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Dryland adaptation in Northeast Brazil: lessons from a community-based pilot project

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Abstract. Family farmers in Brazil's semi-arid region (the Sertão) are highly vulnerable to climate change. In this context, the community-based Adapta Sertão ("adapt Sertão" or "adapt the Sertão") pilot project aims to strengthen the adaptive capacity of such families in the region of Pintadas, State of Bahia, through integration of immediate livelihood needs with community empowerment and market-based incentives. This short paper discusses the project's main components, its results and constraints since implementation in 2006. The project is found to have contributed to rural livelihood improvement of its beneficiaries, especially where related to local capacity building. However, the impacts of the strongest drought recorded in the last 50 years continue to affect beneficiaries. CBA in semiarid Brazil may thus need to interact more broadly with those public policies, plans and programs help reduce vulnerability to climatic, social, environmental and economic stressors in general, in order to help family farmers better to sustainably adapt to future climate change.

Keywords. Agriculture, Climate change, Livelihood, Drought

1. Introduction

1.1 Vulnerability to climate change in semi-arid Northeast Brazil

Family farmers in semi-arid regions worldwide are highly vulnerable to climate change (IPCC, 2007). The Brazilian semi-arid Northeast region (the *Sertão*) is not different from this perspective: farmers in the region have to cope with unreliable and concentrated rainfalls (3 to 4 months), high evapotranspiration levels and recurrent droughts (Carvalho and Egler, 2003). Furthermore, extensive livestock raising, slash-and-burn agriculture, and uncontrolled demand for woodfuel have led to widespread environmental degradation of its unique *Caatinga* biome (40% or 294 mil km^2 of the original area). This includes soil erosion, desertification, fragmentation of forest covers and biodiversity losses (Gariglio et al., 2010). According to climate scientists, these processes will be increasingly affected under future climate change, leading, among other, to more frequent and severe droughts (Marengo et al., 2009).

At the same time, family farmers in the Sertão region suffer from structural poverty and discontinuous and uncoordinated public policies. 30% and 10% of its rural population live in conditions of poverty or extreme poverty, respectively, turning the rural NE into Brazil's poorhouse (Silveira *et al*., 2007). Lack of access to markets or microcredit, exclusion from political processes and inadequate agricultural practices (linked to a lack of technical assistance in general) limit rural livelihoods in the Sertão further (Lemos, 2007; Obermaier, 2011). Lack of rural entrepreneurship is also part of the problem: even where farmers are willing to invest, private firms often detain the monopoly of sales for irrigation and other production technologies, and operate in distant urban centers. This greatly affects dissemination of adequate agricultural technologies.

Despite this unfavorable context, there is also a significant potential for family agriculture. There is a long history of infrastructure works aimed at conveying ephemeral streams into artificial water reservoirs, so-called *açudes*. These reservoirs are often sufficient for irrigated agriculture (Carvalho and Egler, 2003; Hirschman, 1963), but inefficient irrigation practices at farm level such as irrigation by hand or small water trenches (known as "*irrigação de salvação*" or salvation irrigation) yet put considerable burdens on farmers. Otherwise, there is also a high potential for non-irrigated agriculture. This includes the adoption of appropriate cultivars for the semi-arid climate, use of selected seeds for subsistence farming (including native fruit plants from the highly endemic Caatinga) as well as dissemination of good agricultural practices.

1.2 Opportunities for community-based adaptation (CBA)

Community-based adaptation to climate change (CBA) aims to address the myriad of social, environmental and economic problems through community-led processes that are "based on communities' priorities, needs, knowledge, and capacities", and thus contribute to farmers' capacities to reduce their vulnerability to climate impacts and existing structural deficits. Hereby, climate change is considered to be only "one of a range of natural, social, and economic problems that poor people may face" (Reid et al., 2009). In order improve rural livelihoods in this context, CBA often focuses on enhancing family farmers' adaptive capacities, i.e. their asset base from which they can make appropriate adaptation actions and investments (Adger and Vincent, 2005).

