Chapter 4
Adaptation Strategies to Face the Effects of Extreme Hydrometeorological Events on Agricultural Systems

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Introduction

In many Latin American countries most rural low-income population live in exposed and marginal areas (e.g., flood areas, hillsides, arid or semi-arid zones), which puts them in risk of facing the negative impacts of climate change and especially to extreme hydrometeorological events (EHEs; UNISDR 2013). There is clear evidence of ongoing changes in rainfall patterns in South America (Haylock et al. 2006).

For these people, even minor changes in the climate can have a disastrous impact on their livelihoods. The impacts can be intense for subsistence farmers located in fragile environments, where major changes in productivity are expected. These farmers are greatly affected by changes in the normal climate pattern.

The processes of environmental degradation of the agricultural sector contribute to the vulnerability in the face of the effects produced by EHE (CATIE 2010). Such vulnerability is caused by the lack of environmental awareness among farmers, the poor access to land and funds, the scarce investments in infrastructure and the irregular occupation of the soil (CEPAL 2009).

There have been few studies documenting farmers' reactions in the presence of EHE in South America (Torres et al. 2009). Local perceptions on climate risk and impact, as well as the profile of the lifestyles at local scale, can contribute to assess vulnerability and resilience in the context of climate change (Di Falco et al. 2011).

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The emblematic cases may be chosen based on the recurrence, the effect on agricultural production and population, and the response (positive or negative) of the authorities and/or the community, which may be an extreme flood or drought. The central point is to gather information and assess how effective the measures have been taken by the authorities and the farmers to generate further information for decision makers who must face similar phenomena.

Thus, an analysis based on aspects of social and natural capital is necessary to propose effective adaptation measures. Identifying how farmers face EHE, what the main impacts of the event on farming systems are, and, especially what the strategies adopted by farmers are, can help to extract lessons learned that may contribute to the proposition of effective adaptation measures.

Within this context, the purpose of the study was to identify how decision makers deal with situations of extreme weather and what are the aspects that reduce or increase the vulnerability of local farmers in the face of such impacts. This research was conducted in five Latin American countries: Argentina, Brazil, Colombia, Chile and Ecuador. This paper presents the results of Brazil's case study.

Brazil has recently registered EHE, such as droughts and intense floods. These events resulted in heavy losses in the agricultural sector, the supply of water and food, health care and the economy in general (Rittl 2012). Historically natural disasters related to heavy rains in the summer period have been recorded in southeastern Brazil. In this region, the main phenomena related to natural disasters are related to heavy rains, causing floods, landslides, deaths and economic losses. In the southeastern region heavy rains led to floods and landslides in 2008, 2009 and 2011. There is an increasing trend of disasters caused by floods in recent decades, mainly due to the use and disorderly occupation of lands (Tominaga et al. 2009).

The State of Rio de Janeiro is located in southeastern Brazil. Rio de Janeiro state contains several patches of the Atlantic Forest biome, which has its native forest cover highly fragmented or restricted to small portions of land due to successive land use cycles and the pressure exerted by population growth (Rodrigues and Gandolfi 2004). The mountain region of the State of Rio de Janeiro is the most important site of agricultural production, mainly of vegetables, due to the proximity to the City of Rio de Janeiro, a large market. On the other hand, the mountain region of Rio de Janeiro is also one of the most vulnerable in the state. The pressure of rapid population growth in the region, the hilly terrain, the use and occupation of disordered soil associated with the predominance of low-productivity agriculture, mainly horticulture, makes it highly vulnerable.

This study presents lessons learned that contribute to propose effective measures to forward adaptation. Therefore, we analyzed the main impacts on agricultural systems, the strategies adopted by farmers, their achievements, difficulties and the changes adopted to deal with the EHE by the rural community of Barracão dos Mendes, situated in the City of Nova Friburgo, in the mountain region of Rio de Janeiro State. This paper also presents a brief analysis of the aspects of governance, the special laws and regulations to deal with the impacts of extreme weather events on local, regional and national levels.

