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Review

Enhancing adaptive capacity to climate change: The case of smallholder farmers in the Brazilian semi-arid region

André Felipe Simões [a,*], Debora Cynamon Kligerman [b,c], Emilio Lèbre La Rovere [b,c], Maria Regina Maroun [b,c], Martha Barata [b,c], Martin Obermaier [b,c]

[a] School of Arts, Sciences and Humanities (EACH) of the State University of São Paulo (USP), Brazil

[b] Energy Planning Program, Graduate School of Engineering, Federal University of Rio de Janeiro, Centro de Tecnologia, Sala C-211, Cidade Universitária, Ilha do Fundão, Rio de Janeiro, RJ 21941-972, Brazil

[c] Environmental Sciences Laboratory (LIMA) and Center for Integrated Studies on Climate Change and the Environment (Centro Clima), Graduate School of Engineering, Federal University of Rio de Janeiro, Centro de Tecnologia, Sala I-208, Cidade Universitária, Ilha do Fundão, Rio de Janeiro, RJ 21949-900, Brazil

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ABSTRACT

Climate change is one of the main challenges faced by mankind in this century. Although developing countries have little historical responsibility for climate change, they are likely to be most affected by it since they lack resources to cope with or to adapt to its effects. Studies show that the semi-arid northeast region of Brazil – where the country's poorest populations are concentrated – is one of the most vulnerable to climate change and thus likely to suffer its impacts more severely. The present paper addresses these problems by presenting a concrete initiative for strengthening adaptive capacity in the rural community of Pintadas as a first step in the development of a comprehensive methodology to help smallholder farmers in the region adapt to climate change. Based on the project results this paper highlights the integration of development, adaptive capacity and adaptation strategies. Furthermore, the necessity of vulnerability studies and concrete local experiences is highlighted in order to develop adaptation strategies that can alleviate poverty and minimize climate change impacts for the poor.

1. Introduction

The Fourth Assessment Report (AR4) from the Intergovernmental Panel on Climate Change (IPCC, 2007) has provided the clearest scientific analysis yet available on the potential impacts from changing average global surface temperatures. Such impact will be felt worldwide, and although positive consequences are expected in some cases (e.g. increases in soybean yields in some temperate areas of Latin America), most climate change impacts are likely to be negative, including significant risks of biodiversity loss, changes in precipitation patterns, higher occurrence of extreme weather events, and decreases in yields of other crops (IPCC, 2007). It is believed that poor people in developing countries will be particularly affected by such changes as their vulnerability to climate change impacts will be exacerbated by prevalent stresses, such as population increase, diseases (HIV/AIDS and other), current climate hazards and lack of access to basic services such as sanitation and clean energy (IPCC, 2007; Morton, 2007). Climate change is thus a direct threat to sustainable development in these countries.

To minimize the consequences of global climate change, the United Nations Framework Convention on Climate

* *Corresponding author*. Tel.: +55 11 4721 6032.
E-mail addresses: andre@lima.coppe.ufrj.br, afsimoes@usp.br, a.fsimoes@uol.com.br (A.F. Simões).
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Change (UNFCCC) has for a long time focused on mitigation of greenhouse gas (GHG) emissions. However, as GHG emissions trends currently follow those of the worst case scenarios of the IPCC (Richardson et al., 2009), researchers increasingly point at the urgent need to implement adaptation strategies in order to prevent large-scale adverse impacts in particularly vulnerable regions (IPCC, 2007; Pielke et al., 2007).

In Brazil, one of the most vulnerable regions to climate change is the rural semi-arid northeast. Adaptation strategies in this region have been primarily implemented through local development initiatives without clear integration into broader development or even climate change policies. Integration between these local experiences and national climate change strategies, however, could provide important synergies between the building of adaptive capacity and sustainable development practice and policies (Ayers and Huq, 2008).