Of course, family farmers in the Sertão have been coping with, or adapting to, adverse climate and socioeconomic conditions since the earliest days of its colonization (Obermaier, 2011). However, these adaptations can hardly be called sufficient given the continuing high vulnerability of farmers – instead, CBA may be an alternative approach that is more adequate for the context of the Sertão. Given the enormous challenge of climate adaptation in the semi-arid NE of Brazil, a project team consisting of Centro Clima (a university research institute linked to the Federal University of Rio de Janeiro, UFRJ) and REDEH (Human Development Network, a nonpartisan, civil organization working to promote human development and equality among gender, race and ethnicity) thus started *Adapta Sertão* pilot project ("adapt Sertão" or "adapt the Sertão" in English translation, or short AS) in 2006 in the municipality of Pintadas, State of Bahia.

The AS project was initially conceived in 2006 as a communication strategy under the name Pintadas Solar to disseminate solar PV-based water pumps to family farmers, but soon developed into a more holistic approach for climate adaptation. This includes:

1. Enhancing the adaptive capacities of family farmers through appropriate technological modernization and pro-poor market integration
2. Support the development of a systematized CBA approach (for mainstreaming into public policy planning in Brazil's semi-arid region)

This paper shows how, and to what degree AS has been able to achieve its objectives up to today. Accordingly, section 2 presents a background on the project region and its methodology. Section 3 presents the project results, and section 4 obstacles that remain to be overcome. Section 5 closes this paper with the final remarks.

2. Geographical and socioeconomic context

The AS project was started in the municipality of Pintadas, Jacuípe river basin, some 300 km West of Salvador, the capital of the state of Bahia (figure 1). Pintadas lies in the semi-arid interior of Bahia and falls well into the picture high vulnerability to climate change: the entire municipality displays a strong hydrological deficit and poverty levels are very high. The main economic activity in the region is livestock raising and subsistence farming of mainly corn, beans and manioc – all crops that are generally resistant to drought, but have shown low to decreasing yields. Lack of knowledge about good agricultural practices and increased physical water scarcity in the drought-prone region are partly responsible for this. Local daily wages for rural workers in Pintadas vary around only US$ 9 to US 12, but average monthly family incomes in the rural parts of Bahia are usually even lower (US$ 200 or below).

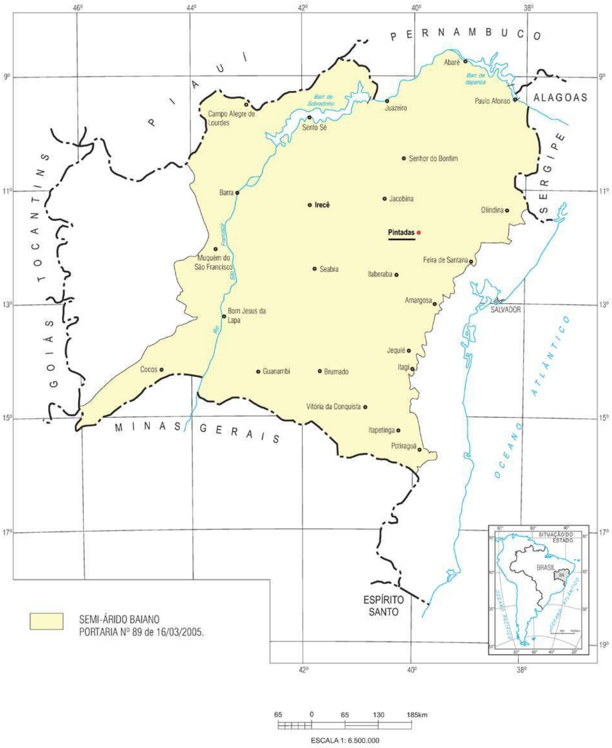

Figure 1. Map of the project region

Source: Superintendência de Estudos Econômicos e Sociais da Bahia (SEI). Pintadas is underlined and marked with a red dot.

Despite this picture, Pintadas is also a privileged case. The community has a history of social mobilization and active leadership that is known well beyond municipality borders. A local network (*Rede Pintadas*) that integrates organizations linked to women's rights, the church, youth culture and farmer associations has over decades created an environment that contributes to poor people empowerment, and which is also open for experimentation. In fact, many of the main actors linked to Rede Pintadas have been, or are still, linked to the prefecture (Fisher and Nascimento, 2003), and this organization has been very conducive to successfully implementing the AS project over a short time period.

