adaptation is a continuous process of development and implementation of strategies and practices in order to moderate, tolerate, and also take advantage of the consequences of climatic events, reducing the vulnerability and/or increasing the awareness and the preparation (Smit et al. 2000). The adaptation involves changes in social and environmental processes, taken by anticipatory (e.g. alert systems, insurance) and reactive (e.g. emergency response, migration) actions (Adger et al. 2007), carried out by individuals and communities or planned and implemented by governments (Adger 2003).

The adaptive capacity is the ability (present or potential) of a system and/or an individual to successfully adjust to climate variability and change. The adaptation capacity is a necessary condition for planning and implementing effective adaptation strategies and measures (Brooks and Adger 2005). It is closely linked to vulnerability, and then is influenced by the degree of economic and technological development, as well as by social factors, such as human capital and governance structure, education, income, and health (Berkhout et al. 2006).

Adger et al. (2007) and Niang-Diop and Bosch (2004) indicate that the adaptation practices can be grouped and classified according to the spatial scale (e.g. local, regional, national); thematic (e.g. water resources, agriculture, tourism, public health); specificity (e.g. multi or single thematic); type (e.g. structural measures, incorporating technological investments); performer (e.g. national or local government, international donors, the private sector, NGOs, local community, individual), and geographic region affected (e.g. flood plains, deserts, mountains).

Not all social groups or its members have the same adaptation capacity and strategy. Small rural communities often are among the most affected by these impacts, as well as the least prepared (Cunha et al. 2010). Table 1 presents diverse strategies for climate change adaptation used in small-scale farming.

The adaptive capacity of small rural communities varies considering the different levels of knowledge, the cultural values, the ability to access natural resources, capital and means of production, the degree of institutional organization (Ostrom 2005), and economic-political, social, technological, and information aspects. Economic-political limits to adaptation in the rural areas are associated with the restricted availability of credit and technical assistance (Vásquez-León et al. 2003; Smit and Skinner 2002), and the lack of integration of public policies (Patz et al. 2000). The social and cultural barrier relates to the different perceptions and level of risk tolerance, the nature of relations between community members, the participation in decision-making processes, and the existence of an integrated network of social institutions (Tompkins and Adger 2004). Major obstacles for adaptation are associated to the existence of incomplete databases, particularly associated to social and economic costs and benefits of the strategies and measures, and the lack of technical knowledge (Barros 2005).

3 Materials and methods

The researches concerning PDA/PADEQ projects were developed through (i) documents analysis and (ii) technical visits. The choice of 15 projects (approximately 15 % of the total

Table 1 Some adaptation strategies and practices of small farmers to combat climate variability and changes

Authors	Strategies and Practices
Niang-Diop and Bosch (2004)	Artificial irrigation and grain storage systems; Information dissemination program; Rural technical capacity activities
Thomas et al. (2007)	Acquisition of fast-growing seeds; Activities migration to less impacted areas; Sale of goods, independent of the quotation, to obtaining immediate money
Magrin and Travasso (2002)	Land use and agro ecological zones changes; Implementation of agricultural risk insurance and irrigation system; Suitable use of artificial fertilizer and of genotypes adapted to new conditions
Smit and Skinner (2002)	Use of new varieties of seed; Implementation of simple meteorological warning systems; Change in compensation programs, subsidies, incentives and agricultural risk insurance; Spatial and temporal changes in agricultural activities; Artificial irrigation systems; Diversification of economical activities
Moran et al. (2006); Brondizio and Moran (2008)	Construction of barriers against fire and water reservoirs for cattle; Fire community warning system; Changes in the pattern of agricultural production

universe of projects) was a joint decision with MMA technicians considering the longevity of the Project, the degree of activities' development, the diversity of strategies and measures, and the heterogeneity in spatial distribution (Fig. 1 and Table 2).

The documents of the PDA/PADEQ projects comprise a wide diversity of products, such as initial diagnoses, monitoring plans, preliminary reports, project summary sheets, databases, and are elaborated by communities' members or by Ministry evaluators. Digital and paper documents were analyzed, utilizing 2 steps. It should be noted that, unfortunately, many of the documents analyzed are written in summary form, without details and data, and often with a simple intention to resolve administrative obligations with funding support and supervision institutions.