In this paper, we present a concrete example of an initiative to strengthen the adaptive capacity of rural communities in the semi-arid region of Brazil. The ongoing initiative tries to link the issue of adaptive capacity with that of sustainable rural development in an initial stage of developing an adaptation methodology for smallholder farmers in that region. This paper discusses the main difficulties and achievements since project inception as well as its implications for climate change policy in Brazil and other developing countries.[1]

Accordingly, the remainder of this paper is organized as follows: Section 2 presents a brief review of the most important climate and socio-economic vulnerabilities in the semi-arid northeast of Brazil and discusses the links between adaptation, adaptive capacity and sustainable development. Section 3 then describes the selection and implementation process of the Pintadas initiative, before Section 4 concludes this paper with a discussion of the main findings.

2. Vulnerabilities in semi-arid northeast Brazil and the imperative for adaptation

2.1. *Climate and social vulnerabilities*

While there have been only few experiences with planned adaptation strategies to future climate change in Brazil, it is recognized that the semi-arid northeast is one of the most vulnerable regions in the country in terms of expected adverse climate change impacts and prevalent social vulnerabilities. This observation particularly applies to smallholder farmers in the region that have to cope with strong hydrological deficits (Carvalho and Egler, 2003; Marengo et al., 2007).

Agriculture in the semi-arid northeast is today already strongly limited due to low marginal sufficiency of rainwater (Krol and Bronstert, 2007). Recent research (IPCC, 2007; Marengo et al., 2007, 2009) indicates that this hydrological deficit will increase – either due to declining rainfalls or increased evaporation – if average temperatures in the northeast continue to rise due to climate change. In particular, the frequency of the droughts that affect the region may increase and result in or increase desertification processes (Marengo et al., 2007).[2] More frequent and intense El Niño Southern Oscillation (ENSO) years could further increase water deficits. As noted by Lemos (2007), extreme droughts occurred in northeast Brazil during the strong ENSO years of 1911–1912, 1925–1926, 1982–1983, and 1997–1998. Furthermore, there is a strong (>90%) likelihood that future regional summer average temperatures (i.e. temperatures in the growing season) will, by the end of this century, exceed the most extreme seasonal temperatures recorded from 1900 to 2006 (Battisti and Naylor, 2009).

Several recent studies (see Jones and Thornton, 2003; Lobell et al., 2008; Margulis et al., 2010) have addressed the question of how these increasing hydrological deficits may impact smallholder farming activities in Brazil. Although differing in their estimates, all authors report declining crop yields for subsistence crops such as beans, corn and manioc.[3] This is a particularly relevant result as current per hectare productivities are already very low in the Brazilian semi-arid smallholder agriculture (Margulis et al., 2010).

The identified climate vulnerabilities may affect about 2 million rural family farmer families currently living in the Brazilian northeast (INCRA and FAO, 2000), frequently under conditions of extreme poverty. Silveira et al. (2007) calculate that between 10% and 30% of the non-metropolitan and rural population in the northeast is considered to be poor or extremely poor, which is the largest share for Brazil (Silveira et al., 2007). Furthermore, access to basic services in this region remains very low (IBGE, 2007), so that fundamental preconditions for rural development are missing. Combined with recurrent droughts, these conditions aggravate and intensify the processes of rural exodus towards larger metropolitan centers, leading to precarious and disorganized land use and huge social problems in the latter. These processes are likely to intensify with climate change (NAE, 2005; Barbieri and Confalonieri, 2008).

2.2. *The Brazilian semi-arid as a climate change hotspot*

While it is clear that poverty cannot be strictly equated with vulnerability, it nevertheless strongly limits the ability to cope

[1] The present work was developed under SouthSouthNorth2 (SSN2), an international network of NGOs and academic institutions established to assist communities and municipalities in the design and implementation of climate change mitigation and adaptation projects that include sustainable development targets. The current paper synthesizes the methodology developed and used by the Brazilian SSN2 adaptation research team, and the results and conclusions here presented do not necessarily represent the opinions of all project partners and institutions. For more information about SSN2 see the project website at http://www.southsouthnorth.org.

[2] The semi-arid Northeast is already most vulnerable to desertification where new desertification areas have been found in the States of Piauí, Pernambuco, Rio Grande do Norte and Ceará (NAE, 2005).