3. Project results

3.1 Development of a systematized CBA approach

The AS project activities were planned to increase local capacity to deal with droughts and improve livelihood conditions. In the initial meetings, farmers identified lack of access to efficient irrigation technology, modern and applied agronomic knowledge and commercialization channels as key constraints. The project team then presented different economic and technological options that were first to be tested at pilot scale, before being approved and embraced by the larger community. While this approach may be perceived as a top-down approach for CBA, all project partners discussed all options openly and decided upon all actions jointly. In fact, given the complexity of some technological systems it was deemed necessary to first include relatively well capacitated beneficiaries for the test phase. At later project stages, the project focus then switched to transferring the newly generated knowledge to other farmers. In this process, project ownership was also gradually transferred to the local community.

Figure 2. Drip-irrigation system run by a female family farmer, Pintadas. *Foto by M. Obermaier*

The AS project can be divided into three distinct phases (see table 1). From early planning stages, the Pintadas project was designed to expand into other regions of the semi-arid NE. Therefore, careful attention was to be given to identify those factors which could turn the pilot phase into a long-term sustainable project. Potentially viable areas in Pintadas were sought for pilot system installation and potential partners were selected based on pre-defined criteria (among other: low income, entrepreneurial spirit, young and female[1]).

Table 1. Project phases and development of the AS project

First project phase (2006-2008)	Implementation of pilot project: 1 drip irrigation system with 1,800 m2 capacity, run by a diesel pump 4 drip irrigation systems with 500 m2 capacity and automatic dripping. 3 of the systems run with a diesel pump, and 1 with a PV pump 2 organoponic systems run by manual pumps (conventional pumps are not required as only 1,000 l of water per week are required at this system size) Initial monitoring and testing of drought-tolerant crop varieties
Second project phase (2008-2010)	Expansion to further three municipalities and start of project dissemination strategy: Installation of 38 irrigation systems benefiting circa 30families in four municipalities (average of 6 people per family) Capacity-building of farmer cooperatives in Pintadas to act as technology retailer (in order to give continuity to diffusion of low-cost appropriate technologies after project termination) Implementation of revolving fund in cooperation with a local credit cooperative (funds are generated through payback of system costs by farmers) Monitoring and economic feasibility analysis continued Development of communications and branding strategy for products produced by beneficiaries (to aggregate value and increase access to new markets)
Third and current phase (2010-to-day)	Further expansion of AS to 15 municipalities in the Pintadas region, including: Continued monitoring and evaluation to measure project impact New 150 system installations (not limited to irrigation systems) Meteorological stations to provide climate data to family farmers Development of silo storage systems for periods of drought (strategic reserves and sales in periods of greater profitability) Selective reforestation of watercourses and dams with fruit trees Logistics for milk production in order to link milk production to regional markets and increase profitability

[1] Young and female beneficiaries are often more interested in low-cost incremental technological change and the livehood improvements that can be derived from these. This may be because they are more interested in changing their immediate environment (young) or feel more responsible for their family and household budget constraints (women).

The exact technical design of each technological system was then based on the necessities of each beneficiary. Furthermore, farmer participation was based on their commitment to the project's objectives and financial contribution – technologies and technical assistance were sold in a kit, and would have to be paid back according to a previously agreed financial plan (based on preferential interest). This step is necessary in order to guarantee commitment and project ownership of the participants. To assess project progress, farmers were directed to record information regarding their activities, such as cultivated area, types of crops planted, number of irrigation-hours, weather conditions, productivity, and income received.

Up to today AS has tested several technological kits and has identified four technological arrangements for irrigation that seem to fit the needs of most small farmers living in the region. The arrangements are mainly based on drip irrigation systems that come in four different sizes: 500 m^2, 1,000m^2, 5,000m^2 and 10,000 m^2 (see example in figure 2). This approach allows for eventual system scaling-up based on the farmer's needs and potential. Early irrigation systems were largely of smaller size in order to allow farmers to accustom themselves with the technology first. Each kit is proposed to support multi-production of grains (corn and beans), fruits (mostly guava, papaya, water melon, citrus), vegetables (all types), and animal feed to increase milk production (sweet sorghum, sugarcane and high yield pasture).