The first step uses some of the criteria suggested by Debels et al. (2009) for the construction of the "Index of Usefulness of Practices for Adaptation (IUPA)" in order to assess the potential success of current and future options for climate variability and change adaptation (Table 3). The second step utilizes a matrix to group, sort, and compare activities in PDA/PADEQ development projects that can be associated with potential climate change adaptation practices and strategies. The evaluation is conducted based on measures options already experienced by small rural communities in different parts of the world (Smit and Skinner 2002; Thomas et al. 2007; Niang-Diop and Bosch 2004; Brondizio and Moran 2008). The activities carried out in the projects are grouped according to their relationship with the technological development, the changes in agricultural production, the adjustment in communities' financial and governmental management, and the strengthening of social networks.

Managers and technicians of three projects were interviewed (Conservation of forest resources and fishing grounds with the generation of income through adding value to products from forest extraction; Proposal for sustainable and solidarity development/ Families of RECA Project; Changes in agricultural practices, biodiversity and empowerment: Seeding agro ecological alternatives for reducing deforestation and fire-setting) (Fig. 2). The projects were chosen from the group of fifteen projects analyzed previously considering the different environments, activities, and forms of production. The questions were grouped into five themes, but with the flexibility to explore new information (Table 4).

4 Results and discussion

The analysis of PDA/PADEQ documents, based in Table 3, highlights the following results regarding the potential success of the projects:

- The projects have a short history: The projects have started between the months of May 2005 and June 2006, and have a defined financing time-extension of 36 months.
- The projects are important in the local context: the MMA funding for the projects examined summarizes a total value of R$ 6,882,703 and an average value of R$ 458,847 per project, which represents close to 15 % of municipal annual budgets where these projects are focused.
- The projects have prospects for continuity: The continuity is based on the social capital formed through capacity-building activities, on the establishing and strengthening of institutional partnerships with public and private entities in order to cooperate with the technical supervision of the certification and marketing activities of sustainable products, on the capability of generating revenues needed for the self-financing of production, and in the management of alternative production (e.g. milk, apiculture).
- Community participation in decision making is ensured: Strategies for the intensification of community participation and autonomy in decisions are: (i) the dissemination of

Table 2 Characterization of PDA/PADEQ projects developed in the Amazon region and chosen for analysis

Project Name	Code	Proponent	Municipality (State)	Objectives and Main Activities
Deployment of integrated databases for environmental protection	1C	Association of fishermen and rural producers community of Coroca	Santarém (Pará)	Rational use of natural resources (pisciculture, Agro-forestry System, beekeeping) in order to improve the life-quality and household income
Sustainable use of family production units on the lower Tocantins	4C	Tipiti - training center for alternative technology	Abaetetuba, Barcarena, Cametá, Igarapé-Miri (Pará)	Capacity-building for the design and monitoring of land use plans of family production units
Inclusion of the methodology of good fire management in Amazon household production	56 C	Amazon environmental research institute	Altamira, Anapú, Santarém, Vitória do Xingu (Pará)	Dissemination of techniques for rational use of fire and Agro-forestry System
Sustainable model of household income	96C	Association of rural producers for mutual aid	Rolim de Moura (Rondonia)	Support for diversification and commercialization of products, Agro-forestry System, technical assistance to producers.
Proposal for sustainable and solidarity development/Families of Reca Project	34C	Association of small Agro foresters - RECA project	Nova Califórnia (Rondonia)	Technical assistance; dissemination and commercialization of sustainable regional products
Conservation of forest and fishing resources with the income generated through adding value to products from forest extraction	74C	Z-16 fishing community	Cametá (Pará)	Expansion of conservation capacity of forest and fisheries resources by adding value to the products (Management of açai production, pisciculture, implementation of community fishing agreements).
Environmental preservation alternatives in family production	4P	Rural workers' union	Pacajá (Pará)	Environmental recovery and conservation in protected areas; agricultural production without the use of fire (Agro-forestry System, nursery seedlings construction).
Retrieving impacted areas and deployment of diversification production systems as an alternative to fire use	7P	Association of small farmers from Altamira	Altamira (Pará)	Small rural management to reduce deforestation and the use of fire as agricultural practice
Changes in agricultural practices, biodiversity and empowerment: Seeding agro ecological alternatives for reducing deforestation and fire-setting	22P	Nova Olinda association for development	Igarapé-Açu (Pará)	Agro-ecological alternatives in order to achieve the sustainable land use (Agro-forestry System, recuperation of impacted areas, agricultural production without the use of fire).
Rural working women protagonists of sustainable local development	26P	Women's movement from Northeast of Pará	Capanema (Pará)	Women's action improvement in sustainable local development