[3] Jones and Thornton (2003) report declining corn yield of 25% by 2055 in semi-arid parts of northeast Brazil. Decreasing production yields for subsistence crops in Brazil are also projected by Lobell et al. (2008): rice, corn and cassava are estimated to have on average about 5% lower yields by 2030. Margulis et al. (2010) report losses up to 20–30% for beans, rice and corn in the semi-arid northeast.

with or adapt to climate change. Climate change may in fact accentuate or reinforce existing vulnerabilities and socio-economic inequalities (Adger et al., 2003) so that, taken together, climate and social vulnerabilities have a tremendous potential to adversely affect poor family farmers in the semi-arid northeast, especially as these – generally speaking – are assumed to have a low adaptive capacity with regard to such impacts (Adger et al., 2003; Morton, 2007).

A rapid appraisal to identify vulnerable regions to climate change is to simply overlay the percentages of poor people in a given region, taken from PNUD et al. (2003) and other relevant statistical sources on regional poverty, with relevant climate sectoral vulnerabilities (in the perspective of geographical localization of the most susceptible areas to the climate change).[4] This allowed for the identification of priority areas with overlapping social and climate change vulnerabilities, the so-called hotspots.[5]

By using this approach it becomes evident that the Brazilian semi-arid region is a hotspot for climate change adaptation: large rural areas are extremely vulnerable to interlinked and growing social and climate vulnerabilities, with access to water becoming a crucial question to be resolved if smallholder farmers in the region are to adapt to even less favorable climatic conditions in the future.

2.3. *Adaptation, adaptive capacity and development*

Adaptation describes longer-term activities that take into account the threat of environmental extremes or changes (Cutter and Mitchell, 2001) and is, whether analyzed for purposes of assessment or practice, intimately associated with the concepts of vulnerability and adaptive capacity (Smit and Wandel, 2006). Attributing adaptation to climate change, however, is not a simple process. Naturally, the uncertainties involved in the assessment and in its theoretical systematization (degree of vulnerability and adaptive capacity) are not less than the uncertainties involved in global climate projections (Adger and Vincent, 2005). This is particularly true for regional and local adaptation processes where, in many cases, no vulnerability mapping is available.

It is also difficult to separate climate change adaptation decisions or actions from other actions triggered by economic or social events (Adger et al., 2005). In developing countries, even the boundary between rural development projects and projects for adaptation to climate change for smallholder farmers is not clear or precise. There are dimensions of conventional rural development that cannot be overlooked when seeking the sustainability of such initiatives. Ayers and Huq (2008) raise this issue when proposing that "good (or sustainable) development (policies and practice) can (and often does) lead to building adaptive capacity. Doing adaptation to climate change often also means doing good (or sustainable) development." Finally, it seems obvious that adaptation to the marginal adverse impacts of climate change alone will not be sufficient to enable smallholder farmers to cope with their increasingly precarious livelihood, and would also be morally difficult to accept as non-climate stressors are currently responsible for much larger impacts on poor people in affected regions such as semi-arid Brazil (Pielke et al., 2007).

In spite of all uncertainties, it can be verified as axiomatic that the inhabitant of the semi-arid region has been suffering for a long time as a result of the natural variability of climate and everything indicates that this tendency will only get worse. Initiatives envisaged for this region are thus essential and urgent.

The case study presented in the following section was conceived within the theoretical background discussed here. As such, the experiment falls within categories (a) and (b) of adaptation projects proposed by the UNFCCC (2008),[6] linking the project to climate-proofing of current and future socio-economic activities as well as to adaptive capacity building within such activities.

In this context, the overall objective of the project can be summarized as the gradual development of a methodology for the implementation of an adaptation program for smallholder farmers in the semi-arid region, where the improvement of local adaptive capacity would be a first step in that direction. Only careful monitoring, as determined by adaptation indicators (another goal of the experiment), will eventually clarify exactly how the project can contribute to adaptation to climate change by smallholder farmers in that region, for example by providing information on necessary adjustments, strategic changes or additional actions.