Depending on the size and topographical characteristic of the area, two main types of water pumps are used: diesel and electric.[2] Solar PV pumps were initially tested, but high per unit costs make this alternative economically unviable compared to diesel and electric alternatives. Agricultural systems were also designed to be less environmentally harmful. This included the use of agroecological practices and awareness raising on scarce soil and water resources, their susceptibility to pollution, dangers of use of agrotoxic fertilizers, chemical herbicides, unconfined pasture, deforestation and environmental degradation in general. For example, farmers are asked not to deforest by emphasizing that the number of animals on a property is not proportional to its profitability, but that agricultural activities must be dimensioned on grounds of the availability of raw materials to supply a balanced diet for all animals.

Later project stages focused on technology and knowledge dissemination to other municipalities, while simultaneously increasing the scope of the project, particularly regarding the integration of market and finance access, continued monitoring and evaluation (necessary as climate change adaptation addresses long-term concerns) and a more refined strategy for making available climate data for family farmers (currently under development).

The actual field work (identification of needs, installation of systems, capacity building and contact with local stakeholders) was initially carried out by REDEH, but was then transferred to the local project partners, in this case local farmer cooperatives and associations. Regional research institutions such as the government Brazilian Agricultural Research Corporation (EMBRAPA) are additional partners that help in the selection, use and testing of drought-resistant native varieties for the production.

The project also integrates several innovative government programs for family farmers. This includes the national Food Acquisition Program (PAA) and School Alimentation Program (PNAE) that purchase food from family farmers (directly or through their associations) at guaranteed prices and without competitive bidding in order to supply local populations in situation of food insecurity and to build up food stocks (CONSEA, 2009). Furthermore, farmers also benefit from the Brazilian microfinance program PRONAF and Brazil's conditional cash transfer Family Fund Program (*Bolsa Família*) that provides small but relevant income transfers to families in poverty. In general, these programs, established to relieve rural poverty in the country, contribute to reducing family farmer vulnerability to climate change (Obermaier, 2012).

3.2 Enhancing family farmers' adaptive capacities

Responses by family farmers to AS have been largely positive. The project has been accepted by the local farmer community given its focus on existing economic, natural and socioecological barriers, and not just more abstract future climate change adaptation. Nevertheless, initial success rates have varied considerably among participants:

- About 30% of beneficiaries clearly benefit from their systems as evidenced by increased income and reduction in harvest losses.
- About 40% of beneficiaries do not make losses but also do not yet show clear improvements compared to their initial situation. This is assumed to be partly due to incomplete monitoring data. In addition, some families do take longer time to assimilate new technologies and practices, and hopefully will move to the group benefitting from the project in short- to medium-term.
- About 30% do not benefit from the implementation, either due to lack of understanding, insufficient efforts or interest to make the systems work, or due to problems unrelated to the project, for example alcoholism, other social problems such as migration due to loss of family member

Based on this information, the following paragraphs summarize the preliminary results on income generation, food security and community empowerment, all essential components for adaptive capacity.

It is clear that current climate variability already limits agricultural production by family farmers in the semi-arid NE. Farmers usually seed their crops just before the rainy season in the period (October–February). However, evidence from interviews and monitoring data indicates that rain patterns have started to change, provoking uncertainty and fear among farmers. Increases in temperatures have been recorded by

[2] Due to the National Program for Biodiesel Production and Use (PNPB), all diesel sold on the Brazilian market is mixed with 5% biodiesel. Therefore, all diesel pumps installed through the project also have a renewable component.