Table 2 (continued)

Project Name	Code	Proponent	Municipality (State)	Objectives and Main Activities
Xingu river alive forever	63P	Rural workers' union of Porto de Moz	Porto de Moz (Pará)	Consolidation and dissemination of agro-ecological practices as an alternative to the use of fire
Agriculture without burning	68P	Rural workers' union	Medicilândia (Pará)	Consolidation and dissemination of agro-ecological practices as an alternative to the use of fire
Integrated environmental management community center	112P	Ouro Verde institute	Carlinda (Mato Grosso)	Improves the quality of life in communities (through the implementation of models of participatory management and sustainable production).
Family farmers promoting environmental balance	141P	Federation of workers in agriculture of Rondônia	Ji-Paraná (Rondonia)	Developing of sustainable alternatives to the reduction of deforestation and burning in the production activities (technical assistance, Agro-forestry System)
Beija-Flor	143P	Rural workers' union	Lucas do Rio Verde (Mato Grosso)	Maintenance of conservation units and deployment of sustainable production experiences (beekeeping, cultivation of medicinal plants)

1C - Implantação de Bases Integradas para Proteção do Meio Ambiente; 4C - Uso Sustentável de Unidades de Produção Familiar no Baixo Tocantins; 56C - Inserção da Metodologia de Bom Manejo de Fogo em Áreas de Produção Familiar na Amazônia; 96C - Modelo Sustentável da Renda Familiar; 34C - Proposta de Desenvolvimento Sustentável e Solidária/Famílias do Projeto Reca; 74C - Conservação dos Recursos Florestais e Pesqueiros com a Geração de Renda através da Agregação de Valor aos Produtos da Extração Florestal; 4P - Alternativas de Preservação Ambiental na Produção Familiar; 7P - Recuperação de Áreas Alteradas e Implantação de Sistemas Diversificados de Produção como Alternativa ao Uso do Fogo; 22P - Mudanças de Práticas Agrícolas, Biodiversidade e Capacitação: Semeando Alternativas Agro ecológicas para Redução do Desmatamento e das Queimadas; 26P - Mulheres Trabalhadoras Rurais Protagonistas do Desenvolvimento Local Sustentável; 63P - Xingu Vivo Para Sempre; 68P - Roça Sem Queima; 112P - Centro Comunitário de Gestão Ambiental Integrada; 141P - Agricultores familiares promovendo equilíbrio ambiental; 143P – Beija Flor

Table 3 Identification and description of some elements used for evaluate the PADEQ/PDA projects, adapted from Debels et al. (2009)

Elements of characterization of the projects	Description	Theoretical bases
Time	Estimated time for the implementation of adaptation practices and/or until obtaining the results	The establishment of temporal limits is required when climate variability adaptation policies and measures are defined (Niang-Diop and Bosch 2004).
Estimated financial costs of the project	Cost of the design, implementation, execution, follow-up, and performance evaluation of the practice or strategy.	The climate change researches have often given attention to the cost of adaptive response measures, using them as a measure to qualify their merits as practice for adaptation (Toman 2006).
Temporal sustainability of the practices	Time after the implementation of adaptation practice in which this is still evolving, particularly using its own resources.	Much of a project's success relates to the persistence and/or sustainability in time of their actions and results (Eriksen and Kelly 2007).
Community participation and autonomy	Population inclusion in the different stages of the adaptation process, and independence degree in decision-making	The adaptation practice success is often related to the possibility of having decentralized, participatory, and democratic decision-making process (Wiseman et al. 2010).

the results of experiments, meetings, and workshops; (ii) the contribution in the processes of activities elaboration, management and implementation along with technicians and experts from NGOs, government, or employed by the project; (iii) the interest and commitment of young people and women with the project in the diagnostics elaboration and collaboration (ex. planting species, construction of nurseries), and the proposition of new productive activities; (iv) the population representation in community and/or cooperative advice council, and (v) technical and administrative training.