3. Selection and implementation of the Pintadas initiative

3.1. *Basic principles and criteria used in the selection and design of the project*

In order to identify appropriate strategies for smallholder farmers to adapt to climate change in rural semi-arid areas of Brazil, the project based its approach loosely on the Adaptation Policy Frameworks (APF) (UNDP, 2004). Introduced in 2004 by the United Nations Development Programme (UNDP) on behalf of the Global Environment Facility (GEF), the APF is a set of guidelines for the development and implementation of

[4] Cutter et al. (2008) show that social vulnerability depends on a variety of factors rather than exclusively poverty. However, poverty and marginalization are considered to be "key driving forces of vulnerability" that "constrain individuals in their coping and long-term adaptation" (Adger et al., 2003, p. 182). Therefore, the rapid appraisal applied here is still useful as a starting point for identification of climate change hotspots.

[5] It should be noted that vulnerabilities have been identified based not only on peer-reviewed literature review (Jones and Thornton, 2003; Krol and Bronstert, 2007; IPCC, 2007; Marengo et al., 2007 and other), but also by review of gray literature and official reports as well as by conducting in-depth interviews with a variety of stakeholders, including smallholder farmers, government officials, and entrepreneurs.

[6] According to this proposal adaptation actions can be grouped into three broad categories: (a) Actions that climate-proof socio-economic activities by integrating future climate risk; (b) Actions that expand the adaptive capacity of socio-economic activities to cope with future and not only current climate risks; (c) Actions that are purely aimed at adapting to impacts of climate change and would not otherwise be initiated.

adaptation strategies. The APF aims to help countries to integrate adaptation concerns into the broader goals of national development and to support adaptation processes to protect and enhance human well-being in the face of climate change, including climate variability. The main steps of the AFP are:

1. Careful application of the scope of works and design processes.
2. Strong stakeholder participation: this requires an active and sustained dialogue among affected individuals and groups.
3. Assessing and enhancing adaptive capacity: this depends on the level of information regarding the current vulnerability of the country, but implementing the APF does not require an abundance of high quality data, or extensive expertise in computer-based models; rather, it relies upon a thoughtful assessment and a robust stakeholder process.
4. Analysis of adaptation to cope with current and future climate change.
5. A program to monitor, evaluate and improve the impact of the adaptation activity (UNDP, 2004).

For the present case, the project team made minor adjustments to APF requirements in order to facilitate project identification and implementation of regional adaptation projects, maintaining, however the major steps of the AFP process. The adapted methodology of the project is known as the *SSN Adaptation Project Protocol* (SSNAPP).[7]

Based on this methodology, nine potential adaptation projects were identified in climate change hotspot areas. The project's potential to contribute to poverty reduction and sustainable development was then considered (Ayers and Huq, 2008), followed by an evaluation of the project's feasibility. The SWOT methodology was applied in order to identify and assess the main Strengths, Weaknesses, Opportunities and Threats. Specific consideration was thereby given to projects which had the actual capacity of showing concrete results within 2 years, the time during which funding for the project partners was available.

From application of the APF/SSNAPP framework it was decided that the pilot initiative would be implemented in the community of Pintadas, situated in the semi-arid region of the Brazilian northeast about 300 km West of Salvador, capital of the state of Bahia. Increasing efficiency of water resource use for productive applications[8] via small-scale irrigation was identified by the project team as a potential strategy for smallholder farmer adaptation to climate change. Furthermore, the project design included strategies to increase and diversify family production (including horticulture) as means to generate income as well as build adaptive capacity of smallholder farmers in the region. As such, the initiative presented in this paper intends to take a step forward by optimizing water uses particularly for productive uses and thus going beyond pure subsistence needs.

3.2. *Project background*

Pintadas falls well into the picture of limited adaptive capacity to climate and social vulnerabilities: the entire municipality displays a strong hydrological deficit and poverty levels are very high (cf. Section 2.1). The main economic activity in the region is subsistence farming of mainly corn, beans and manioc – all crops that are generally resistant to drought but have shown low and decreasing yields, mostly due to lack of knowledge about best agricultural practices and adverse climate impacts in the region. Additionally, productive uses of water resources in agriculture and livestock raising are increasingly limited as a result of growing hydrological deficits, not only due to physical scarcity of water resources, but also due to ill-use of existing water sources (e.g. inefficient irrigation by water trenches or by hand).