Table 2. Profitability of irrigation systems for seven family farmers in Pintadas (US$)

		F1	F2	F3	F4	F5	F6	F7
System cost		1,553	1,722	5,485	5,337	1,978	3,817	1,193
Revenues	2010	1,123	920	2,357	2,453	1,859	1,154	500
	2011	0	117	47	1.140	675	11	68
Expenses	2010	316	22	396	958	198	652	54
	2011	35	0	111	442	44	37	0
Total (revenues - expenses)		772	1,015	1,897	2,194	2,292	477	514
Monthly income*		96	78	172	183	208	53	43

* Counts only those months where the family did use the irrigation systems.

some farmers, so that new and better adapted crops varieties will have to be planted to survive longer drought periods and higher temperatures. The technological systems (particularly efficient drip irrigation) address these concerns directly by making farmers less dependent on increasingly concentrated and uncertain rainfalls (in terms of intensity and duration), thus in principle reducing their vulnerability to drought.

However, dry weather conditions in 2011 marked the beginning of a very severe (and still ongoing) drought in the region. This drought, which is now considered to be the most severe drought that occurred in the NE during the last 50 years (Stauffer, 4 January 2013), has reduced project-related irrigation activities strongly (see table 2). In the absence of other activities, reducing vulnerability to drought (and thus climate change) through technological modernization may thus be limited to smaller scale temperature increases, but not extreme events that deplete local water resources.

Of course, events like the current drought also directly affect food security and income generation. Where successful, irrigation has contributed to growth in agricultural productivity. This means that farmers have more crops to use for their subsistence and to sell to local and regional markets, which, in general, also leads to income increases. Preliminary results – on monitored properties – have shown that crop losses without irrigation are in the range of 70% to 90% on the average, implying that farmers in the region manage to harvest only 10% to 30% of their potential. Irrigation systems, not surprisingly, showed lower crop losses in the order of 10% to 30%, however only during normal dry periods. Furthermore, farmers tend to diversify their agricultural activities with irrigation, which can increase their resilience to adverse climatic impacts. Nevertheless, these results vary considerably with each farmer, his skill and dedication to the project activities, microclimatic conditions, and availability and quality of land.

Table 2 shows the revenues from irrigation for seven farmer families (F1 to F7) with irrigation systems. The data refers only to the results for irrigated plots, including the sale of vegetables and fruit. All other incomes are excluded.[3]

Based on the information in table 2 the drought impacts on revenue streams are clearly visible. Except for two farmers (F4 and F5) all beneficiaries show very low incomes in 2011 (beginning of the extreme drought), with three actually suffering small losses. (To the contrary, in 2010, all farmers still showed net income gains between US$ 446 to US$ 1.961.) In fact, monthly average incomes for 2010 and 2011 (last line of table 2) continue to be below average regional rural incomes (US$ 200) or the Brazilian minimum wage (US$ 338), so that participating families require other income sources to complete their income. In this context, originally calculated system payback times (3 to 4 years) are clearly impossible for family farmers, meaning that their monthly repayments for the technology kits had to be temporarily suspended.

As such, the project seems yet to have been more effective in building local expertise regarding technology implementation (e.g. allowing local cooperative members to plan and install complex irrigation systems) and management, although farmers have also enhanced their capacities by learning new technologies and agricultural practices. This highlights the socioeconomic functions of new technologies in climate adaptation: first, project beneficiaries may realize higher yields during droughts compared to other farmers with no irrigation. Second, farmers may use savings made during normally productive years to protect themselves against the impacts of droughts.

In this regard, dissemination of appropriate technologies and agricultural practices through market-based instruments has been a component where the project has made progress. In a participatory process, local farmer associations or cooperatives have been capacitated to become retailers and technical assistance providers for production technologies and inputs such as irrigation systems, water pumps or drought-tolerant seeds. The systems are now designed and implemented by the cooperatives' technicians and go to the farmers at a considerably cheaper price as contracts with the technology manufacturers guarantee cooperatives to become local distributors, thus eliminating any middlemen. Farmers themselves receive funding to implement their systems from available local and federal micro-credit schemes. The advantage of relying on local cooperative or farmer association members for this is that they often have the trust of their farmer associates, and that they are more responsive in case of technological problems in the municipality. Furthermore, through this mechanism the local cooperatives can realize small but important incomes to pay the technicians and cover operational costs, as they can put small markups on the technological kit prices. In another line, the local cooperative in

[3] This excludes other incomes not directly related to AS activities, including income from selling milk and non-irrigated products, non-farm activities or pensions and cash transfers.