Table 5 presents the comparative matrix analysis among the various projects, with the most notable in gray that present some activity or practice that could be considered as an adaptation strategy or measure to climate variability and change. All PDA/PADEQ projects have developed at least one practice or strategy of climate variability and change adaptation among the fourteen defined subgroups. Most activities carried out in the PDA/PADEQ

Fig. 2 Interviews carried out along with project members in the municipalities of Cametá (*left*) and Igarapé Açu (*right*), both in the State of Pará, Brazil

Table 4 Main questions, grouped by themes, applied to PDA/PADEQ projects managers and technicians

Thematic	Questions
Community perception	Which is the perception regarding the climate variability, extreme events and change issues in the region? Is there some remembrance of the impacts of weather events in recent years? How would you describe the use of climate information?
Vulnerability of small rural community and their activities	Which production, ecosystems, and/or populations are particularly vulnerable to climate variability, extreme events and change?
Potential for adaptation	Does the community's adaptive capacity relate to technological development, access to and use of government programs, the forms of production, and/or the strengthening of social networks?
Weight of climate factor in the implementation of adaptation measures	Do adaptation practices take into account climate change alone, or consider other pressures and risks (e.g. economic, political, social)?
Consideration of the project as an adaptation strategy or practice	Which is the contribution that the project has given to the climate impacts vulnerability reduction?

projects present no or little relationship with the identified climate variability and change adaptation strategies and practices - Nine projects show one or two activities, and only two had the largest amount: the project 22P with five activities, and the 7P with four activities (Fig. 3).

The main practices and strategies in PDA/PADEQ projects belong to groups "changes in agricultural production" and "strengthening of social networks". In the first group, the production diversification is highlighted by the incorporation of new activities, and products (e.g. apiculture, management of açai (*Euterpe oleracea*) and medicinal plants, fish farming), and innovative forms of production (e.g. changes in the use of fire in the agricultural activities, Agro-Forestry System (SAF). The second group has a particular emphasis on education, technical training and research processes at the small rural and riverside communities with relation to sustainability of productive activities and preservation of the environment (eco-agro, food safety practices, new productive activities, changes in the use of fire, forest fire prevention and control, waste management, planting and management of forest seedlings, environmental education, and açai and medicinal plants), as well as in public awareness to disseminate information, and improve the understanding between the population and the decision-makers. Almost no activity was related to the groups "Technological development" (Use of new varieties of grains and instruments; Development and use of early warning systems and meteorological data acquisition) and "Change in financial and governmental management" (Modification of natural disasters relief procedures; Non-planned products commercialization; Income diversification).

The result of the application of the interviews with managers and technicians of three PDA/PADEQ projects are presented.

4.1 Conservation of forest and fishing resources with the income generation through adding value to products from forest extraction –74C

Climate change is not discussed in the community, being known indirectly (e.g. by press). The interviewed had not considered the origin of the observed impacts (e.g. fishing stock's decrease and increase of erosion and sedimentation processes in the Tocantins River) in

climate variability and change. The main points of the project in implementation of potential measures to adapt to climate changes relate to the ability to

(i) Have access to and use of funding programs and cooperation with governmental and non-governmental organizations - the British Embassy in Brazil financed a drinking

Table 5 Comparative analysis matrix of PADEQ/PDA projects considering the activities developed and that could be associated with practices and strategies of climate change adaptation (in gray). The practices and strategies are grouped and sorted according to Smit and Skinner (2002), Thomas et al. (2007), Niang-Diop and Bosch (2004), and Brondizio and Moran (2008)

Practices and strategies of climate change adaptation		Project													
Group	Subgroup	74 C	1 C	4 C	34 C	56 C	96 C	4 P	7 P	22 P	26 P	63 P	68 P	112 P	141 P	143 P
Technological development	Use of new varieties of grains and instruments															
	Development and use of early warning systems and meteorological data acquisition															
Changes in agriculture production	Diversification of products and activities															
	New procedures															
	Alteration in place															
	Implementation of artificial irrigation practices															
	Variation of the production schedule															
Change in financial and governmental management	Modification of natural disasters' relief procedures															
	Non-planned products commercializatio															

Practices and strategies of climate change adaptation		Project														
Group	Subgroup	74 C	1 C	4 C	34 C	56 C	96 C	4 P	7 P	22 P	26 P	63 P	68 P	112 P	141 P	143 P
	n															
	Income Diversification															
Strengthening of social networks	Encouraging social organization															
	Education, training, and research in the communities															
	Public environmental awareness campaigns															
	Climate extreme events' risk management															

water treatment unit; the Banks of Brazil and of the State of Pará, a juvenile station, the Fishing National Secretariat, an ice factory, and the FASE NGO, a palm treatment unit (Fig. 4); (ii) Diversify the production by the incorporation of new production activities to traditional fishing and extractives activities, such as the aquaculture, the forestry, the production of juvenile and fodders for fishes, as well as the processing of açai and bee honey; and (iii) Improve the organization and community awareness regarding the implementation sustainable development models.