Methodology

This work is part of a regional research project funded by the Inter-American Institute for Global Change Research through the Seed Program Projects (TISG-II). This Institute promoted two colloquia on knowledge integration in the interface between science and politics, during which it was possible to form a network of experts in the field of environment and rural development. These colloquia resulted in a project called "Lessons learned in dealing with the effects of extreme weather events in ecosystem services and agricultural systems in Latin America" (Argentina, Brazil, Colombia, Chile and Ecuador).

For the development of this project five case studies were chosen. Each case study was selected according to two criteria: the work of the researchers involved in the project and the occurrence of extreme weather events of major proportions that affected the agricultural sector in each Latin American country participating in the project. The case studies are: in Argentina, 'Floods and droughts in agro-ecosystems of wetlands in the Lower Paraná Delta'; in Brazil, 'Floods in the mountain region of Rio de Janeiro state'; in Chile, 'A country of contrasts experiences dry times'; in Colombia, 'Floods and Droughts, a challenge for Colombian agriculture'; and in Ecuador, 'The Ecuadorian coastal farmer reaction to floods and droughts'.

In this chapter, the results of the Brazilian case study will be presented, specifically in the rural community of Barracão dos Mendes, located in Nova Friburgo municipality, in the State of Rio de Janeiro. This region is one of the most important sites of agricultural production, mainly of vegetables, and also one of the most vulnerable in the state.

The technique to map actors (Gutiérrez 2007; Gondim 2002) was used to identify the key players and understand the plot of social relationships in the study site. The analysis was based on the case study that characterizes and describes the experiences of different actors and social groups in the occurrence of EHE in the agricultural sector. Thus, the events were described, initially based on primary sources (interviews with farmers and technical and policy-making agencies) and secondary sources (databases, scientific articles, official reports, press releases, etc.).

To develop the study case, we carried out a general characterization of the study area (Barracão dos Mendes) and of the EHE that occurred in the mountain region (in January 2011). Interviews with previously selected family farmers took place in the rural communities of Barracão dos Mendes on 18 and 19 November 2013. The interviews took place in a free format; however, property and production system data, the main impacts of the EHE, the aid measures received by the farmers and the lessons learned from their point of view were registered.

The lessons learned drawn from this study are indications collected on the characterization of local vulnerability, interviews with farmers, field observations, information collected from the decision makers to the agricultural sector and the characterization of adaptation and governance measures.

Study Area

The Barracão dos Mendes rural community is located in the Rio Grande Watershed in the municipality of Nova Friburgo, Rio de Janeiro (22° 16′ 55″ S and 42° 31′ 52″ W), at an average height of 985 m, in the Atlantic Forest biome, some 200 km from Rio de Janeiro City. The landscape is mountainous in a very hilly area and the topography ranges from steep slopes to large lowland extensions (CPRN 2002).

The climate is tropical altitude. Average temperatures are around 18 °C, the average temperature in summer is 24 °C and in winter 13 °C, with frost in floodplains and hailstorms in the summer. The average rainfall is 1650 mm/year. Rainfall distribution is very unequal, with 60% of the total annual rainfall occurring from December to March (summer), with accumulated deficits in winter, from May to July (INMET 2013).

There are some 256 properties belonging to family farmers in Barracão dos Mendes communities. Most of the properties have less than 10 ha. The agricultural system in Barracão dos Mendes is intensive, characterized by commercial polyculture (horticulture), whose seasonality of crops allows the intensive use of land throughout the year (SEAPEC 2011).

Common tillage is widely used, mainly plowing using tractors downhill, contributing to soil loss, silting of streams and sediment transport. These facts largely contribute to local erosion. Continued land use for crops and pastures impoverished and compacted soils, and these areas are still productive due to the intensive use of fertilizers and agrochemicals. In Barracão dos Mendes the appropriate techniques recommended for hillside conditions (for example, minimal tillage) are not usually adopted.

The remaining forests are located only in the higher areas, and they are often secondary forest covers of the Atlantic Forest. Human activities significantly affected all local waterways, due to the techniques used in production, such as low hill plowing (without contour).

Results

Aspects of Local Vulnerability and Impacts

The mountain region of Rio de Janeiro is highly vulnerable to the impacts caused by EHE. The factors that contribute to the risk of disasters are mainly local environmental characteristics of this mountain region, with steep slopes and formed by rocks covered by a thin layer of soil. These features generate quite unstable soils and liable to landslides (Busch and Amorim 2011).