Pintadas has also started to help farmers access local markets by setting up a market stall with 40 associates at the city's weekly market, and by selling farmers' produce through the recent PAA and PNAE programs.

4. Obstacles and solutions

Despite progress, several barriers continue to affect the project outcomes. As noted above, while the irrigation systems allow for new revenue streams under normal dry weather conditions, the beginning extreme drought in 2011 strongly affected irrigated and non-irrigated production. These outcomes may greatly affect farmers' motivation to adopt new technologies and practices – although this is difficult to measure. Integrating CBA activities with public disaster risk reduction strategies and broader structural changes related to sustainable poverty reduction – i.e. activities largely beyond a pilot project's scope – thus will likely be necessary in the longer run to guarantee a more sustained vulnerability reduction to climate change in the Sertão.

Due to lack of organized and regularly recorded data, the project team continues to have difficulties to draw robust conclusions on the effectiveness and long-term sustainability of project activities. While the AS project adopted a participatory approach with specific workshops to design a monitoring system, it was not easy for farmers to undertake this task, particularly as they could not see how they would benefit from such action. In many cases, the data recorded was incomplete, requiring substantial review, or were recorded with several days of delay, bringing "perceptions" and "memories" into the data. In order to alleviate these problems, local technicians have now been hired just for the purpose of registering data over a selected number of properties. This seems to be the only approach under which monitoring can work for the moment. Additional financing for these activities has been made available through two small-scale research grants from the Brazilian National Council for Scientific and Technological Development (CNPq) and the Climate & Development Knowledge Network (CDKN).

Another problem relates to technology management. The selection of the adequate systems, installation, maintenance, and technical assistance was hampered initially as the AS project was to handle these activities over to local cooperative technicians. Predictably, more difficulties arose where this personnel was formerly untrained (e.g. without a formal degree as agronomic technician). However, ongoing capacity building courses for technicians have reduced these constraints significantly. Ideally, technical assistance provided in CBA will find a mix between integrating qualified agronomists and local technicians, with the latter taking over these activities at local level at some point in time, integrating both the dissemination of new appropriate agricultural technologies and practices while also reducing barriers at farm-level to incorporate this knowledge into daily farming practices.

A final constraint for sustainable expansion of the project activities is the lower social organization (or level of empowerment) outside Pintadas. As noted above, the history of Pintadas in particular for the Sertão in terms of local empowerment, and these conditions cannot be assumed for other municipalities. It is believed that the experiences of the project and Rede Pintadas can serve as a good example for other municipalities facing similar problems with regard to climate change impacts. The approach adopted by the project – to strengthen community leadership and cooperativism independently of often unreliable and swiftly changing political favors – may contribute to this process. In some cases there are already encouraging results: for example, in several municipalities new market channels for products produced by farmers have now been implemented by local cooperatives, including product branding strategies. This not only contributes to income generation but also local capacitation.

5. Discussion and future steps

Adaptation to climate change has become a hotly debated topic throughout the past few years. The poorest of the poor are predicted to carry most hardship of the expected impacts, but they are not those responsible for the problem. In this context, CBA projects like AS aim to reduce vulnerability to climate change by integrating livelihood improvements with more specific climate adaptation components. So far, in spite of its limits, the project has had success in both contributing to the enhancing of adaptive capacities of family farmers in the project region (objective 1), as well as in its contribution to a more systematized adaptation approach in the NE, particularly related to CBA (objective 2). Benefits in relation to reduced vulnerability to drought are measurable under normal dry conditions, but the extreme drought in the past two years has reduced income generation and thus also early gains in food security. Furthermore, for several farmers the project approach seems to be less adequate, highlighting that even within communities priorities, needs, knowledge, and capacities often vary considerably. In other words, there is no "one size fits it all" for climate adaptation in poor rural dryland areas.