Adaptive changes implemented by the project are based on economic pressure provoked by the regional decline in fish stocks. However, for the interviewed the project has already contributed to the adoption of adaptive changes to cope with climate change and variability, particularly reducing vulnerability through productive activities diversification, recovery and forests of açai, the promotion of fisheries agreements, and the stimulation to technical training.

4.2 Proposal for sustainable and solidarity development/RECA project - 34C

The climate issue is very timidly incorporated in various activities and discussions within the project. However higher temperatures, less magnitude, and off-season rainfall, and more frequent occurrences of the phenomenon known locally as "friagem" are recognized. It is related to episodic incursions of midlatitude air to the east of the subtropical Andes occur year round at intervals of 1–2 weeks (G*arreaud* 2000), All components of the project are considered vulnerable to climate change because of the activities' deep dependence on

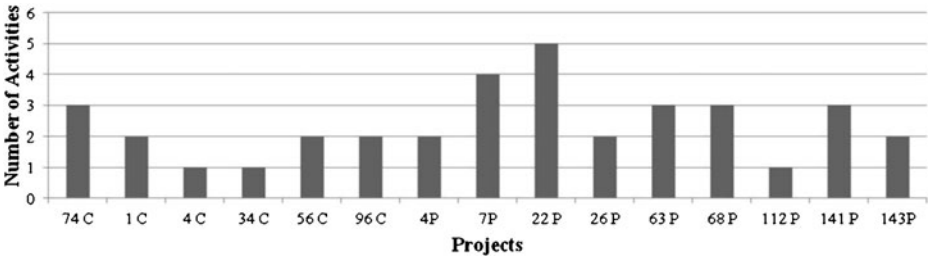

Fig. 3 Distribution of activities related to the adaptation strategies and practices of climate variability and changes using the data from Table 5

natural resources and climate. The members of the community already feel discomfort when executing field activities due to high temperatures, the partial development and destruction (e.g. pupunha (*Bactris gasipaes*), cupuaçu (*Theobroma grandiflorum*)) of agricultural products and fruits by the decrease of water availability, and community's dietary changes preferably based on already-affected individual production. The largest climate vulnerability of the project relates to hydrometeorology dependence, used for human consumption, agriculture, and the development of industrialized productive activities (engine cooling, washing fruit, and sterilization of glassware, etc.).

According to the interviewed, the project potential on implementation of climate change adaptation measures is: (i) the incorporation of thermal insulation in residences and simple innovation on agricultural tools, the genetic improvement of plants and trees of greater adaptability, and the development of leaves-based fertilizers along with the Brazilian Agricultural Research Company (EMBRAPA); (ii) the ability to request NGO and governmental technical advisory programs and bank loans, to have a plan to pay members benefits in advance in case of necessity, and to stock agriculture products in association with National Company of Food Supply (CONAB); (iii) the inclusion of new activities and changes in the already existent production procedures, allowing to diversify income sources throughout the year, such as a low-level industrialization of the natural resources (e.g. oil from pupunha palm and cupuaçu and chestnut (*Bertholletia excels*) seeds), and cultivation of coffee, rice, corn, peanuts, honey (Fig. 4), and (iv) the strengthening of technical and decision-making process capacity. The economic profit is a fundamental factor to the incorporation, after approval of the majority of the community, of adaptation changes. However, it is highlighted that the project already contributes to the adoption of adaptive practices to cope with climate change and variability impacts, such as the preservation of the forest, the reforestation of

Fig. 4 A fish farming station at the project 74C (*left*), industrialization processes of pupunha palm at the project 34C (*center*), and new technologies in agricultural production such as equipment used in the grinding of capoeira at the project 22P (*right*)

fluvial headwaters and margins, the implementation of SAF, and permanent awareness and training of the community in order to achieve a sustainable production.