Combined with the natural vulnerability, the risks are even worse due to the historical occupation of the riverbanks and streams, the removal of vegetation strips that protect the waterways; irregular construction in the hillside areas; accumulation

of garbage on the slopes and deforestation. In this context, the strong summer rains often cause erosion, flooding and landslides.

In the last 25 years flooding with landslides occurred in 1987, 1988, 1999, 2000, 2003, 2007, 2008 and 2011, which led to hundreds of dead, missing, homeless or displaced residents. However, none of these events can be compared to what happened in January 2011, considered the largest natural disaster ever seen in the country. Between the evening of 11 January 2011 and the morning of the 12th, a strong storm occurred in the mountain region of Rio de Janeiro State, especially in the Cities of Petropolis, Teresópolis and Nova Friburgo.

In the mountain region, the large volume of rain combined with soil saturation and the natural vulnerability of the region caused overflowing of rivers and streams and landslides, destroying bridges, roads, rural buildings, houses and crops, leading to over 900 deaths, hundreds of missing and more than 30,000 homeless people. The entire region was covered by mud, hundreds of houses were swept away by land and dozens of people were buried. The tragedy also caused geographical changes in the area: rivers, streams and canals had their courses changed (Canedo et al. 2011).

Barracão dos Mendes was one of the most affected places by landslides and flooding. Losses were registered in agricultural areas by overflow of mud from the flood, erosion and landslides, as well as suppression of crop areas. Several agricultural areas became unproductive due to leaching of fertilizers and laminar and deep soil erosion. According to information of the Department of Agriculture and Rural Development of Nova Friburgo, the loss of areas exploited in this activity exceeds 1500 ha, of which the majority of the affected areas were planted with horticulture. About 1400 ha suffered superficial laminar erosion and 153 crops were partially or totally wasted (SEAPEC 2011). Most crops were damaged, either by deposition of mud and stones, or sand. What was left could not be sold due to the depreciation of production. The devaluation of agricultural products was due to the widespread information that the vegetables were being irrigated with water that contained human remains. The price of agricultural production fell sharply.

Governance Aspects

In Brazil, government institutions directly related to the use of planning and land use (environment), land development (agriculture) and risk management (civil defense) in the three levels of government (national, regional and municipal) are well structured, in the same way as the entire legal framework referring to the question.

The Ministry of National Integration organizes the actions and programs related to risk management and disasters and it has capillarity in all levels of the Brazilian government. The Brazilian Civil Defense is the agency chosen by the ministry to deal with these phenomena and is organized in the form of a system: the National Protection and Civil Defense System. The National Secretariat of Protection and

Civil Defense—SEDEC is the central body of the system, responsible for coordinating the actions of protection and civil defense throughout the country. SEDEC provides, in addition to preventive actions, assistance to those affected by disasters and response actions. All these services are made possible through a transfer of resources to states and municipalities under states of emergency.

Although the theme of disaster risk reduction (RRD) has advanced in Brazil, few preventive actions have been implemented, according to Brazil's plan risk reduction, presented to the United Nation in 2009. It generates higher expenditures to attend to the affected population (emergency action) in comparison with the total spent on prevention (Busch and Amorim 2011).

Therefore, in the case of the mountain region, the natural vulnerability of the region is widely recognized and documented. The Agenda 21 of Nova Friburgo developed from 2006 to 2008 contains the identification of risk areas, steep and irregular occupation of slopes by illegal settlements. The council also prepared the Action Plan for Sustainable Development and requested resources to implement the National Fund for the Environment in 2010. This document presents the negative aspects to local rural development, among others: the poor education and health services in the field, insufficient environmental monitoring due to lack of infrastructure and labor.