CBA approaches also need to be discussed in the context of ongoing development efforts in the semi-arid region of Brazil. Living conditions in the region have increased steadily in the past decades, and so have livelihood options for family farmers. Public jobs, temporary or permanent migration, government transfer programs, jobs in the private sector, or old age pensions complete the complex picture of rural livelihoods for many families today. In fact, many rural families today engage in off-farm activities or migrate, thus minimizing their climate risk – including to climate change. In the light of recent extreme events, CBA in semiarid Brazil may thus need to interact more broadly with those public policies, plans and programs help reduce vulnerability to climatic, social, environmental and economic stressors in general, in order to help family farmers better to sustainably adapt to future climate change. CBA is thus not a fixed concept, but a process where scale and scope of adaptation activities are flexible as climate and society change.

Current expansion of the AS project continues to rely on public funding giving the difficulties to integrate bottom-up initiatives into public policies. This poses a considerable challenge for future similar projects. However, by providing an impetus for the development of local market development

– including in technology dissemination – the project's approach incentivizes both farmer and cooperative alike, and this may make the project activities more sustainable, even when funding runs out.

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References

Adger, W.N. and K. Vincent (2005), "Uncertainty in adaptive capacity". *C. R. Geoscience*, Vol. 337, pp. 399–410.

Carvalho, O. and C.A.G. Egler (2003), *Alternativas de Desenvolvimento para o Nordeste Semi-árido*, Banco do Nordeste, Fortaleza.

CONSEA (2009), *Building up the National Policy and System for Food and Nutrition Security: the Brazilian Experience*, CONSEA, Brasília.

Fisher, F. and A. Nascimento (2003), "Projeto Rede Pintadas", in: Lotta, G.S., Barboza, H.B., Teixeira, M.A.C., Pinto, V. (eds.), *20 Experiências de Gestão Pública e Cidadania*. Programa Gestão Pública e Cidadania, São Paulo.

Gariglio, M.A., Sampaio, E.V.S.B., Cestaro, L.A., Kageyama, P.Y. (eds.) (2010), *Uso Sustentável e Conservação de Recursos Florestais da Caatinga*, Serviço Florestal Brasileiro/Ministério do Meio Ambiente, Brasília.

Hirschman, A.O. (1963), "Brazil's Northeast", in: *Journeys Toward Progress: Studies of Economic Policymaking in Latin America.* Twentieth Century Fund, New York, pp. 11–92.

IPCC (2007), *Climate Change 2007*, Cambridge University Press, Cambridge.

Lemos, M.C. (2007), *Drought, Governance and Adaptive Capacity in North East Brazil: A Case Study of Ceará*, Human Development Report Office Occasional Paper 2007/50, http://hdr.undp.org/en/reports/global/hdr2007-8/papers/Lemos_Maria%20Carmen.pdf

Marengo, J., Jones, R., Alves, L.M., Valverde, M. (2009), "Future Change of Temperature and Precipitation Extremes in South America as Derived from the PRECIS Regional Climate Modelling System", *International Journal of Climatology*, vol. 30, pp. 1–15.

Obermaier, M. (2011), *Velhos e Novos Dilemas nos Sertões: Mudanças Climáticas, Vulnerabilidade e Adaptação no Semiárido Brasileiro*, PhD Thesis, Universidade Federal do Rio de Janeiro, Rio de Janeiro.

Obermaier, M. (2012), *Brazil's Public Policy Package for Successful Farmer Adaptation*, ELLA Policy Brief, Practical Action, DFID, Lima, http://ella.practicalaction.org/

Reid, H., Alam, M., Berger, R., Cannon, T. et al. (2009), "Community-based Adaptation to Climate Change: An Overview", *Participatory Learning and Action*, vol. 60, pp. 11–33.

Silveira, F.G., X.X.Y. Carvalho, C.R. Azzoni, B. Campolina et al. (2007), *Dimensão, Magnitude e Localização das Populações Pobres no Brasil*, Texto para Discussão 1278, IPEA, Brasília.

Stauffer, C. (4 January 2013), *Worst drought in decades hits Brazil's Northeast*, Reuters, www.reuters.com/article/2013/01/04/us-brazil-drought-idUSBRE9030HM20130104