4.3 Changes in agricultural practices, biodiversity and empowerment: seeding agro ecological alternatives for reducing deforestation and fire-setting-22P

The variability and climate change are not discussed in the community, but most of its members that have resided in the region for more than 15 years, recognize transformations, particularly temperature increases, and in some cases, the decline in rainfall magnitude and frequency. Agricultural activities are planned based on local people's knowledge and forecasts.

There is not a clear association between existing development problems with the climate, therefore the community does not realize that it is vulnerable to climate change and variability. Among the main positive points of the project in relation to the development of climate change adaptation capacity are included (i) technological development through the incorporation of new tools to eliminate the agricultural use of fire; genetically modified plant species, and leaves and organic material fertilizers; (ii) the diversification of the production by the incorporation of new fruit (e.g. papaya (*Carica papaya L.*), lemon (*Citrus limonium*), açai), and timber trees (e.g. Mahogany (*Swietenia macrophylla*), Paricá (*Schizolobium amazonicum*)) to traditional subsistence crops, and conformation of SAF; and (iii) the strengthening of social networks - environmental awareness and the technical training of project members (Fig. 4).

Project members are incorporating adaptations to their productive activities considering the economic (e.g. diversification of production), and environmental aspects (e.g. reduction of deforested area and soil preservation), factors considered that could support also adaptation to climate change impacts.

5 Conclusions

The objective of the study is not the assessment of the success of these projects through the calculation of each contribution to the sustainable development of the community.

The responses of people, communities and governments to climate variability and change impacts combine initiatives of mitigation of the causes, and of adaption of the effects. Clearly, the PDA/PADEQ projects contribute to mitigation of Greenhouse Gases (GHG) concentration looking for decreasing deforestation, reforestation and the replacement of burnt plant coverage practices for agricultural activities.

The analysis of the relationship between the sustainable development projects and adaptation strategies and measures to climate change and variability is not a simple task. It is quite difficult to evaluate the cost-effectiveness of measures (particularly non-quantifiable benefits), to include the spatial heterogeneity of vulnerability and adaptive capacity, and to assess the success of the results considering the project's short and recent history. However, some of the activities developed by the PDA/PADEQ projects could be classified as climate change adaptation strategies and measures.

Adaptation strategies and measures are common in the progress of the projects over time, but are implemented considering the demand for improvements in financial conditions, but none of the projects examined is explicitly mentioned the factors of climate variability, change, and extreme events.

The amount of activities developed in projects that could be associated with climate change adaptation practices is very low (average 20 %), however, two strategies and

practices have been exposed by the PDA/PADEQ projects visited and analyzed as the most important in strengthening the adaptation capacity. On one hand, there is the social organization and the process of awareness and training of its members regarding the adoption of sustainable economic, social and environmental development models. On other hand, there is the diversification of the types and forms of agricultural production. Both strategies and practices are recommended due to the slow-change scenarios and long-term climate.

It is important to mention that perhaps the greatest role of the projects relates to the strengthening of the already existing adaptation capacity, creating good conditions for incorporation in the community activities, of new strategies and adaptation measures, now clearly associated to the objective to reduce the vulnerability to climate change and variability impacts.

In the Amazon region, the difficulties and/or obstacles to implementing many of the adaptation strategies and practices are closely related to the small rural communities' vulnerability factors, but more particularly, associated to the different perception of the existence of a *real* hazard originated in new climatic conditions that could impact people and community activities. The differences arise from environmental characteristics of the project location and geographical origin of its members. The perception and awareness are higher in projects located in high climate variability areas (e.g. project RECA in Rondonia) and whose members migrate from regions with remarkable climatic variability (e.g. southeastern region of Brazil). Adaptation practices that use new or upgraded technologies, even still incipient, are common in communities with family tradition in these practices (e.g. European immigrants).

While these projects were not planned in the context of climate change, the boundaries between the goals of sustainable development, the reduction of vulnerabilities, and adaptation to the impacts of climate change are sometimes confused. In this sense it is possible to assess positively the experiences of PDA projects as potential adaptation options for small rural and riverside communities in a climate change scenario.

Finally, it is believed that many advances have been achieved, especially in the process of building methodologies. However, new future prospects can be described, including the importance of interview for not only the managers and technicians of the projects, but applications of this type of study to other government programs production support in the region, as well as in other communities (e.g. indigenous peoples).

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