Despite this picture Pintadas is also known as a privileged case. The community has a history of social mobilization and active leadership that is known well beyond municipality borders[9] which, added to the fact that the community embraced from early on the idea of efficient irrigation projects, greatly helped implementation of the project in Pintadas.

3.3. *Case study: the Pintadas project*

The initial stages of the Pintadas project, as developed by the Brazilian SSN2 team, consisted in irrigation optimization in a small farming community of the municipality. The actual field work (identification of needs, installation of systems, capacity building, contact with local stakeholders) was mainly carried out by a national NGO (REDEH, *Network for Human Development*) while scientific support was supplied by researchers from the Federal University of Rio de Janeiro (UFRJ). The technologies used aimed at improving the agricultural productivity of the selected family farms and serving as a demonstration model for other families in the region. Given the social and climate vulnerabilities found in semi-arid northeast Brazil, photovoltaic solar water pumps and drip irrigation systems were seen as an effective strategy to tackle poverty and adapt the region's communities to the impact of climate change. Benefits from irrigation, and such productive systems could, under the best circumstances, make the community more resistant to droughts and future climate variability, generating income, diversifying production, stimulating entrepreneurship and helping to maintain food security (Obermaier et al., 2009).

According to Adger et al. (2005), actions associated with building adaptive capacity can include communication of climate change information, build awareness on potential

[7] For more information on SSNAPP see SSN Capacity Building Team (2006) and SSN (2007).

[8] Given the expected climate change impacts in semi-arid Brazil, increasing water storage capacity, e.g. the construction of cisterns for human and animal consumption, is an initial step required for reducing vulnerability of small farmers. Such programs have been implemented in several regions of the semi-arid northeast (Hirschman, 1965; Carvalho and Egler, 2003). However, our evaluation has shown that under more severe droughts caused by climate change this is not enough for ensuring food security and income generation, which require the productive use of water, e.g. through small drip irrigation schemes.

[9] Again, the short time for project implementation (2 years) made it necessary to find partners with a strong level of social organization in order to facilitate its execution.

impacts, contribute to well-being and economic growth, and help exploit new opportunities. The project thus did not only focus on adequate technology provision (installation of *hardware*), but included significant capacity building and climate change education components (*software*). Furthermore, the Pintadas project also sought to provide for the organization of local and regional discussion forums involving politicians, representatives of universities and research institutions, equipment manufacturers as well as the proper smallholder farmers. The idea was to create and consolidate a network for the identification and dissemination of good practices for smallholder farming in the semi-arid region in the light of climate change. Such an integrated strategy for building adaptive capacity was expected to make the project more sustainable and thus its effectiveness as an initial step for creating an adaptation strategy for smallholder farmers in the region

From the early planning phase, the Pintadas efficient irrigation project was designed to expand into other regions of the semi-arid northeast. A partnership was established between REDEH, a local NGO, and Pintadas Women's Association. This partnership was instrumental in getting the SSN adaptation project underway. Several potentially viable areas in Pintadas were scouted for the pilot system's installation, and potential partners were selected based on predetermined criteria (e.g. low income, entrepreneurial spirit, youth and gender) to strengthen social dynamization. The precise technical design of each irrigation system was based on the specific needs of each beneficiary. Following this process, a total of seven efficient irrigation systems were installed on seven properties:

- 1 drip irrigation system with 1800 m^2 capacity and regulated nozzles, powered by a diesel pump;
- drip irrigation systems with 500 m2 capacity and automatic drip delivery. Three of these systems are powered by diesel pumps, and the other by a PV (solar powered) pump;
- 2 organoponic[10] systems with manual pumping (conventionally powered pumps are not needed for systems of this size since only 1000 liters of water per week are required).

Both organoponic and drip irrigation are technologically mature systems which can provide crop yield improvement while simultaneously requiring less water resources than conventional systems, making both systems extremely attractive for the semi-arid northeast.