However, in this case study we have found that the risk prevention actions and disasters had not been implemented with the necessary effectiveness to deal with the EHE. There was no effective contingency plan or proper risk planning with defined responsibilities to deal with emergencies and carry out streamlines as necessary responses to abnormal events. On the other hand, in terms of emergency actions the role of the Rio de Janeiro State's Department of Agriculture and Livestock (SEAPEC) was crucial. Soon after the tragedy, SEAPEC carried out emergency actions and currently collaborates to restructure agricultural areas affected by the rains in January 2011. Technical performers of SEAPEC developed along with rural households projects to start the recovery of productive activities and provided the necessary guidelines for access to federal government emergency loans to the farmers.

Lessons Learned

In this case study, we could observe that the occurrence of EHE helped to raise awareness regarding environmental problems in rural areas. In the region, the lack of planning to use natural resources results in problems such as soil erosion and pollution of rivers. Some farmers began to question their agricultural practices and their consequent environmental impacts, which could result in increased local vulnerability. There was an increase in the dissemination and awareness of the importance of adopting soil conservation practices and water and agro-ecological production practices. Some local farmers point out, for example, the importance of

plantations for ground cover with leguminosae spp, the benefits of crop rotation and tillage, among others.

These results converge to the notion of sustainable adaptation as defined by O'Brien and Leichenko (2003), as they indicate measures that reduce vulnerability and promote long-term resilience in an environment of climate change. This sustainable adaptation can be a useful and widely applicable approach to adapt to prevention because it can increase nature's capacity to cushion the adverse effects through the sustainable provision of ecosystem services.

Regarding governance aspects, government institutions that deal with reduction risk are well structured in all three-government levels. Nevertheless, the integration of local plans and government programs related to risk prevention and disaster plans and local development programs is important to generate efficient adaptation measures. In this case, that includes the local farmers and seeking feasible solutions to be deployed, considering the importance of the local diagnosis and the proposition of actions that consider the environmental, economic and cultural site. The Agenda 21 set an example of local initiatives. It includes boards and committees of river basins involving the diagnosis of problems and the preposition of solutions with broad involvement of society.

Regarding adaptation measures, as mentioned above the lessons learned refer to the need to strengthen and implement risk prevention strategies to disasters, i.e., adaptation measures related to the prevention of losses, both human and economic. Although the institutional framework is well structured, adaptation measures related to risk prevention do not seem to be sufficient. In this issue, the question of planning and land use plays a major role, regarding both the occupation of the slopes in mountain regions and subject to landslides and the illegal occupation and pollution of rivers. Therefore, the need to strengthen local government institutions and community associations to deal with risk prevention becomes a central point. Thus, it was found that in addition to the natural and socio-economic vulnerabilities on site, there is also an institutional and organizational vulnerability to deal with risk prevention in the region.

Conclusion

Floods and landslides are recurrent situations in the mountain region of the State of Rio de Janeiro; however, adaptation measures related to prevention were insufficient in the face of the severe impacts reported in the case study. Greater emphasis on prevention strategies is necessary, such as planning, strengthening of rural communities, containment of work slopes, improvement of warning systems, among other adaptation measures that may increase the resilience of the agricultural production of rural communities. The results of the case study suggest that the integrated management of the community level landscapes allows the agricultural producers to adopt adaptation measures in due course and prepare rural communities to face the EHE.

The environmental degradation processes in the agricultural sector greatly contribute to the vulnerability to EHE. Its causes involve the lack of environmental awareness among farmers, lack of access to land and capital, the few investments in infrastructure and the illegal occupation of land. It shows the importance of institutional mobilization to strengthen the actions that benefit or increase the organization and participation of rural communities in the discussion of local environmental solutions, participation in environmental education, the dissemination of sustainable agricultural practices, and other actions that contribute to spread measures related to the protection of natural resources and socio-economic empowerment of the people. Thus, it is clear that it is important to invest in the dissemination of measures related to the protection of natural resources and the provision of ecosystem services that can enhance the resilience of agriculture systems in the face of EHE.

On the farmers' lack of knowledge and preparation, this limit could be overcome by empowering communication between the government, researchers, agricultural extension agents and farmers. We suggest that community strategies support the integration of these levels and allow the search for new alternatives—some of them, connected to the performance of regulatory environmental services that may reduce environmental impacts. Either way, we must stress the importance of the government´s role, guiding the development of policies to ensure the continuation of prevention actions and action plans to reduce risks rather than just emergency actions.

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