In order to assess project progress farmers were directed to record information such as cultivated area, type of crops planted and number of irrigation-hours, weather conditions, productivity and income earned. While efforts were made to increase awareness among farmers on the importance of recording production and technical data, some participants gradually lost interest in doing so because they could not see the practical use of recording data. For that reason, the initial project assessment was based on only 5 months worth of data. Despite such limited information, the results nevertheless show that participating family farmers managed to earn additional monthly income ranging from R$ 60.00 to R$ 200.00,[11] or up to about half a minimum wage (IBGE, 2007). While such improvements may seem small, compared to the low average incomes in semi-arid Brazil they may constitute an important improvement in rural livelihood if the positive changes of the project can be maintained or even expand in the future.

The project presented has recently changed its name to *Adapta Sertão* [12] and has significantly widened its activities and regional scope based on substantial financing from the German Federal Environment Ministry under the International Climate Change Initiative (2008–2010). At this time, continuity of the project is secured via funding from CNPq, the Brazilian National Council of Technological and Scientific Development. The project's focus is now on monitoring smallholder famer activities in the region – especially during drought periods – with the specific target of seeking to systematize the results of the installed systems for a potential inclusion in future strategies to strengthen smallholder farmers against increasingly severe droughts. The project team is currently in dialogue with national government representatives (in particular the Brazilian Ministry of the Environment) regarding the potential dissemination of efficient irrigation systems on an experimental scale in the semi-arid region as part of a public policy, e.g. within the Brazilian National Plan on Climate Change or the National Program for the Prevention of Desertification.

4. Discussion and final observations

The Pintadas adaptation project – after the first implementation phase – is still under development. In addition to an increase in income due to surplus production being sold on the local market, data obtained from the field (before and after the project start-up) has shown an initial improvement in agricultural productivity as well as in diversity of production. Some participating families have become strongly conversant with the technology installed on their properties, as well as more aware of climate change and efficient water use issues. Three key factors for project sustainability have been identified:

1. Build awareness on current climate variability and future climate change and their potential impacts → induce farmers to monitor rainfalls and economic variables such as yields on their property, and to make use of more reliable information on climate variability and change.
2. Build capacity at local (community) level for technology diffusion and technical assistance → for smallholder farmers often relying on inefficient and obsolete agricultural practices.
3. Social dynamization as key factor for success → human resources formation for technological innovation and

[10] Organoponics is a system which uses compost or organic fertilizer to take nutrients to the roots, using very small amounts of water. It is an *efficient irrigation system*, in contrast to hydroponics' extensive use of water.

[11] In May 2010, R$1.00 was valued at approximately US$0.53.

[12] See project website at: http://www.adaptasertao.net for more information.

continued interest in project activities, focusing particularly on young and female participants as project multipliers.

In short, the project did not focus only on implementing adequate technologies (*hardware*), but to an even larger degree on building local capacity for introducing innovations and supplying technical assistance (*software*) as well as increasing the economic opportunities for participating farmers and thus also their self-interest and dedication to make the project a success. This included the integration of components such as teaching organic farming practices, help with commercialization channels as well as beginning courses on planning and implementation of irrigation systems for local technicians.[13] Therefore, the uniqueness of the project relies in the combination of the three factors above mentioned (climate change adaptation component, diffusion of small-scale irrigation techniques and social organization), associated with an innovative scheme of stakeholder integration (smallholder farmers, local communities, equipment manufacturers, technology providers, credit cooperatives, municipality government, NGOs, university researchers and financial institutions).

Adaptation strategies in the semi-arid region have been often implemented through local development initiatives without clear integration into development or even climate change policies. The Pintadas project is one of the first to link such ''unplanned'' experiences with adaptation to climate change issues, making the farmers in the region more conscious on expected future impacts.

Of course, all project results have yet to be analyzed with great care since the project started only recently. It is clear the ultimate success of the project will depend on whether the technological choices prove in fact to be adequate in front of climate change impacts, particularly regarding potential future droughts and related hydrological deficits. It is thus also too early to state that the approach adopted will effectively strengthen the adaptive capacity of farmers with regard to climate change. However, by focusing particularly on extensive project *software* provision it is believed that farmers can reduce their vulnerability to these impacts via income generation, diversification of production, stimulation of rural entrepreneurship, and better food security as well as simultaneously serving as potential example for other smallholder farmers in the region. The occurrence of the El Niño this year may provide interesting results for project effectiveness as rainfalls are expected to be below long-term averages in the project region.

The experiences with Pintadas have shown that adaptation within communities is an extremely difficult process. In the case of Pintadas, however, many potential problems and conflicts were avoided by providing information and technical assistance, while simultaneously bringing local stakeholders and municipality representatives to the implementation process.[14] However, even with such support, the need to address cultural skepticism, to build local capacity or repeatedly explain good agricultural practices and optimal irrigation methods in participative dialogues became evident.

It is clear that the question of adaptation to climate change must be viewed as more than a simple response to environmental emergencies or disasters. Many adverse climate impacts will take decades to come to full effect and therefore cannot be reduced to emergency-response scenarios. Furthermore, it is essential that government, society and companies establish and strengthen a dialogue on issues pertaining to climate change if policies are to succeed in reducing Brazil's vulnerability and increasing its adaptive capacity.

It will be necessary to improve knowledge about all the factors that comprise Brazil's vulnerability in relation to global climate change before a broad governmental policy aiming at minimizing adverse impacts caused by global environmental problems can be implemented. The magnitude of risks associated with climate change warns against inaction. No time should be lost in attaining full knowledge regarding regional impacts of climate change so that national policy measures on adaptation can be initiated and implemented.

In terms of social vulnerability and despite recent surveys pointing to a reduction in poverty (IBGE, 2007; Neri, 2008) large parts of the Brazilian population is still living in poverty, especially in the semi-arid northeast. It is precisely in these semi-arid areas that climate change is expected to produce its greatest impacts, due to the prospect of reductions in the frequency and intensity of the rains or increased evaporation due to temperature increases (Marengo et al., 2007, 2009). The Pintadas project idea, involving the introduction of efficient irrigation technologies, strengthening local capacity and raising climate change awareness, arose exactly as a response to the expected impacts of climate change in this region.

The effectiveness of adaptation strategies is related to two issues – assessing impacts and vulnerabilities, and developing response options. The project under consideration, being located in a semi-arid area, had water scarcity as one of its criteria; the response option, which took into account the badly managed water availability of the region, was the optimization of water resources through the use of more efficient irrigation systems such as drip irrigation and organoponics. However, what appears successful in the short term may turn out to be less successful in the longer term (Adger et al., 2005). Furthermore, the period of implementation of the Pintadas project is as yet too short to permit the drawing of conclusions about the full efficiency of the strategy involved or its extension over a larger scale since future local and regional water availability is still unknown.

Smit and Wandel (2006) highlight that for agricultural systems facing water shortage exposures; a simple adaptation might be to use more drought resistant cultivars. A more

[13] The current project stage involves the introduction of a revolving fund for project consolidation and possible expansion as well as the introduction of drought-resistant seeds for subsistence and energy crops. These issues will be discussed in a forthcoming publication of the authors.

[14] This observation is partly evidenced by the fact that the Pintadas pilot project has recently been selected as one of the five winners of the SEED award for Entrepreneurship in Sustainable Development (out of 400 projects), which explicitly praised the implementation process and the adaptation-development focus of the project.

substantial adaptation might be to shift away from crop farming to pastoralism. An even more substantial adaptation might be to abandon farming altogether. Seeing the semi-arid northeast as a great ''edaphoclimatic patchwork'' it becomes clear that the region as a whole needs to be better known, explored and analyzed regarding the particular vulnerabilities so that a consistent adaptation methodology can be developed according with each specific socio-environmental context. Mapping vulnerabilities to future climate change impacts more precisely and linking these to existent non-climate stressors will be essential for future strategy implementation.

Brazil has so far undertaken very few efforts on climate change adaptation, and what has been done is not yet sufficient in view of the sheer magnitude of possible large-scale climate change impacts. These impacts will not limited to the semi-arid regions or smallholder farmers, but include scenarios such erosion in densely populated coastal areas, biodiversity losses, health impacts in cities or losses in hydropower electricity generating capacity (Margulis et al., 2010).

These multiple facets of potential adaptive capacity and adaptation strategies will need to be considered. Based on the experiences from the Pintadas project, initiatives that combine poverty reduction and adaptation components may gain considerable support for mainstreaming into national policies due to local acceptance, while simultaneously providing an important component for regional development. Because of the multidimensional natures of resilience and adaptive capacity and inherent uncertainties (Adger and Vincent, 2005; Cutter et al., 2008), the expansion and continuity of regional pilot projects on adaptive capacity such as Pintadas will be essential so that problems can be identified and potential response strategies can be tested and assessed against social vulnerabilities as well as current and future climate variability.

Supporting concrete actions and bringing these to the mainstream can prove an important effort to alleviate poverty and minimize the adverse impacts of climate change for poor people, not only in Brazil, but also in other developing countries. The question, however, remains how implementation of similar activities could be achieved in regions that cannot rely on the efficient action of public authorities or that of reputable external entities. A proposal that aims to involve popular participation in such contexts, in the light of its implementation in Pintadas, deserves careful study of its purposes and of its acceptance by the participants (Maroun, 2007).

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André Felipe Simões has a B.A. in Metallurgical Engineering at Papal Catholic University of Rio de Janeiro - PUC/RJ (1994), Master's Degree in Metallurgical and in Science of the Material at Papal Catholic University of Rio de Janeiro (1997) and D.Sc. in Energy Planning at the Federal University of Rio de Janeiro - UFRJ (2003). Actually, he is Professor at the School of Arts, Sciences and Humanities of the University of São Paulo - EACH/USP. His experience is in Energy and Environmental Planning, mainly in Climate Change, Electric Power Universalization, Transportation Sector and Environment, Carbon Credits Market, Renewable Energies, Mitigation and Adaptation Alternatives, and Environmental Engineering.

Debora Cynamon Kligerman has a B.A. in Civil Engineering from the State University of Rio de Janeiro and a Master's Degree and D.Sc. from the Federal University of Rio de Janeiro (2001). She is a researcher at the Department of Sanitation and Environmental Health of the National School of Public Health of the Oswaldo Cruz Foundation, having experience in Sanitary Engineering, particularly Environmental Legislation related to environmental sanitation, public health, solid residue, environmental education, environmental administration, and adaptation to climate change.

Emilio Lèbre La Rovere has a B.A. in Systems and Industrial Electric Engineering at Papal Catholic University of Rio de Janeiro, B.A. in Economy and Master's Degree in Systems and Computation Engineering at the Federal University of Rio de Janeiro (UFRJ), and D.Sc. in Economic Techniques at École des Hautes Études en Sciences Sociales de Paris. He is Associated Professor of the Energy Planning Program at UFRJ, where he coordinates the Interdisciplinary Laboratory of Environment (LIMA) and the Center of Integrated Studies on Environment and Climate Change (Centro Clima).

Maria Regina Maroun has a B.A. in Mechanical Engineering and Master's Degree in Energy Planning at UFRJ (2007). Now she works in the Third Sector (OSCIP Popular Water Services), as president of the organization and is technically responsible for Socio-environmental projects. She has professional experience in consultancy of hydroelectric power stations projects.

Martha Macedo de Lima Barata has a B.A. in Actuarial Sciences at UFRJ (1983), B.A. in Economical Sciences at the Cândido Mendes University (1983), Master's Degree in Energy Planning and D.Sc. in Energy and Environmental Planning at the UFRJ. Now she is coordinating the Commission of Environmental Administration of the Oswaldo Cruz Foundation.

Martin Obermaier obtained his Master's Degree in Economics from the Freie Universität in Berlin. He is currently working on his PhD thesis at the Energy Planning Program of the Federal University of Rio de Janeiro in which he analyzes the problems of family farmer inclusion within the Brazilian National Program on Biodiesel (PNPB). His further research areas include rural electrification, climate change and social investments.